

ISSN: 3105-3262 | Quarterly Publication

Peer-reviewed, Open-access & International!

The Operating Room Global Journal (TORGJ)

VOLUME 2 ISSUE 3 | SEPTEMBER 2026

*Theme: "Advancing Surgical and Health Outcomes Through Innovation,
Evidence & Systems Strengthening"*

In this Issue:

- KNOWLEDGE AND ATTITUDE OF SURGICAL PATIENTS TOWARDS ANESTHESIA AND ANESTHETISTS: INSTITUTIONAL BASED CROSS-SECTIONAL STUDY
- THERANOSTICS IN ONCOLOGY: INTEGRATING MOLECULAR IMAGING AND TARGETED RADIONUCLIDE THERAPY FOR PRECISION CANCER CARE
- KNOWLEDGE AND ATTITUDE OF STAFF NURSES AT UNIVERSITY OF ILORIN TEACHING HOSPITAL TOWARDS NURSING ANAESTHESIA PROGRAMME
- PREVENTION AND MANAGEMENT OF HYPOTENSION DURING SPINAL ANESTHESIA: A NARRATIVE REVIEW
- ARTIFICIAL INTELLIGENCE FOR AUTOMATED DETECTION OF LARGE VESSEL OCCLUSION: STATE OF THE ART, CLINICAL APPLICATIONS AND FUTURE PERSPECTIVES
- TASK SHIFTING AND SAFE SURGICAL CARE IN RURAL ADAMAWA, CAMEROON: A CROSS-SECTIONAL PROVIDER SURVEY

Volume 2
Issue 3, 2026.

- IMPACT OF THE COVID-19 PANDEMIC ON ADULT LITERACY TRENDS IN PAKISTAN: A PRE-POST COMPARATIVE TIME-SERIES ANALYSIS (2017–2024)
- EARLY POSTOPERATIVE RECOVERY OUTCOMES OF MINIMALLY INVASIVE VERSUS CONVENTIONAL CARDIAC SURGERY IN ADULT PATIENTS IN PAKISTAN: A RETROSPECTIVE COHORT STUDY
- DIAGNOSTIC AND THERAPEUTIC MANAGEMENT OF A PAINFUL THYROID MASS WITH DISCORDANT THYROTROPIN AND THYROID HORMONE MEASUREMENTS: A CASE REPORT
- STRATEGIC MEASURES TO OVERCOME BARRIERS TO PREVENTIVE CERVICAL CANCER SCREENING AMONG WOMEN ATTENDING TERTIARY HEALTH FACILITIES IN NORTHWESTERN ZONE, NIGERIA
- INCIDENCE AND PREDICTORS OF REBOUND PAIN FOLLOWING PERIPHERAL NERVE BLOCK AMONG ORTHOPEDICS SURGICAL PATIENTS

The Official Journal of The Operating Room Global
Centre For Education, Research and Innovation.
www.torgceri.org



SDG 3 | SDG 4 | SDG 9 | SDG 10
Supporting the UN Sustainable Development Goals

CC-BY 4.0 Licensed



<https://torgjournal.org/>

TABLE OF CONTENTS

Contents	2
Contributors and Publication Details	3
Editorial Team	4
Letter from the Editor-in-Chief	5

FEATURED

- Knowledge and Attitude of Surgical Patients towards Anesthesia and Anesthetists: Institutional Based Cross-sectional Study 8
- Theranostics in Oncology: Integrating Molecular Imaging and Targeted Radionuclide Therapy for Precision Cancer Care 17
- Knowledge and Attitude of Staff Nurses at University of Ilorin Teaching Hospital Towards Nursing Anaesthesia Programme 37
- Prevention and Management of Hypotension During Spinal Anesthesia: A Narrative Review 56
- Artificial Intelligence for Automated Detection of Large Vessel Occlusion: State of the Art, Clinical Applications and Future Perspectives 66
- Task Shifting and Safe Surgical Care in Rural Adamawa, Cameroon: A Cross-Sectional Provider Survey 76
- Impact of the COVID-19 Pandemic on Adult Literacy Trends in Pakistan: A Pre-Post Comparative Time-Series Analysis (2017-2024) 88
- Early Postoperative Recovery Outcomes of Minimally Invasive Versus Conventional Cardiac Surgery in Adult Patients in Pakistan: A Retrospective Cohort Study 96
- Diagnostic and Therapeutic Management of a Painful Thyroid Mass with Discordant Thyrotropin and Thyroid Hormone Measurements: A Case Report 108
- Strategic Measures to Overcome Barriers to Preventive Cervical Cancer Screening among Women Attending Tertiary Health Facilities in Northwestern Zone, Nigeria 117
- Incidence and Predictors of Rebound Pain Following Peripheral Nerve Block Among Orthopedics Surgical Patients 125

CONTRIBUTORS

1. Mahmud Zubaina Yerima
2. Mahammad A. Sabo
3. Babani M. Iliya
4. Abdullahi Adamu
5. Ahmed Shuaibu Tsafi
6. Peter Matthew George
7. Arda Işık
8. Fatima Jaweria
9. Myada A. Ibrahim
10. Zia Un Nisa
11. Saman Aziz
12. Muhammad Muzammil Ramzan
13. Muhammad Wajid Munir
14. Adebisola Adenike Owokole
15. Megbar Dessalegn
16. Ishaan Bakshi
17. Anas Jahangir
18. Muhammad Hashim
19. Hira Khan
20. Atia Ur Rehman
21. Fatima Ashraf
22. Racheal Olufunmilayo Oyelude
23. Chuwang Bitrus Zi
24. Phillip A. Ojo
25. Prashant Anand
26. Hriday Singh Rawat
27. Dawit Tafesse Darsema
28. Umar Siraj Wodale
29. Haji Ahemed Motma
30. Desalegn Yimam Mohammed
31. Abas Ali Hassen

Publication:

Volume 2 Issue 3 | September 2026

Theme: “Advancing Surgical and Health Outcomes Through Innovation, Evidence & Systems Strengthening”

This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

Journal:

The Operating Room Global Journal (TORGJ)

ISSN: 3105-3262 (Online)

www.torgjournal.org

Editorial Office:

torgjournal@operatingroomissues.org

Editorial@torgjournal.org

Publisher:

The Operating Room Global Centre for Education, Research & Innovation.

+353-894245101

Co. Limerick, Ireland.

www.torgceri.org



THE OPERATING ROOM GLOBAL
JOURNAL (TORGJ)

MEET THE TEAM



Dr. Asjed Sanaullah
Editor-in-Chief,
Pakistan.



**Dr. Zakir Hussain
Parry**
Statistical Editor,
India.



Ms. Zinat Atif
Editorial Secretary,
Bangladesh.



Dr. Ishaan Bakshi
Section Editor & Editorial
Board Member,
India.



Mr. Danjuma Aliyu
Section Editor & Editorial
Board Member,
Nigeria.



**Mr. Sayed Ahabab
Hussain**
Section Editor & Editorial
Board Member,
Pakistan.

The Operating Room Global Journal (TORGJ) is an open-access, peer-reviewed, multidisciplinary international journal committed to advancing evidence-based knowledge.

Journal DOI: 10.64573/torgj | ISSN: 3105-3262 | Published Quarterly

Open Access | Licence: CC BY 4.0

www.torgjournal.org

LETTER FROM OUR EDITOR-IN CHIEF

Innovation in healthcare is not measured by how advanced an idea appears, but by how reliably it changes what happens to a patient.

It is from this premise that I am pleased to present Volume 2, Issue 3 of The Operating Room Global Journal, under the theme *“Advancing Surgical and Health Outcomes Through Innovation, Evidence and Systems Strengthening.”*

The urgency could not be clearer. Surgery contributes an estimated 13% of the world’s disability-adjusted life years, yet complications occur in up to one in four patients undergoing inpatient operations, with at least half of surgery-related harm considered preventable. At the same time, cervical cancer continues to claim approximately 350,000 lives annually, with nearly 94% of deaths occurring in low- and middle-income countries. These figures remind us that the central challenge is not simply discovering better interventions; it is ensuring that evidence, technology, skilled professionals, and effective systems reach the people who need them.

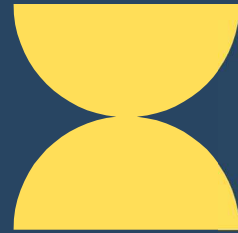
The eleven contributions in this issue reflect that broader responsibility. From precision oncology and artificial intelligence to anaesthesia safety, postoperative recovery, pain, surgical workforce development, health-professional education, patient engagement, cancer prevention, and population health, the collection demonstrates that meaningful progress rarely comes from a single discipline.

The future of surgery and healthcare will belong to systems that learn faster, collaborate better, measure outcomes honestly, and translate evidence into equitable action.

As we close this issue, our invitation is therefore simple: let innovation be purposeful, evidence be consequential, and systems be designed around the patient.

With appreciation,

Dr. Asjed Sanaullah
Editor-In-Chief,
The Operating Room Global Journal (TORGJ)



(Editor-in-Chief, TORGJ)

**Theme:
“Advancing
Surgical and
Health
Outcomes
Through
Innovation,
Evidence &
Systems
Strengthening”**

**Innovation in
healthcare is not
measured by how
advanced an idea
appears, but by
how reliably it
changes what
happens to a
patient.**

Join us for thought-provoking clinical presentations from world-renowned faculties.

Register for upcoming TORG live webinars with Q&A opportunities

After registering, you would receive a personalised link by email for joining the session.

Scan the QR Code to register for upcoming webinar or visit www.operatingroomissues.org/upcoming-webinar



The Operating Room Global (TORG) is an Approved CPD Provider.



www.torgjournal.org

Start a Submission

The Operating Room
Global Journal (TORGJ)

- Submit an Article
- Read this Issue online
- Scan QR Code or visit
- <https://doi.org/10.64573/torgj0726003>

SCAN
ME



The Operating Room Global Journal (TORGJ) Vol 2 Issue 3 Sept 2026

THE OPERATING ROOM GLOBAL (TORG)
WWW.OPERATINGROOMISSUES.ORG

TORG MEMBERSHIP JOIN NOW

Your Gateway to
Professional Growth
and Networking.

TORG



Become a TORG Member

Scan QR Code to learn more or visit:
<https://www.operatingroomissues.org/torg-membership/>

SCAN
ME



Are you looking to elevate your career in the field of surgical care? Joining The Operating Room Global (TORG) can be the key to unlocking unparalleled professional growth and a vast network of like-minded professionals.

JOIN OUR COMMUNITY!

Knowledge And Attitude of Surgical Patients Towards Anesthesia and Anesthetists: Institutional Based Cross-Sectional Study

Authors: Dawit Tafesse Darsema^{1,3*}, Umar Siraj Wodale¹, Haji Ahemed Motma¹, Desalegn Yimam Mohammed², Abas Ali Hassen¹

¹ Werabe University, College of Medicine and Health Science, Department of Anesthesia.

² Werabe Comprehensive Specialized Hospital, Werabe, Ethiopia.

³ The Operating Room Global (TORG).

DOI: <https://doi.org/10.64573/torgj2607003>

***Corresponding Author:**

Dawit Tafesse Darsema

dawit.tafesse90@gmail.com

Declaration:

Authors' Contribution:

Equal contributions.

Conflict of Interest: No conflict of interest.

Funding: No funding received.

Article History:

Received: 11-07-2026

Accepted: 24-07-2026

Available Online: 31-07-2026

QR access this Article



ABSTRACT

Background: Anesthesia was misconceived as a behind the screen specialty. Despite considerable developments in its scope, anesthesia maintains with a poor public image, clients are not even aware of an anesthetist as a medically qualified health practitioner, particularly in undeveloped nations.

Objective: To assess knowledge and attitude of surgical patients toward anesthesia and anesthetist in WCSH from March 1 to 30, 2025 GC

Method: Institution-based, cross-sectional study was conducted from March 1 to 30, 2025 GC in Werabe comprehensive specialized hospital. Data was collected through interviews using a structured digital questionnaire to gather relevant information and Descriptive statistic and Binary logistic regression analysis was performed to explain the study participants with study variables and to identify the association between the level of knowledge and independent variables.

Results: Of the 151 respondents, 79 people (52.3%) claimed that they knew about the concept of anesthesia. Among them, 86% referred to anesthesia as "putting patients asleep." Almost all (92.1%) of the participants were aware of the fact that anesthesia is mandatory for surgeries. On the other hand, less than half (39.7%) of the respondents knew who decides whether a patient is fit for anesthesia or not.

Conclusion: The perception of most patients is that anesthesia is all about 'putting patients to sleep. There was poor knowledge of patients regarding the role of anesthetists beyond the confines of the operating theatre.

Keywords: Knowledge and Attitude, Elective Surgery, Anesthesia, Anesthetist, Ethiopia.

INTRODUCTION

Anesthesia is an essential component of modern healthcare that enables safe and painless surgical procedures and contributes significantly to perioperative care. [1] Apart from the administration of anesthetic drugs, there are many other duties that an anesthetist performs, such as preoperative assessment, intraoperative monitoring, pain control after surgery, critical care, and resuscitation in emergency situations. However, despite all these tasks, anesthesiology is little known among ordinary people as a specialty that only makes patients go to sleep. [2, 3]

Patients' knowledge and perceptions of anesthesia and anesthetists have important implications for perioperative care. Adequate understanding of anesthesia helps reduce fear and anxiety, improves communication between patients and healthcare providers, facilitates informed decision-making, and enhances satisfaction with surgical services. [3-5] Conversely, misconceptions and poor awareness may lead to unnecessary anxiety, lack of trust in anesthetic care, and inadequate appreciation of the contributions of anesthetists. [6, 7]

Studies conducted in different countries have demonstrated substantial gaps in patients' knowledge regarding the roles and responsibilities of anesthetists. [4, 6, 8] Similar findings have been reported in several African and Asian countries, where many patients are unaware that anesthetists are medically trained professionals responsible for monitoring vital functions, determining fitness for anesthesia, and managing complications during and after surgery. [2, 8] In Ethiopia, previous studies have also shown limited public awareness and misconceptions about anesthesia and anesthetists. [9, 10] However, evidence from different regions of the country remains limited and may vary according to socio-demographic characteristics and healthcare settings.

Assessing patients' knowledge and attitudes toward anesthesia and anesthetists is essential for identifying knowledge gaps and designing strategies to improve public awareness and patient-centered perioperative care. Therefore, this study was conducted to assess the knowledge and attitudes of adult patients undergoing elective surgery toward anesthesia and anesthetists at Werabe Comprehensive Specialized Hospital, Central Ethiopia, between March 1 and 30, 2025.

METHODS

Study area

The study was conducted in the Werabe comprehensive specialized Hospital/WCSH, Central Ethiopia Regional State. WCSH is found in the central Ethiopia, which is 175 km from the capital city, Addis Ababa. The hospital provides healthcare services to more than 1.5 million catchment populations and is a referral center for three primary hospitals and 34 health centers. It gives emergency, outpatient, and in-patient specialized care in medical, surgical, pediatrics, gynecology, obstetrics, Ophthalmology, ENT, psychiatry, adult ICU (Intensive Care Unit neonatal intensive care unit (NICU) and operation theater wings.

Study design and period

An institution-based, cross-sectional study was conducted from March 1 to 30, 2025 GC.

Study Population

Target Population: All adult Surgical Patients undergoing elective surgeries in Werabe Comprehensive Specialized Hospital was the target population.

Source population

Adult elective surgical patients admitted to the Werabe Comprehensive Specialized Hospital

Study population

All consecutive adult elective surgical patients admitted to the general surgical, orthopedic, gynecology, otorhinolaryngology (ENT), and plastic surgery wards.

Inclusion criteria

All patients 18 and above years old, admitted to the surgical, orthopedic, gynecology, ENT wards and plastic ward, and patients who consented to participate in the study in the WCSH were included in the study.

Exclusion criteria

Patients with severe medical or surgical conditions, psychiatric problems, and patients who are unable to speak, or having hearing difficulty was excluded from the study.

Variables of the Study

Dependent variables

- Level of knowledge to ward anesthesia and anesthetist

- Patient attitude toward anesthesia and anesthetist

Independent variables

- Age, sex, level of education, previous anesthetic/surgical experience, residence, and occupation were the independent variables.

Sample Size and Sampling Technique

Sample size determination

For sample size determination single population proportion formula was used. Based on a study conducted in Dilla University referral hospital [10], 42% of patients knew that Anesthetists is the one who give Anesthesia ($P = 0.42$)

We calculated the sample size as: $n = \left(Z \alpha \frac{\infty}{2} \right)^2 p(1 - p) / d^2$

Where, n = sample size, Z = the standard score corresponding to 95% confidence interval (1.96) P = the proportion of the respondent that had good knowledge toward anesthesia (0.42). [10]

D = margin of sampling error to be tolerated (0.05)

$$n = (1.96)^2 \cdot 0.42(1-0.42) / (0.05)^2 = 374$$

The total number of surgical operations that were done through the elective process in the preceding year was less than 10,000 based on the records of surgical registration. Hence, there was use of finite population correction formula for determination of the sample size as below: $N = n / (1 + n/N)$

Where, N = Total number of patients took anesthesia for the last one month ($N = 220$), n = sample size ($n = 374$)

$$N = 374 / (1 + 374/220)$$

$N = 139$ we add 10% non-respondent rate then finally $n = 153$

Data collection techniques

The questionnaire was developed by adapting items from previously published studies [2, 3, 10, 11] and was prepared in both English and Amharic. Participants were interviewed in Amharic by two trained data collectors. The data collection process was supervised by two senior MSc anesthetists to ensure data quality and consistency.

This study also conducted in accordance with the ethical principles outlined in the World Medical Association Declaration of Helsinki for Medical Research Involving Human Subjects. [12] In addition, the study was reported in compliance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. [13]

Data quality management

To ensure the quality of data, a pilot study for pre-testing of the data collection tool (the questionnaire) was conducted at Alem Gebaya Primary Hospital, Central Ethiopia Regional State on 10 consecutive elective surgical patients who were not included in the main study. Internal consistency of the survey was evaluated using Cronbach's alpha coefficient. The score of 0.70 or above for Cronbach's alpha coefficient was used as an indication of acceptable reliability. Item-total correlation and "Cronbach's alpha if item deleted" were studied to determine poorly performing items and to evaluate how they affect the internal consistency of the scale.

Data processing and analysis

First, the data was collected using kobotool box app, and then the data was transferred to and checked in SPSS version 27. Descriptive statistic was used to explain the study participants with study variables. Bivariate analyses have been performed to determine the association between the outcome variable and each independent variable. Only variables with a p -value less than 0.25 during bivariate analysis were entered into the multivariate analysis. Finally, the strength of the association between the independent variables and the level of knowledge and attitude of patients on anesthesia and anesthetists was presented by odds ratio and 95% Confidence interval. A P -value less than 0.05 were considered statistically significant. The goodness-of-fit of the final multivariable logistic regression model was assessed using the Hosmer–Lemeshow goodness-of-fit test. A p -value greater than 0.05 was considered indicative of an adequate model fit.

Multicollinearity among independent variables was assessed using the variance inflation factor (VIF), and there was little or no multicollinearity was observed among the independent variables ($VIF < 10$).

RESULTS

Socio-Demographic Characteristics of Study Participants

A total of 151 study participants were involved in this study, two participants with incomplete data was excluded from the study with a response rate of 99%. Of these 72 (47.7%) were males and 79 (52.3%) were female. About 29 (19.2%), were in the age category between 18 and 24 years, 65 (43.04%) between 25 and 40 years, 57 (37.7%) is greater or equal to 40. The mean age of participants was $38.9 \pm (13.3)$ years.

Regarding educational status 27(17.9%) were illiterate, 39 (25.8%) can read and write, 31 (20.5%) completed elementary school, about 30 (19.9%) joined high school, and the rest 24 (15.9%) were graduated from university/college. 92 (60.9%) were urban residents and 59 (39.1%) live in rural areas.

Most participants make their daily living by private businesses (55, 36.4%), by farming (45, 29.8%), and government employees were 25 (16.6%) and the rest 27 (17.9%) were in the others category which involves housewives, students and even participants with no job.

Previous History of Anesthetic Exposure

Regarding previous anesthesia exposure, 73(48.3%) patients responded that they have received anesthetic drugs for different surgical interventions. Among these thirty-nine (25.8%) took anesthesia once, twenty-eight (18.5%) took it twice and the rest six (4%) took it three or more times. General anesthesia (33, 21.9%) and regional anesthesia (33, 21.9%) was the type of anesthesia received by most patients, about 5 (3.3%) patients were took local anesthesia and about 2 (1.3%) patients did not remember or don't know the type of anesthetic they have taken.

Patient Knowledge of Anesthesia and Anesthetist

Out of 151 participants, 79 (52.3%) of the patients know about anesthetist of this 57 (72%) were knew anesthetists as university graduates who trained to give anesthesia, 12 (15.2%) as assistance of surgeon, 10 (12.7%) as nurses who trained to give anesthesia.

Majority of the patients 139 (92.1%) believed that anesthesia is necessary for surgery.

On the assessment of patient's knowledge about the role of anesthetists, majority 68 (86%) of patients replied that anesthetists put the patients to sleep, monitor vital sign (5, 6.3%), anesthetizing and monitoring (5, 6.3%) and do major surgery (1, 1.2%)

When we assess who will decide on your fitness for anesthesia, 60 (39.8%) patients said the anesthetists will decide, while 63 (41.7%) said the surgeon, 14 (9.3%) were said nurses and the rest 14 (9.3%) don't know.

Majority of patients 54 (35.8%) also thought the Surgeons determines if they could eat before surgery and again 50 (33.3%) thought the anesthetist was responsible for it.

Table 1 Level of knowledge of surgical patients toward Anesthesia and Anesthetist in Werabe Comprehensive Specialized Hospital, Werabe, Ethiopia. (n=151)

Knowledge of patients toward anesthesia and anesthetists		Frequency	Percentage
Is anesthesia necessary for surgery	Yes	139	92.1%
	No	12	7.9%
Which type of do you prefer for your surgery	General anesthesia	87	57.6%
	Regional anesthesia	43	28.5%
	Local anesthesia	12	7.9%
	I don't know	9	6%
Do you know risk of anesthesia	Yes	53	35.1%
	No	98	64.9%
In monitoring vital sign during surgery	Anesthetist	77	51%
	Surgeon	55	36.4%
	Nurses	13	8.6%
	I don't know	8	4%

Who do you think estimates and transfuse blood in OR when it required	Anesthetists	45	29.8%
	Nurses	50	33.1%
	Surgeons	26	17.2%
	I don't know	30	19.9%
Do anesthetists have role in managing non-surgical pain?	No	5	6.3%
	Yes	70	88.6%
	I do not know	4	2.6%
If you face breathing difficult either in PACU or ward, do you think the anesthetist has role in managing it?	No	6	7.5%
	Yes	72	91.1%
	I don't know	1	1.2%

The bi-variable logistic analyses showed that; age, residency, previous anesthesia exposure and literacy level was associated with the patient's knowledge of anesthesia and anesthetists.

On multivariate analysis, when we compare patients who can't read or write plus patients who can only read or write with patients completed high school or college, they are 86.4% less likely to know about anesthesia and anesthetists. [AOR 0.136 (0.046 - 0.397) P =0.00]

Similarly, when we compare patient who had no previous anesthesia exposure with those patients who had previous anesthesia exposure, they are 75.5% less likely to know about anesthesia and anesthetists. [AOR: 0.245 (0.109 - 0.551) P = 0.001]. Other variables like the gender, occupation, and age of the patients were not significantly related with the level of knowledge about Anesthesia and Anesthetists.

Table 2 Factors associated with level of Knowledge of surgical patients toward anesthesia and anesthetist in Werabe Comprehensive Specialized Hospital, Werabe, Ethiopia. (n=151)

Variable		Knowledge level		Crude Odds Ratio	Adjusted Odds Ratio	P-value (AOR)
		Good	Poor			
Gender	Male	40 (55.6%)	32 (44.4%)	1.243(0.657-2.353) P > 0.2		
	Female	39 (49.4%)	40 (50.6%)			
Age	18 – 40	54 (60.0%)	35 (40.0%)	2.220 (1.148-4.294) p < 0.018	0.575 (0.226 - 1.459)	0.244
	>40	25 (42.3%)	37 (66.1%)			
Residency	Rural	20 (33.3%)	39 (66.7)	0.280 (0.141-0.555) P < 0.001	0.898 (0.355 - 2.271)	0.822
	Urban	59 (64.1%)	33 (35.9%)			
Literacy level**	Can't read or write + Only can read	18 (27.3%)	48 (72.7%)	0.200 (0.070 - 0.574) P < 0.01	0.136 (0.046 - .397)	0.000
	Elementary	17 (56.7%)	13 (43.3%)	1.760 (0.720-4.304)	0.409 (0.140 - 1.192)	0.101
	High school/college	44 (80%)	11 (20%)			0.001
Occupation	Farmer	9 (20%)	36 (80%)	0.200 (0.070 - 0.574)	.350 (0.100 - 1.221)	0.100
	Gov't/private business	55 (68.8%)	25(31.2%)	1.760 (0.720-4.304)	1.589 (0.574 - 4.396)	0.372

	Student/unemployed	15 (55.6%)	12(44.4%)			0.029
Previous anesthesia exposure **	Yes	51 (69.9%)	22 (30.1%)			0.000
	No	51 (65.4%)	27 (34.6%)	0.242 (0.122 - 0.477)	0.245 (0.109 - 0.551)	0.001

Keys: COR: Crude Odd Ratio (unadjusted); AOR Adjusted Odd Ratio (controlled for other variables) and **, key significance association ($p < 0.05$)

Attitude of the patient toward Anesthesia

Assessment of patient's attitude toward Anesthesia were addressed as agree, disagree or neither of the two. Majority of patients 149 (98.7%) agreed to meet the anesthetist peri-operatively. 115 (76.2%) patients think the surgeons tell all the necessary information they need to know while, 28 (18.5%) disagreed, the rest 8 (5.3%) don't know who is going to tell them the information.

Ninety (59.6%) patients were more nervous about the surgery than anesthesia. 75 (49.7%) patients also agreed that anesthetists do explain what is going to happen peri-operatively, while 64 (42.4%) disagreed. For question 'how do you feel about your safety when you put under anesthesia' seventy-seven (51%) replied I feel safe, 60(39.7%) not sure about their safety and the rest 9.3% replied 'I don't feel safe.

For a variety of reasons, including prolonged sleep in the postoperative period (12, 7.9%), waking up during surgery (25, 16.6%), not waking up after anesthesia (54, 35.8%), and other issues including postoperative discomfort (10, 6.6%), the majority of patients (101, 66.9%) are afraid of anesthesia.

Table 3 the attitude of surgical patients towards Anesthesia and Anesthetists in Werabe Comprehensive Specialized Hospital, Werabe, Ethiopia. (n=151)

Attitude of Patients towards anesthesia and anesthetists		Frequency	Percentage
A good operation needs a teamwork from both anesthetist and surgeon	Disagree	5	3.3%
	Agree	144	95.4%
	Neither agree nor disagree	2	1.3%
How do you think the relationship between the anesthetist and surgeon	The anesthetists perform his job under the surgeon's order	40	26.5%
	The surgeons perform his job under anesthetist's order	12	7.9%
	Each has different roles	69	45.7%
	I don't know	30	19.9%
how do you feel about your safety when you put under anesthesia	I feel safe	77	51%
	I'm not sure about my safety	60	39.7%
	I don't feel safe	14	9.3%
Do you afraid of anesthesia	No	50	33.1%
	Yes	101	66.9%
The reason for the fear toward anesthesia	Not waking up after anesthesia	54	35.8%
	Postoperative pain	10	6.6%
	Prolonged sleep on postoperative period	12	7.9%

	Waking up in the middle of surgery	25	16.6%
I would like to meet the Anesthetist peri-op	disagree	0	0
	agree	149	98.7%
	Neither agree nor disagree	2	1.3%
All I need to know is what my surgeon tells me	Disagree	28	18.5%
	Agree	115	76.2%
	Neither agree nor disagree	8	5.3%
I am more nervous about anesthetic than surgery	Disagree	90	59.6%
	Agree	37	24.5%
	Neither agree nor disagree	24	15.9%
Anesthetists don't explain what is going to happen	Disagree	75	49.7%
	Agree	64	42.4%
	Neither agree nor disagree	12	7.9%

DISCUSSION

Anesthesia is one of the key specialties that make major and advanced surgeries possible. Health awareness is on the increase worldwide, and even Ethiopia is not an exception. Astonishingly, only slightly more than half (52.3%) of the respondents knew about anesthetists, while 58.94% have good attitudes towards anesthesia and anesthetists.

A large proportion (86%) believed anesthetists are mainly responsible for putting patients to sleep, which aligns closely with findings from a study conducted in Singapore (88%) [14] and this may be due to a general belief among people that anesthesia is all about putting patients to sleep and waking them up. Only 39.7% of patients in our study recognized that anesthetists assess whether a patient is fit for anesthesia. This gap in knowledge may be attributed to the limited interaction patients have with anesthetists, who are often occupied in the operating theatre with little time for pre- or post-operative communication.

We assessed several factors for their association with patients' knowledge about anesthesia and anesthetists. Educational status (patients who can only read or write versus patients completed high school or college), and previous anesthetic exposure were significantly associated with knowledge of anesthesia and anesthetists at p-value of < 0.05, which was almost similar finding with study done in University of Gondar [11], Debre Tabor University Referral Hospital [3] and Korle-Bu Teaching Hospital Ghana [2]. In contrast to earlier research done in Tikur Anbessa Hospital [9] and India [15], which showed no relationship between the previous surgical or anesthetic experience of the patient and his knowledge about anesthetist, our research has shown a positive correlation. According to the authors of the studies mentioned above, the reason for such a result was in the limited duration of pre-anesthetic consultations that do not allow patients to realize the presence of an anesthetist. The relatively longer preoperative visit time of patients with anesthetists, in this study setup may contribute to significant increase on knowledge of the patients.

The general public, particularly in low- and middle-income countries, frequently misunderstands the role of anesthesia and is highly unaware of the responsibilities of an anesthetist within and outside the operating room. This knowledge gap is starkly evident in our study, where a mere 6.3% of patients recognized that anesthetists monitor patients intra-operatively under anesthesia. Furthermore, this role confusion extends to other critical perioperative tasks. Specifically, only 29.8% of patients correctly identified anesthetists as the individuals responsible for administering blood transfusions, while 41.7% of patients mistakenly attributed these vital responsibilities anesthetist (determining fitness for anesthesia) to surgeons.

This figure is drastically lower than the awareness levels reported internationally, such as the 80% found at Victoria University Hospital in Ireland [16], 25% in Hong Kong [8], and 18.8% in a Korean study. [17] The limited awareness of anesthetists observed among patients in the current study may be attributed to the relatively low educational attainment of the study population, as nearly half of the participants had a lower level of education compared with those included in the previously cited studies.

CONCLUSION

This study revealed that patients have very limited knowledge and good attitudes regarding anesthesia and the role of anesthetists. Most patients associate anesthesia solely with “putting patients to sleep,” indicating a narrow and superficial understanding of the field. There is a significant lack of awareness about the critical and multifaceted roles anesthetists play in ensuring safe and comprehensive healthcare delivery.

Improving public understanding of anesthesia can lead to several benefits. First, well-informed patients are less likely to experience fear and anxiety, contributing to better surgical outcomes and greater appreciation for anesthetic services. Second, increased recognition can enhance the job satisfaction of anesthetists. Lastly, it can help attract more students to the profession, addressing the severe shortage of anesthetists in Ethiopia.

RECOMMENDATIONS

Pre-anesthetic counseling in hospitals needs to be improved through face-to-face consultation between each surgical patient and an anesthetist prior to undergoing surgery. The anesthesiologists need to enhance their communications with patients by explaining clearly the roles played by anesthetists in surgery, the methods of anesthesia employed, and the risks and benefits involved in anesthesia. The Ministry of Health and policy makers need to promote public awareness on anesthesia by conducting media campaigns, community awareness programs and educating the public on the importance of anesthesia as part of national health education strategies.

ETHICAL CONSIDERATION

Before starting of data collection, a written support letter was obtained from Werabe University, Department of Anesthesia and submitted to respective Hospital administrative offices. Before the starting of data collection, a written informed consent was obtained, and participant information was protected by concealing identities through coding and maintaining rigorous confidentiality protocols during data collection.

OPERATIONAL DEFINITION

Attitude: the way the participants (patients) think or understand anesthesia and anesthetists. A patient was considered as having positive attitude if he/she answered more than half of correct behavior questions (out of 9 score points).

Knowledge: the facts known by the participants (patients) gained by experience or learning, and participants are considered to have a good knowledge if they correctly answer half or more of the questions regarding anesthesia and anesthetists (out of 7 score points).

ACKNOWLEDGEMENTS

Not applicable.

FUNDING

This case report was not funded by any person or institution.

DECLARATION OF COMPETING INTEREST

The authors have no conflicts of interest to disclose in relation to this work.

REFERENCES

1. George, S., *Anesthesia: Principles, Clinical Practice, and Recent Advances*. Journal of Society Medicine, 2025. **4**(12): p. 401-408.
2. Djagbletey, R., et al., *Patients' knowledge and perception of anaesthesia and the anaesthetist at a tertiary health care facility in Ghana*. Southern African Journal of Anaesthesia and Analgesia, 2017. **23**(1): p. 11-16.
3. Fentie, Y. and T. Simegnaw, *Awareness and its associated factors towards anesthesia and anesthetists' among elective surgical patients in Debre Tabor Comprehensive Specialized Hospital, North Central Ethiopia 2021: Cross-sectional study*. Annals of medicine and surgery, 2021. **68**: p. 102640.

4. Irwin, M., S. Fung, and S. Tivey, *Patients' knowledge of and attitudes towards anaesthesia and anaesthetists in Hong Kong*. 1998.
5. Vahabi, S., et al., *Assessment of knowledge of general and local anesthesia among patients undergoing elective surgery*. The Open Anesthesia Journal, 2024. **18**(1).
6. Smith, A. and S. Mannion, *Irish patients knowledge and perception of anaesthesia*. 2013.
7. Djagbletey, R., et al., *Patients' knowledge and perception of anaesthesia and the anaesthetist at a tertiary health care facility in Ghana*. Southern African Journal of Anaesthesia and Analgesia, 2017. **23**(1): p. 18-23.
8. Hussein, A.M., et al., *Patients' knowledge and perception of anesthesia and the anesthesiologist at a tertiary hospital in Mogadishu, Somalia*. BMC anesthesiology, 2025. **25**(1): p. 460.
9. Naod, B., W. Admasu, and Y. Ahmed, *Patients' knowledge and attitude towards anesthesia in Tikur Anbessa specialized hospital*. Int J Anesth Res, 2016. **4**(5): p. 229-235.
10. Hailu, S., T. Girma, and T. Regasa, *Assessment of patient's perception and knowledge towards anesthesia services at Dilla University Referral Hospital, South Ethiopia, 2021: a cross-sectional study*. IJS Global Health, 2022. **5**(5): p. e79.
11. Arefayne, N.R., et al., *Patients' knowledge and perception of anesthesia and the anesthetists: cross-sectional study*. Annals of medicine and surgery, 2022. **78**: p. 103740.
12. Association, W.M., *World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects*. Jama, 2013. **310**(20): p. 2191-2194.
13. Cevallos, M. and M. Egger, *STROBE (STrengthening the Reporting of OBservational studies in Epidemiology)*. Guidelines for reporting health research: a user's manual, 2014: p. 169-179.
14. Wang, J., S. Wang, and R. Zeng, *Knowledge and attitude of surgical patients and their families toward anesthesia*. Frontiers in Medicine, 2024. **11**: p. 1371785.
15. Khan, S., M. Amin, and R. Najeeb, *Patients' knowledge And Perception Of Anesthesia And The Anesthetists At A Tertiary Health Care Facility, Gmc Srinagar-A Cross Sectional And Prospective Study*. 2023.
16. Care, S.I., et al., *A survey of patients' knowledge of anaesthesia and perioperative care*. Orthopaedics, 1998. **23**: p. 74.
17. Almutairi, N.G., et al., *Public knowledge and perception of anesthesia, anesthesiologists' expertise, and their role among Saudi citizens residing in Saudi Arabia*. Cureus, 2023. **15**(8).

CITE THIS ARTICLE:

- **APA (7th edition):** Darsema, D.T., Wodale, U.S., Motma, H.A., Mohammed, D.Y. and Hassen, A.A., 2026. *Knowledge and attitude of surgical patients towards anesthesia and anesthetists: Institutional based cross-sectional study*. The Operating Room Global Journal (TORGJ), **2**(3). Published 31 July. Available at: <https://doi.org/10.64573/torgj2607003>
- **Harvard:** Darsema DT, Wodale US, Motma HA, Mohammed DY, Hassen AA. Knowledge and attitude of surgical patients towards anesthesia and anesthetists: Institutional based cross-sectional study. *The Operating Room Global Journal (TORGJ)*. 2026 Jul 31;2(3). <https://doi.org/10.64573/torgj2607003>
- **Vancouver:** Darsema, Dawit Tefesse, et al. "Knowledge and Attitude of Surgical Patients towards Anesthesia and Anesthetists: Institutional Based Cross-Sectional Study." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 31 July 2026, <https://doi.org/10.64573/torgj2607003>
- **MLA (9th edition):** Darsema, Dawit Tefesse, et al. "Knowledge and Attitude of Surgical Patients towards Anesthesia and Anesthetists: Institutional Based Cross-Sectional Study." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 31 July 2026, <https://doi.org/10.64573/torgj2607003>
- **Chicago (Author-Date):** Darsema, Dawit Tefesse, Umar Siraj Wodale, Haji Ahemed Motma, Desalegn Yimam Mohammed, and Abas Ali Hassen. 2026. "Knowledge and Attitude of Surgical Patients towards Anesthesia and Anesthetists: Institutional Based Cross-Sectional Study." *The Operating Room Global Journal (TORGJ)* **2** (3), July 31. <https://doi.org/10.64573/torgj2607003>

Theranostics In Oncology: Integrating Molecular Imaging and Targeted Radionuclide Therapy for Precision Cancer Care

Authors: Ishaan Bakshi^{1*}, Prashant Anand², Hriday Singh Rawat³

¹ Director, Quality and Performance Monitoring, The Operating Room Global (TORG)

² MSY5, University of Technology, Mauritius

³ MSY3, University of Technology, Mauritius

DOI: <https://doi.org/10.64573/torgj2607004>

*Corresponding Author:

Dr. Ishaan Bakshi

ishaan_bakshi@yahoo.com

Declaration:

Authors' Contribution:

Equal contributions.

Conflict of Interest: No conflict of interest.

Funding: No funding received.

Article History:

Received: 14-07-2026

Accepted: 26-07-2026

Available Online: 03-08-2026

QR access this Article



ABSTRACT

Background: Theranostics has become a key pillar of precision oncology, combining molecular imaging and targeted radionuclide therapy for individualized cancer diagnosis, treatment selection and response assessment. Theranostics, however, utilizes tumor-specific molecular targets to guide tailored patient care as opposed to conventional techniques that are focused primarily on morphological or histological classification. Its role in neuroendocrine tumors, prostate cancer and differentiated thyroid carcinoma has been demonstrated in clinical studies and is being explored in an increasing number of solid and hematologic malignancies.

Objective: This state-of-the-art overview covers the biological bases, clinical applications and emerging evidence of theranostics in modern oncology.

Methods: It provides a critical evaluation of major advancements in radiopharmaceutical research, quantitative molecular imaging, tailored dosimetry and artificial intelligence and discusses their potential for treatment optimisation as well as the limits that still prevent their broad use. We reviewed emerging molecular targets such as fibroblast activation protein (FAP), human epidermal growth factor receptor 2 (HER2), C-X-C chemokine receptor type 4 (CXCR4), gastrin-releasing peptide receptor (GRPR) and delta-like ligand 3 (DLL3), together with advances in alpha-particle therapy, ligand engineering and next-generation radiopharmaceuticals. Moreover, we discuss unmet obstacles such as the varied clinical evidence, the legal and infrastructural barriers, the availability of isotopes, cost-effectiveness, and the requirement of standardization of dosimetry and multidisciplinary integration.

Results: Theranostics has already changed the way some malignancies are treated, but for it to be used more widely in clinics there will need to be good quality data comparing different treatments, more access to radionuclides globally and new technology will need to be incorporated into everyday practice. Future progress is likely to include alpha-particle therapy, AI-guided tailored dosimetry, FAP-targeted theranostics, radiogenomics, combination radionuclide-immunotherapy approaches, and expanded radionuclide production. This study critically evaluates the current data and future approaches and highlights theranostics as an emerging platform that may revolutionize customized cancer therapy.

Keywords: Theranostics; Precision oncology; Nuclear medicine; Radiopharmaceutical therapy; Molecular imaging; Targeted radionuclide therapy; Prostate-specific membrane antigen (PSMA); Peptide receptor radionuclide therapy (PRRT); Lutetium-177; Alpha-particle therapy; Personalized dosimetry; Artificial intelligence; Precision medicine.

INTRODUCTION

Cancer is a prominent cause of morbidity and mortality worldwide, contributing to about 1 in 6 deaths globally and posing a large clinical, societal and economic burden. Despite advances in molecular biology, targeted therapies, immuno-oncology and precision medicine, treatment outcome is very diverse due to significant inter- and intratumoral heterogeneity. Standard imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) mainly provide anatomical information and often do not correspond to the molecular characteristics that drive tumor biology and treatment response.

The same may be said for standardized systemic treatment procedures which may not sufficiently address the biological tumor heterogeneity, underlining the necessity for approaches integrating molecular diagnosis with customized therapy.

Theranostics, the combination of molecular imaging with targeted radionuclide therapy of the same biological target, has become an important breakthrough in precision oncology. This integrated method allows patient selection, treatment planning and response assessment in one molecular framework and connects diagnostic findings directly with therapeutic decision making. Thus, nuclear medicine has transformed from a largely diagnostic field to an important therapeutic specialty with an increasing role in personalized cancer management.

An example of this is radioactive iodine in differentiated thyroid cancer, one of the first successful examples of precision medicine. The last two decades have witnessed an enormous expansion of theranostics applications driven by breakthroughs in radiochemistry, molecular biology, hybrid imaging (PET/CT, PET/MRI and SPECT/CT) and radionuclide manufacture. These advances have permitted the highly sensitive imaging of tumor-specific targets and the invention of radiopharmaceuticals that can selectively transport therapeutic radionuclides to malignant tissue, laying the technological groundwork for current oncologic theranostics.

The best clinical data to date are from neuroendocrine tumors and metastatic prostate carcinoma. ^{177}Lu -DOTATATE peptide receptor radionuclide therapy (PRRT) has been established as a standard treatment for somatostatin receptor-positive neuroendocrine tumors by the NETTER-1 trial, and ^{177}Lu -PSMA radioligand therapy has shown significant survival and disease-control benefits in metastatic castration-resistant prostate cancer in the VISION and TheraP trials. The investigations have clearly established theranostics as an evidence-based therapeutic paradigm and not as an experimental technique. However, therapeutic effectiveness has been confined to a few cancers and evidence for wider use is mostly from early phase research. Whether the optimistic outcomes in new indications translate into comparable survival improvements is a question that requires confirmation in suitably powered randomized trials.

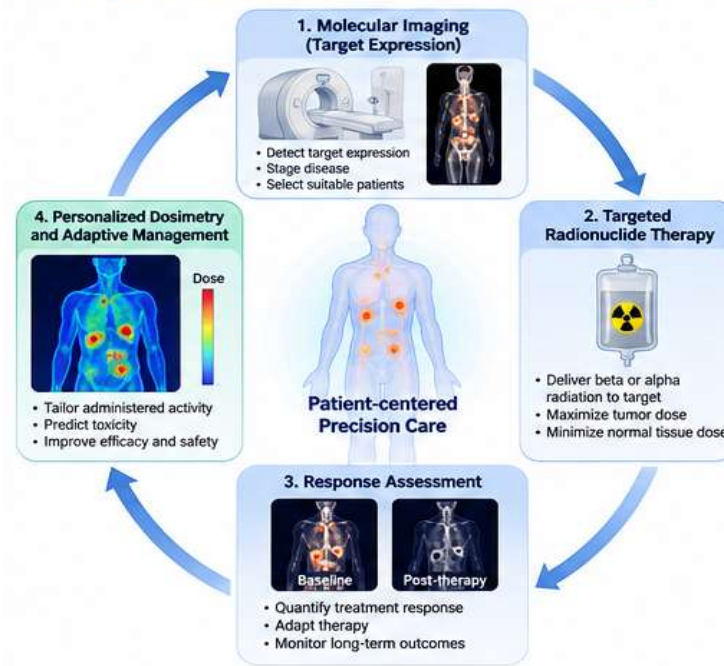
The therapeutic landscape is rapidly changing with the exploration of novel molecular targets such as fibroblast activation protein (FAP), human epidermal growth factor receptor 2 (HER2), C-X-C chemokine receptor type 4 (CXCR4), gastrin-releasing peptide receptor (GRPR), and integrins in a variety of solid and hematologic malignancies. Parallel improvements in alpha particle emitters, in particular ^{225}Ac and ^{212}Pb , offer the promise of enhanced cytotoxicity from high-linear-energy-transfer radiation, and may help to overcome resistance to conventional beta-emitting therapies. But many of these techniques are still exploratory, and significant questions about long-term safety, optimal patient selection, dosimetry and comparative effectiveness still need to be answered.

Technological innovation is also transforming the practice of theranostics. Artificial intelligence, radiomics, quantitative imaging and machine learning are increasingly employed in lesion detection, image reconstruction, tumor segmentation, response prediction and treatment planning. Similarly, personalized dosimetry has developed as an important component of radionuclide therapy, allowing patient-specific adjustment of given activity to maximize tumor irradiation while minimizing damage. While these improvements may allow for increased treatment precision, the limited standardization, varying validation across institutions, and the lack of widely approved clinical workflows impede their routine use.

The advancement has been impressive yet there are still important impediments to the mainstream use of theranostics. Access is restricted in many healthcare systems because of limited radionuclide manufacturing capacity, complex supply chains, regulatory variability, reimbursement issues, infrastructural needs and shortages of specialist multidisciplinary knowledge. In addition, the cost-effectiveness of advanced theranostic approaches and their incorporation into standard oncology pathways are not well established, particularly in low- and middle-income countries. Solving these problems will need coordinated efforts by clinicians, researchers, regulatory bodies and industry and government.

In this state-of-the-art review, we critically appraise the progress of oncologic theranostics from its historical basis to its contemporary function in precision oncology. We review biological rationale, key clinical data, established and emerging molecular targets, advances in personalized dosimetry, artificial intelligence and next generation radiopharmaceuticals, focusing on current controversies, implementation challenges and future research priorities. The review is to provide a balanced perspective on the benefits and limitations of theranostics, incorporating established knowledge and developing data as the field continues to revolutionize customized cancer therapy.

Figure 1. The Theranostic Paradigm in Precision Oncology



METHODS

Literature Searching Strategy

A complete literature search was undertaken using PubMed/MEDLINE, Embase, Scopus, Web of Science and Google Scholar to discover related papers on oncologic theranostics. The main search includes papers from January 2015 to December 2026, with crucial earlier works included to offer historical background. Search terms included a combination of Medical Subject Headings (MeSH) and free-text keywords, including theranostics, molecular imaging, radiopharmaceutical therapy, PET/CT, PET/MRI, SPECT/CT, PSMA, somatostatin receptor, PRRT, lutetium-177, actinium-225, fibroblast activation protein (FAP), CXCR4, HER2, radiomics, artificial intelligence, and personalized dosimetry. Boolean operators were used to enhance retrieval and reference lists of key publications, international recommendations and consensus statements were hand-searched for further relevant studies.

Selection and Synthesis of Evidence

This article is a narrative review; formal systematic review techniques and meta-analysis were not conducted. Evidence was selected according to methodological quality, clinical relevance, scientific impact and contribution to the field, with priority given to randomised controlled trials, multicentre studies, pivotal phase II/III trials, international guidelines, consensus statements and high-quality reviews. Conflicting evidence was critically appraised based on study design, methodological constraints and sources of heterogeneity rather than stated outcomes.

The literature was thematically synthesized on the biological basis of theranostics, established and emerging clinical applications, landmark trials, novel molecular targets, personalized dosimetry, artificial intelligence, radiopharmaceutical innovations, implementation challenges and future directions. Special attention was given to evidence impacting recommendations from organizations such as SNMMI, EANM, NCCN and ESMO while emphasizing knowledge gaps and areas needing more inquiry.

Methodology Limitations

Given the narrative nature of this review, no formal risk-of-bias assessment was performed, nor were studies scored for quality, nor data quantitatively synthesized. We made every attempt to include the most influential and methodologically solid research, although expert judgment inevitably enters study selection and interpretation. Thus, the findings should be interpreted in light of the evolving evidence base, especially in areas of rapid development where high-quality comparative and long-term clinical data are lacking.

BIOLOGICAL FOUNDATION OF THERANOSTICS

Theranostics is based on the combination of molecular imaging and targeted radionuclide therapy with a common biological target. Unlike conventional oncology where patient selection is performed on the basis of morphological or histological classification, theranostics utilizes tumor-specific genetic changes to select patients, give treatment and measure response in a single framework of precision medicine.

The malignant transformation leads to the modification of gene expression, receptor density, metabolism and tumor microenvironment, therefore generating molecular targets that are selectively expressed in cancer cells. These targets are exploited by radiolabeled ligands for diagnostic imaging and therapeutic radionuclide administration, allowing for non-invasive confirmation of target expression prior to therapy. This technique improves patient selection, lowers needless toxicity and increases therapeutic precision. However, expression of the target alone is not enough to predict therapeutic effect, as tumor heterogeneity, receptor dynamics and radiopharmaceutical pharmacokinetics also play a role in treatment success.

Successful theranostic targets have high expression in tumor versus background, are biologically stable, and have good ligand accessibility. Examples that have been clinically validated include prostate-specific membrane antigen (PSMA) in prostate cancer and somatostatin receptor subtype 2 (SSTR2) in neuroendocrine tumors. Besides receptor expression, ligand properties, including binding affinity, internalization, intracellular retention and metabolic stability, are key drivers of therapeutic efficacy and constitute major areas of study of radiopharmaceuticals.

The biological response is also influenced by the radionuclide chosen. β -emitting isotopes like ^{177}Lu and ^{90}Y generate a cross-fire effect, which is beneficial for heterogeneous or bulky tumors. α -emitters like ^{225}Ac and ^{212}Pb emit high-linear-energy-transfer radiation over a short distance, resulting in dense DNA double-strand breaks with minimal collateral damage. Alpha-particle therapy has demonstrated promise in resistant malignancies; however, long-term safety, optimal dosimetry and comparative clinical benefit of alpha-particle therapy are still under investigation, emphasizing the need for prospective randomized studies. Therapeutic efficacy beyond direct DNA damage. Radionuclide therapy also causes apoptosis, vascular damage, senescence, and immunogenic cell death, which provides a biological foundation for combining theranostics with immune checkpoint inhibitors and other systemic medicines. However, the clinical evidence for these combinations is in its infancy, and optimal sequencing and patient selection procedures have yet to be determined.

One of the main advantages of theranostics is the characterization of whole-body tumor heterogeneity. Unlike single-site biopsies, molecular imaging assesses target expression across all lesions, which facilitates better treatment selection, prognostication, and tracking of treatment response. Quantitative imaging biomarkers, including standardized uptake value (SUV), metabolic tumor volume (MTV) and radiomics characteristics combined with artificial intelligence may further refine patient categorization. However, the main barriers to clinical use are the heterogeneity of acquisition techniques, minimal external validation, and the lack of standardized analysis pipelines.

While significant advances have been made, some biological difficulties remain such as temporal variations in receptor expression, acquired resistance, heterogeneous biodistribution of radiopharmaceuticals, and complicated tumor and immune microenvironment interactions. Bridging these knowledge gaps through the integration of molecular biology, radiobiology, computational science, and translational research will be critical for the development of next generation theranostic methods and the expansion of their therapeutic impact.

CURRENT CLINICAL APPLICATIONS OF THERANOSTICS

Neuroendocrine Tumors

The most mature and well recognized use of oncologic theranostics is the treatment of neuroendocrine tumors (NETs). Most well-differentiated gastroenteropancreatic NETs over-express the somatostatin receptor subtype 2 (SSTR2), which allows sensitive molecular imaging with ^{68}Ga -DOTATATE, ^{68}Ga -DOTATOC, or ^{64}Cu -DOTATATE PET/CT and the selection of patients for peptide receptor radionuclide therapy (PRRT). This imaging-guided method is an example of precision oncology, as it confirms that the target is expressed before treatment.

The therapeutic counterpart, ^{177}Lu -DOTATATE PRRT, selectively delivers β -radiation to SSTR-positive tumor cells after receptor-mediated internalization. Compared to older ^{90}Y -based therapies, ^{177}Lu offers a better efficacy-to-toxicity ratio, with better dosimetric properties and lower renal toxicity.

The landmark NETTER-1 experiment showed that ^{177}Lu -DOTATATE is the standard of therapy for progressive, SSTR-positive midgut NETs with significant benefits in progression-free survival, objective response rates, and quality of life compared to high-dose octreotide. Long-term follow-up showed lasting disease management and an acceptable safety profile, leading to regulatory approval and inclusion in international standards. Subsequent observational studies have supported its treatment in pancreatic and bronchial NETs, while high-quality randomized evidence beyond midgut tumors is rare.

Patient selection is still critical and depends on appropriate receptor expression on PET/CT, assessment of tumor differentiation, renal function, bone marrow reserve and performance status. PRRT is well tolerated and transient hematopoietic toxicity is the most prevalent side event, whereas severe nephrotoxicity has become uncommon with modern amino acid renal protection. Rare long-term problems such as myelodysplastic syndrome and acute leukemia require continuous surveillance, particularly after repeated treatment cycles.

It has a well-established role, but still a number of unanswered questions. Further research is required to determine the best sequencing of PRRT with systemic therapy, the benefit of customized dosimetry compared to fixed dosage regimens, retreatment techniques and the impact of combination regimens. Innovative techniques, e.g. the use of alpha-emitting radionuclides, may improve results in resistant disease, although there is yet no convincing randomized data. Thus, NETs remain the gold standard for successful theranostics, but further improvement of treatment techniques is necessary to optimize long-term efficacy and safety.

Prostate Cancer

Oncologic theranostics has become the most rapidly developing application in prostate cancer, with the success of prostate-specific membrane antigen (PSMA)-targeted imaging and radioligand therapy. PSMA is overexpressed in advanced, metastatic and castration-resistant prostate cancer and its receptor-mediated internalization permits longer intracellular retention of radiolabeled ligands, making it a suitable target for diagnostics and therapy.

The advent of PSMA PET/CT with either ^{68}Ga -PSMA-11 or ^{18}F -DCFPyL has revolutionized disease staging and recurrence detection with metastatic lesions detected with significantly higher sensitivity than conventional imaging. PSMA PET also acts as a predictive biomarker beyond diagnosis by validating target expression and selecting patients most likely to benefit from PSMA-directed radioligand therapy, which reflects the theranostic principle of imaging-guided treatment selection.

The therapeutic equivalent, ^{177}Lu -PSMA-617, delivers β -radiation specifically to PSMA-expressing tumor cells with limited exposure of the surrounding tissue. The landmark VISION trial demonstrated significant improvements in overall survival, radiographic progression-free survival, prostate-specific antigen response, and quality of life in metastatic castration-resistant prostate cancer (mCRPC) patients, establishing ^{177}Lu -PSMA-617 as a standard of care after androgen receptor pathway inhibition and taxane chemotherapy. The TheraP trial also revealed improved PSA responses and a better toxicity profile compared to cabazitaxel and the PSMAfore study points to the advantage of initiating radioligand therapy earlier in the disease phase. Together, these data support an increasing importance of PSMA-targeted therapy in the therapeutic continuum.

But despite these gains, some limits remain. Tumor heterogeneity and variable PSMA expression, particularly in tumors with neuroendocrine differentiation or PSMA-negative metastatic clones, can adversely affect therapeutic efficacy. Dual-tracer imaging using FDG PET may reveal biologically aggressive PSMA-negative illness that is likely to be refractory to radioligand therapy. Poorly understood resistance mechanisms such as downregulation of PSMA expression, altered receptor trafficking, increased DNA repair, and clonal evolution are active areas of inquiry.

Overall, ^{177}Lu -PSMA therapy is generally well tolerated with xerostomia and mild to severe hematological toxicity being the most prevalent adverse events, and clinically relevant nephrotoxicity is rare. Alpha-emitting radioligands like ^{225}Ac -PSMA show promise in ^{177}Lu -refractory patients, but their use is limited by availability of radionuclides, salivary gland toxicity, and the absence of long-term prospective data. Finally, while PSMA-targeted theranostics have transformed the

management of advanced prostate cancer, there remain critical unanswered questions about ideal sequencing, combination with systemic therapies, personalized dosimetry, cost-effectiveness, and long-term outcomes. Addressing these difficulties in randomized trials will be critical to maximize therapeutic benefit and permit application to earlier stages of disease.

Differentiated Thyroid Cancer

Differentiated thyroid cancer (DTC) is the prototype and most durable example of oncologic theranostics. Prior to the era of precision oncology, radioactive iodine provided a compelling example of a single molecular target for disease localization as well as treatment. This NIS-based paradigm set the stage for the principles of molecular target validation, imaging-guided patient selection, and targeted radionuclide therapy that are the foundation of modern theranostics.

The maintenance of NIS expression in well-differentiated papillary and follicular thyroid carcinomas allows for the selective uptake of radioactive iodine, which can be exploited for diagnostic imaging, remnant ablation, adjuvant therapy, and treatment of metastatic disease. Radioiodine therapy is a mainstay of management and, for appropriately selected patients, provides the opportunity for long-term follow-up using serum thyroglobulin.

Therapeutic efficacy is highly dependent on tumor differentiation. Well-differentiated tumors are often sensitive to radioiodine, whereas dedifferentiation is linked to the loss of NIS expression and the development of radioiodine-refractory differentiated thyroid carcinoma (RAIR-DTC). Recent breakthroughs in redifferentiation therapy with BRAF and MEK inhibitors have proven the potential to reinduce radioiodine absorption in selected individuals, opening new therapeutic perspectives. But clinical experience is still limited, and durable long-term benefit has still to be demonstrated. ^{18}F -FDG PET/CT complements radioiodine imaging in advanced disease via the well-recognized 'flip-flop' phenomenon, whereby radioiodine-negative tumors frequently show increased glucose metabolism. FDG PET is thus particularly useful in patients with elevated thyroglobulin levels and negative radioiodine scans by providing prognostic information and identifying patients unlikely to benefit from further radioiodine therapy.

While radioiodine therapy has a good long-term safety profile, high cumulative dose treatment may lead to salivary gland dysfunction, xerostomia, lacrimal damage, acute bone marrow suppression and, infrequently, subsequent cancers. As a result, current ATA, ETA, and NCCN guidelines recommend a risk-adapted approach to radioiodine, selectively treating patients who are most likely to benefit clinically and sparing those with low-risk disease from unnecessary treatment.

Despite decades of clinical success, there are still various hurdles such as optimum patient selection, personalized dosimetry, RAIR-DTC management and integration with targeted medicines. Moreover, although radioiodine continues to be the paradigm for successful theranostics, extending radionuclide therapy beyond NIS-dependent disease would necessitate validation of other molecular targets and high-quality prospective investigations. Thus, thyroid cancer remains not only the historical basis of theranostics but also a platform for the development of next-generation precision radionuclide therapies.

Bone Metastases

Bone-targeted radionuclide therapy is a unique application of theranostics that exploits the biology of osteoblastic activity rather than tumor-specific receptors. It is mostly utilized in patients with advanced malignancies, notably prostate cancer, in whom diffuse skeletal metastases cause discomfort, pathological fractures, spinal cord compression and reduced quality of life. Bone-seeking radiopharmaceuticals preferentially localize to sites of active bone remodeling, thus enabling focal irradiation of numerous metastatic lesions with limited exposure to the surrounding tissues.

Early β -emitting drugs like ^{89}Sr and ^{153}Sm -EDTMP were beneficial for palliation of pain but did not increase overall survival and resulted in substantial myelosuppression, thereby restricting their long-term clinical utility. A notable breakthrough was the development of the α -emitter ^{223}Ra -dichloride, which delivers high-linear-energy-transfer radiation with a relatively short tissue range, resulting in strong tumor cell death with minimal bone marrow toxicity.

The major ALSYMPCA study has demonstrated ^{223}Ra to be a standard of care in patients with symptomatic, bone-predominant metastatic castration-resistant prostate cancer (mCRPC) without visceral metastases. Treatment significantly increased overall survival, delayed symptomatic skeletal events and improved quality of life. Radionuclide therapy can offer both symptomatic alleviation and survival advantage. Therefore, international guidelines recommend ^{223}Ra in selected patients after multidisciplinary evaluation.

Despite clinical value, there are considerable restrictions. The ERA-223 trial demonstrated increased fracture risk when ^{223}Ra was coupled with abiraterone and prednisolone without concomitant bone-protective treatment, resulting to modifications in clinical practice and routine use of bisphosphonates or denosumab in suitable patients. Evidence for bone-seeking radionuclides beyond metastatic prostate cancer, however, remains limited, and no comparable survival benefit has been found in breast cancer or other solid tumors. Further research are needed to define appropriate treatment sequencing, combination techniques, personalized dosimetry, and patient selection. New radiopharmaceuticals that target both the bone microenvironment and tumor-specific biomarkers may improve treatment accuracy further, although their clinical value is experimental.

Breast Cancer

With advances in molecular imaging and radiopharmaceutical development, breast cancer has become an emerging theranostic area. ^{18}F -FDG PET/CT is still the standard for staging and response assessment but does not give target-specific information for radionuclide therapy. Thus, theranostic research has selected actionable molecular targets that enable the whole-body assessment of tumor biology and targeted treatment.

Human epidermal growth factor receptor 2 (HER2) is the most studied target and is overexpressed in ~15–20% of breast tumors. Radiotracers such as ^{89}Zr -trastuzumab and ^{64}Cu -labeled trastuzumab derivatives offer non-invasive evaluation of HER2 expression in primary and metastatic lesions, bypassing the constraints of a single site biopsy, and allow for detection of spatial or temporal receptor heterogeneity. These imaging methods can potentially improve patient selection for HER2-directed therapy and provide complementary information to standard immunohistochemistry.

Another interesting target is fibroblast activation protein (FAP) produced by cancer-associated fibroblasts in the tumor microenvironment. In early trials, FAPI PET showed promising diagnostic performance and a strong tumor-to-background contrast, while FAP-targeted radioligand treatment offers a new approach by targeting the tumor stroma instead of directly targeting malignant cells. Additional investigational targets including GRPR, estrogen receptor (ER), CXCR4, PD-L1 and integrins further emphasize the biological heterogeneity of breast cancer and opportunities for receptor-specific imaging and therapy.

Despite these breakthroughs, breast cancer theranostics are still primarily experimental. Patient selection is difficult due to heterogeneous receptor expression across molecular subtypes, metastatic locales and treatment stages, and the sluggish pharmacokinetics of antibody-based tracers may limit clinical usefulness. Additionally, therapeutic radioligands have only shown early-phase study activity and their relevance compared to existing HER2-targeted therapies, such as monoclonal antibodies and antibody-drug conjugates, has not been established.

Progress will depend on prospective multicenter trials showing considerable gains in survival, quality of life, and cost-effectiveness. Additional advances in patient selection can be obtained through standardized imaging methods, optimization of ligand design, tailored dosimetry, and integration with artificial intelligence and genomic analysis. Breast cancer, while not yet as clinically mature as NETs or prostate cancer, is one of the most potential areas for expansion of theranostic uses outside the conventional receptor-driven malignancies.

Lung Cancer

Lung cancer is the biggest cause of cancer-related death globally, with significant genetic and clinical variability. The management of non-small cell lung cancer (NSCLC) has been altered by precision oncology, with genomic profiling and tailored medications, however theranostic applications are still in early research. Lung cancer, unlike prostate cancer or neuroendocrine tumors, lacks a molecular target that is universally expressed, requiring subtype-specific methods.

Emerging targets, such as fibroblast activation protein (FAP), have received much attention due to their high expression in cancer-associated fibroblasts in the tumor microenvironment. FAPI PET shows fast tumor uptake and high tumor-to-background contrast. Preliminary investigations indicate enhanced detection of primary and metastatic lesions in selected patients with respect to conventional ^{18}F -FDG PET. Therapeutically, FAP-targeted radioligands give the ability to target the tumour stroma rather than malignant cells alone, however clinical efficacy has to be demonstrated.

Another intriguing target is delta-like ligand 3 (DLL3) which is strongly expressed in most small cell lung cancers (SCLC) but weakly expressed in normal tissues. DLL3-directed radiopharmaceuticals have generated promising preclinical and early clinical data. Other investigational targets being evaluated for receptor-specific imaging and radionuclide therapy include CXCR4, mesothelin, integrin $\alpha\beta 3$, and GRPR. These strategies combined reflect the biological diversity of lung

cancer and highlight the need for future theranostic strategies to be built on individualized molecular profiling rather than a one-size-fits-all platform.

Notwithstanding these developments, ^{18}F -FDG PET/CT persists as the clinical standard for staging, therapy planning and response assessment. However, FDG represents tumor metabolism and not actionable molecular targets and cannot be used to directly guide radionuclide therapy. The shift from metabolic to receptor-specific imaging represents a major milestone in the development of clinically effective lung cancer theranostics.

Most of the existing evidence is derived from preclinical and early clinical investigations. Challenges for patient selection and therapeutic development include tumor heterogeneity, dynamic target expression, rapid disease progression, and lack of validated predictive biomarkers. Large prospective trials are therefore needed to prove the safety, efficacy and cost-effectiveness of developing radiopharmaceuticals and to define their function alongside surgery, radiation, targeted treatments and immunotherapy. Lung cancer offers an exciting opportunity for theranostics, but the effective translation into ordinary clinical practice will depend on the identification of solid molecular targets and high-quality clinical evidence.

Glioblastoma and Other Central Nervous System Tumors

Glioblastoma (GBM) and other high grade central nervous system (CNS) tumors continue to be some of the most difficult cancers to treat because of extensive infiltration, substantial intratumoral heterogeneity, treatment resistance, and the blood-brain barrier (BBB) limiting drug delivery. GBM does not have a uniformly expressed molecular target like those found in neuroendocrine tumors or prostate cancer, rendering theranostic development mostly exploratory and reliant on customized molecular profiling.

Most notably, CXCR4, which is involved in tumor growth, angiogenesis and glioma stem cell maintenance, is one of several targets under intensive investigation. First results with CXCR4-directed PET tracers and therapeutic radioligands have been promising in preclinical and early clinical research. Other intriguing targets include fibroblast activation protein (FAP), integrin $\alpha\text{v}\beta\text{3}$, epidermal growth factor receptor (EGFR) variations, interleukin-13 receptor α2 (IL13R α2), and neurokinin-1 receptor, although none of these have yet showed significant clinical evidence for widespread use.

In neuro-oncology, molecular imaging already complements conventional MRI. Amino acid PET tracers as ^{18}F -FET, ^{11}C -methionine (MET) and ^{18}F -FDOPA improve tumor characterisation and can aid to differentiate recurrence from treatment-related alterations. While these tracers are not, per se, theranostic, they highlight the utility of functional imaging in biopsy guidance, treatment planning and response assessment, and lay the groundwork for future receptor-specific imaging.

Efficient distribution across the BBB is a fundamental hurdle to radiation therapy. Convection-enhanced delivery, focused ultrasound-mediated BBB breakdown, nanoparticle-based devices and smaller targeting ligands are some of the efforts to boost intracranial medication penetration. Radionuclide therapy is also being studied in combination with radiation, temozolomide, antiangiogenic drugs and immunotherapy, to exploit complimentary biological pathways.

Although experimental breakthroughs are promising, clinical translation is still restricted. Most data are based on preclinical studies or modest early phase research, and few randomised studies have shown a survival benefit. Tumor heterogeneity, target variability, barriers to transport across the BBB, and resistance mechanisms still pose obstacles to widespread clinical application. Future advances will rely on the identification of robust molecular targets, enhanced transport of drugs into the brain and confirmation of these strategies in well-designed, prospective clinical trials. Glioblastoma is one of the most challenging diseases to cure, but also one of the most exciting opportunities for next generation theranostic innovation.

Hematologic Malignancies

Hematologic malignancies constitute an exciting yet comparatively under-investigated field of oncologic theranostics. Unlike solid tumors, many lymphoid and plasma cell neoplasms display homogeneously lineage-specific surface antigens and are readily accessible to circulating radiopharmaceuticals, making them excellent candidates for targeted radionuclide therapy. Nevertheless, the clinical uptake has been slower than that of neuroendocrine tumors and prostate cancer, despite good scientific explanation, because of the rapid breakthroughs in immunotherapy and cellular therapies.

CD20-directed radioimmunotherapy with ^{90}Y -ibritumomab tiuxetan and ^{131}I -tositumomab was the first clinical success in B-cell non-Hodgkin lymphoma (NHL). These agents combined specificity of monoclonal antibodies with targeted delivery of radiation and produced durable responses in selected patients with relapsed or refractory indolent lymphoma. However, their use declined because of logistical complexity, prolonged myelosuppression, reimbursement issues, and competition

from highly effective rituximab-based regimens and CAR T-cell therapies. Although these medications are not widely used now, they demonstrated the notion of targeted radionuclide therapy in hematologic malignancies.

In addition to lymphoma, CXCR4 has emerged as a promising theranostic target in multiple myeloma, where it is involved in plasma cell homing, disease progression, and treatment resistance. Non-invasive receptor profiling can be achieved with PET imaging using CXCR4-directed tracers and initial clinical investigations with therapeutic radioligands showed promising activity in strongly pretreated patients. BCMA (B-cell maturation antigen), already established as a target for CAR T-cell and antibody-drug combination treatments, is also being explored for radiological imaging and treatment. Other targets including CD37, CD38, CD45 and CD123 are also under intense examination in preclinical and early clinical studies.

Despite these gains, there are a number of difficulties that impede routine adoption. Bone marrow irradiation remains the primary dose-limiting hazard and requires cautious patient selection, tailored dosimetry, and thorough hematology monitoring. Clinical experience is limited, however, α -emitting radionuclides may improve the therapeutic index by delivering highly localized radiation. Randomized comparative data are also lacking for most investigational radiopharmaceuticals and their appropriate integration with the constantly emerging immunotherapies yet to be determined.

Future advancement will require prospective multicenter trials, uniform dosimetry, and sensible combinatorial approaches with immunotherapy and cellular treatments. Although hematologic theranostics have not reached the same clinical maturity as NETs or prostate cancer, the availability of highly selective molecular targets and the continuing progress in radiopharmaceutical engineering position this as one of the most exciting frontiers for precision radionuclide therapy.

CLINICAL EVIDENCE SUPPORTING CONTEMPORARY THERANOSTICS

The growing amount of high-quality clinical evidence demonstrating that molecular imaging-guided radionuclide therapy improves clinically meaningful outcomes in selected cancers has driven the integration of theranostics into modern oncology. In the last 10 years, important, randomized trials have shown that theranostics is an evidence-based therapy method that can lengthen survival, slow disease progression, improve symptom control and quality of life. These investigations are characterized by the use of molecular imaging as a predictive biomarker to limit treatment to patients with sufficient target expression, optimizing therapeutic efficacy and avoiding needless harm.

The strongest evidence is in neuroendocrine tumors and metastatic prostate cancers. The NETTER-1 trial demonstrated ^{177}Lu -DOTATATE as the standard of care for progressing somatostatin receptor-positive neuroendocrine tumors, with significant increases in progression-free survival, objective response and quality of life. Similarly, the phase III VISION trial demonstrated significant overall and radiographic progression-free survival benefits with ^{177}Lu -PSMA-617 in metastatic castration-resistant prostate cancer, whereas the TheraP trial showed a better biochemical response as well as a more favorable toxicity profile compared with cabazitaxel. More recently, the PSMAfore study has supported early use of PSMA-targeted therapy, demonstrating that radioligand treatment may be most successful before the development of advanced treatment resistance.

Alpha-particle treatment also has increasing evidence. The ALSYMPCA study showed that in patients with symptomatic bone-predominant metastatic castration-resistant prostate cancer, ^{223}Ra -dichloride increased overall survival, delayed skeletal-related events and improved quality of life. Importantly, this study extended the scope of theranostics by demonstrating that radionuclide therapy can target the tumor microenvironment in addition to tumor-specific receptors. Together these trials have established some key principles of modern theranostics such as (1) molecular target validation before therapy as a prerequisite for patient selection, (2) clinically meaningful benefits beyond imaging responses to include survival, symptom control and patient reported outcomes, and (3) radionuclide therapy shows an acceptable safety profile when administered in experienced multidisciplinary teams. Therefore, theranostic approaches are currently recommended for specific malignancies by worldwide organizations such as SNMMI, EANM, NCCN, and ESMO.

But these developments leave major gaps in evidence. Most randomized trials have been in advanced disease, and it remains unclear whether the ideal timing of radionuclide therapy is in earlier treatment settings. In general, trial participants have been highly selected, which may limit generalizability to ordinary practice. Furthermore, there is a lack of direct comparisons between competing radiopharmaceuticals, defined dosimetry techniques, verified response criteria, long-term safety data, and thorough cost-effectiveness evaluations. Many of these constraints are anticipated to be addressed by ongoing research

examining alpha-particle treatment, novel molecular targets, individualized dosimetry, and combination tactics with immunotherapy and targeted medicines.

In conclusion, the current data base clearly supports theranostics as a key component of precision oncology in selected tumors but also highlights the need for further refinement through prospective head-to-head trials and wider validation in the real-world setting. Future advancement will depend on not only expanding therapeutic indications, but also on optimizing patient selection, treatment sequencing and personalized treatment delivery.

Personalized Dosimetry: The Foundation of Precision Radionuclide Therapy

Personalized dosimetry is essential in precision radionuclide therapy, taking into account the large interpatient variations in radiopharmaceutical biodistribution, tumor absorption, organ function, and radiation sensitivity. Although molecular imaging allows for proper patient selection, most licensed radionuclide therapies are provided at set activities, despite a large variability in received radiation doses between patients. Therefore, the same treatment regimens may have different therapeutic effectiveness and toxicity, indicating the necessity of personalized treatment strategies.

Dosimetry is the calculation of radiation absorbed by tumours and normal tissues, based on quantitative imaging, pharmacokinetic modelling and computer techniques. PET/CT and SPECT/CT have enhanced the patient-specific assessment of radiopharmaceutical distribution. Voxel-based dosimetry enables three-dimensional characterization of dose heterogeneity within tumors. The accuracy of dose prediction and treatment planning has also increased with the advent of computational methods such as the Medical Internal Radiation Dose (MIRD) formalism and Monte Carlo simulations.

There is emerging clinical evidence for dosimetry-guided therapy. Large variety of tumor and organ absorbed doses was observed in studies on ^{177}Lu -DOTATATE peptide receptor radionuclide therapy (PRRT) and ^{177}Lu -PSMA radioligand therapy, even with the same given activity. Individualized dosimetry can improve the therapeutic index by enhancing tumor irradiation, while minimizing exposure to dose limiting organs such as the kidneys, salivary glands, liver and bone marrow. Early studies also indicate relationships between the amount of tumor radiation absorbed and responsiveness to treatment, however globally agreed dosage thresholds have yet to be developed.

Bone marrow dosimetry is particularly hard due to complicated marrow structure, fluctuating tumor infiltration and imaging restrictions. Moreover, routine use of individualized dosimetry is inhibited by the necessity of several imaging time points, specialized software, trained personnel, and the absence of established protocols among institutions. Such efforts, like those made by EANM, SNMMI and the MIRD Committee to harmonize are therefore crucial to promote wider clinical implementation.

Artificial intelligence is projected to accelerate clinical deployment by automating organ segmentation, lesion delineation, kinetic modeling, and dose calculation while integrating imaging with clinical and genetic data to predict therapeutic response and toxicity. Most AI-based dosimetry systems, however, are still exploratory and need prospective validation before they can be used routinely. Similarly, while dosimetry driven therapy is biologically attractive, few definitive randomized trials have shown improved survival or lower toxicity compared to fixed activity regimens. Future studies should therefore focus on standardized techniques, clinically verified dose thresholds and prospective outcome-driven trials to establish individualized dosimetry as the standard of care in radionuclide therapy.

Artificial Intelligence and Digital Transformation: Redefining the Theranostic Ecosystem

The integration of complicated imaging, molecular, clinical, and dosimetric data into precision treatment regimens is fast revolutionizing theranostics by artificial intelligence (AI). Modern radionuclide therapy is increasingly multimodal information-driven, integrating quantitative PET/SPECT imaging, anatomical imaging, laboratory biomarkers, genomic profiling, and treatment history, which presents analytical hurdles beyond typical statistical approaches. Thus, AI has emerged as a crucial facilitator of data-driven precision oncology, supporting decision-making across the theranostic route from diagnosis and patient selection to treatment planning, response assessment and longitudinal follow-up.

One of the earliest therapeutic uses of AI has been in the reconstruction and interpretation of images. Deep learning methods increase picture quality, reduce noise, cut acquisition times and permit lower radiotracer dosages while maintaining diagnostic accuracy. AI also permits automated lesion recognition, segmentation, and assessment of tumor burden, lowering observer variability and enhancing workflow efficiency. When used in conjunction with radiomics, machine learning has the ability to extract quantitative imaging aspects that correlate with tumor phenotype, receptor expression, treatment

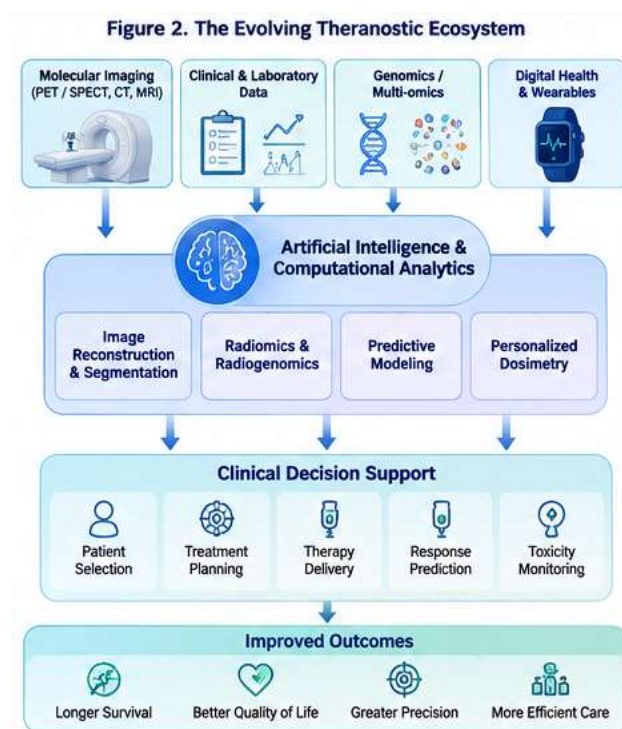
response and prognosis, hence providing a potential for more sophisticated patient classification than traditional image interpretation alone.

The use of AI is also predicted to be important in individualized radionuclide therapy. Automated organ segmentation, voxel-based dosimetry and kinetic modeling can greatly simplify the calculation of individualized dose, and predictive algorithms incorporating imaging, genomic and clinical data may improve the prediction of treatment response and treatment-related toxicity. These improvements provide the prospect of adaptive radionuclide therapy where the delivered activity is tailored based on individual patient characteristics and treatment response.

In addition to imaging, AI also contributes to the developing discipline of radiogenomics, which links imaging phenotypes with genomic and molecular traits to enable non-invasive evaluation of tumor biology. Integration of imaging with transcriptomic, proteomic and circulating biomarker data may further enhance patient selection and allow for longitudinal monitoring without recurrent tissue biopsies. These multimodal data streams could in the future be used to build digital twin models to mimic the evolution of disease and predict personalized treatment outcomes, although such applications remain primarily experimental.

Despite much promise, widespread clinical implementation is restricted. Most AI models have been trained on retrospective, single-center datasets and typically lack external validation across varied populations and imaging platforms. Other issues include diversity in acquisition techniques, poor model interpretability, regulatory ambiguity, data privacy, and potential for algorithmic bias. AI should be considered a clinical decision-support tool, not an independent decision-maker, and medical monitoring is relevant at this time.

Future advancement will require prospective multicenter validation, uniform reporting templates, transparent and explainable algorithms, and incorporation into routine clinical operations. AI has the potential to improve the accuracy, efficiency and personalization of theranostics, but its ultimate therapeutic usefulness will depend on demonstrating real gains in patient outcomes, not just computational performance.



Emerging Molecular Targets and Next-Generation Radiopharmaceuticals: Expanding the Horizons of Precision Oncology

The clinical success of somatostatin receptor (SSTR)- and prostate-specific membrane antigen (PSMA)-directed theranostics has encouraged the exploration of other molecular targets to broaden the application of radionuclide therapy to a broader spectrum of cancers. An ideal theranostic target should exhibit excellent tumor selectivity, low expression in normal tissues, favorable pharmacokinetics and repeatable radiopharmaceutical labeling. However, the rapid progress in molecular

biology, radiochemistry and translational oncology has hastened the creation of several interesting targets, although most are still in early clinical investigation.

One of the most promising of these has been fibroblast activation protein (FAP). FAP is largely expressed by cancer-associated fibroblasts of the tumor microenvironment (TME) and is strongly expressed in many epithelial malignancies, unlike the common targets expressed on tumor cells. First investigations show promising tumor-to-background contrast with FAPI PET and therapeutic radioligands with ^{177}Lu , ^{90}Y and ^{225}Ac are tested in the clinic. Targeting the tumor stroma in addition to malignant cells may overcome limitations related to tumor heterogeneity, although durable clinical benefit has not been established yet.

Other key targets for study are HER2, CXCR4 and gastrin-releasing peptide receptor (GRPR). Radiolabeled HER2-directed antibodies, affibodies and nanobodies provide whole-body characterization of receptor heterogeneity and may augment current HER2-targeted therapy in resistant disease. CXCR4-directed imaging and therapy have shown promise in hematologic malignancies. GRPR-directed radiopharmaceuticals may offer an alternative or complementary approach in prostate and breast cancers, particularly in tumors with heterogeneous PSMA expression. Other targets such as integrin $\alpha\beta 3$, carbonic anhydrase IX (CAIX), mesothelin, DLL3 and neurotensin receptor are in preclinical and early phase clinical research.

Progress in radiopharmaceutical engineering is keeping pace with this and opening up therapeutic opportunities. Novel ligand platforms such as nanobodies, affibodies, antibody fragments, cyclic peptides, aptamers and small-molecule inhibitors can offer better tumor penetration, faster blood clearance and lower background activity than conventional monoclonal antibodies. Simultaneously, the focus is turning not just beyond ^{177}Lu to α -emitting radionuclides such as ^{225}Ac , ^{212}Pb and ^{213}Bi but also towards new β -emitters such as ^{161}Tb , permitting the selection of the isotope according to tumor biology and lesion features. Bispecific radiopharmaceuticals and multifunctional nanotheranostic platforms further try to address tumor heterogeneity by simultaneously targeting various biological pathways.

The rapid progress does not easily translate into routine clinical practice. Most novel radiopharmaceuticals are mainly supported by preclinical or early phase clinical studies with little randomized evidence for superiority over conventional medicines. Moreover, successful clinical translation requires not only target specificity, but also favourable pharmacokinetics, scalable production of radionuclides, standardised manufacturing, regulatory approval and cost-effectivity. Variability in target expression between tumor types and during disease evolution thus increases the usefulness of molecular imaging for patient selection.

Future advances will probably combine new molecular targets with alpha-particle therapy, personalized dosimetry, artificial intelligence-assisted ligand design, and radiogenomics. However, the ultimate success of next generation theranostics will depend on establishing compelling comparative clinical evidence indicating major gains in survival, quality of life and healthcare value rather than technological innovation alone.

Table 1. Established and Emerging Theranostic Targets in Oncology

Target	Main Cancer Types	Imaging Agent (Examples)	Therapeutic Agent (Examples)	Clinical Status
Somatostatin receptors (SSTR)	Neuroendocrine tumors	^{68}Ga -DOTATATE	^{177}Lu -DOTATATE	Established
PSMA	Prostate cancer	^{68}Ga -PSMA-11	^{177}Lu -PSMA-617 ^{225}Ac -PSMA	Established
Sodium-iodide symporter	Differentiated thyroid cancer	^{123}I / ^{131}I	^{131}I	Established
FAP	Multiple solid tumors	^{68}Ga -FAPI	^{177}Lu -FAPI ^{225}Ac -FAPI	Early clinical
HER2	Breast, gastric and other cancers	^{68}Ga -trastuzumab fragments	^{177}Lu -HER2 ^{225}Ac -HER2	Early clinical
CXCR4	Hematologic and solid tumors	^{68}Ga -pentixafor	^{177}Lu -pentixafor ^{225}Ac -pentixafor	Early clinical
GRPR	Prostate, breast, gastrointestinal	^{68}Ga -RM2	^{177}Lu -RM2	Investigational

Alpha-Particle Therapy: Redefining the Therapeutic Index of Radionuclide Therapy

Alpha-particle treatment is one of the most promising recent advancements in radionuclide therapy and has the ability to overcome the limitations of conventional β -emitters radiopharmaceuticals. Unlike β -particles, alpha particles have high LET and a very narrow range in tissue ($<100\ \mu\text{m}$) to produce dense, irreversible DNA double strand breaks while

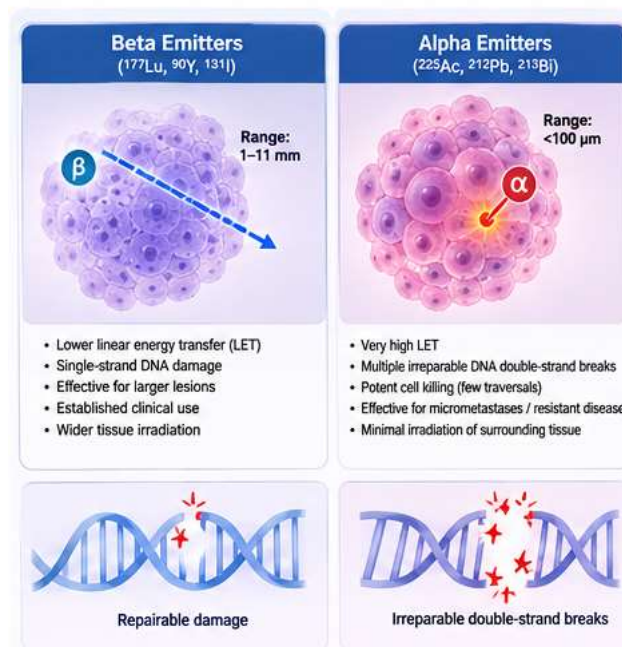
sparing surrounding normal tissues from irradiation. These features make alpha emitters particularly appealing for the treatment of micrometastatic illness, heterogeneous malignancies and tumors resistant to traditional radionuclide therapy. Of the radionuclides now under investigation, ^{225}Ac has been shown to have the most clinical interest. Early experiences with ^{225}Ac -PSMA have demonstrated encouraging biochemical and imaging responses in patients with metastatic castration-resistant prostate cancer, including those with progression after ^{177}Lu -PSMA therapy, indicating that alpha therapy may overcome resistance to β -emitting radioligands. Other experimental alpha emitters include ^{212}Pb , ^{213}Bi , ^{211}At and ^{227}Th are under evaluation in a spectrum of solid and hematologic cancers, targeting targets such as somatostatin receptors, HER2, FAP, CXCR4, CD33 and mesothelin.

Notwithstanding these favorable results, many problems impede widespread clinical acceptance. Xerostomia is the major dose-limiting hazard of ^{225}Ac -PSMA, reflecting physiological PSMA expression in salivary glands, and efficient gland-protective measures are still to be found. Other challenges are the restricted production of radionuclides, complicated radiochemistry, redistribution of daughter radionuclides and unavailability of defined microdosimetric methodologies. In addition, the existing clinical data are mainly from small, single-arm or early-phase investigations, and the evidence on long-term safety and comparative efficacy remains limited.

Alpha-particle treatment is also being investigated in combination with immune checkpoint inhibitors, DNA damage response inhibitors, PARP inhibitors and external beam radiation. High-LET radiation may promote antitumor immunity by inducing immunogenic cell death and modifying the tumor microenvironment, providing a strong biological basis for combination strategies. However, these techniques remain exploratory and require prospective study of their optimum sequencing and toxicity profiles.

Moving forward will involve increasing radionuclide production capacity, enhancing the stability of chelators, improving personalized dosimetry, and conducting adequately powered randomized clinical trials. The combination with artificial intelligence, quantitative imaging, and predicted dosimetry may improve further patient selection and treatment planning. Although alpha-particle therapy has the potential to improve the therapeutic index of radionuclide therapy, its ultimate role will depend on demonstrating sustained clinical benefit, acceptable toxicity and cost-effectiveness relative to established beta-emitting radiopharmaceuticals.

Figure 3. Beta vs Alpha Emitters: Physical and Biological Comparison



Combination Treatment Strategies: Integrating Theranostics into Multimodal Cancer Care

Theranostics is increasingly being employed as part of a multi-modal cancer care rather than a stand-alone treatment. Tumor progression is driven by genetic heterogeneity, clonal evolution, and interactions with the tumor microenvironment; hence, durable disease control is generally achieved by combining targeted radionuclide therapy with surgery, systemic therapy,

immunotherapy, or external beam radiotherapy (EBRT). These tactics try to exploit complimentary biological pathways, while keeping toxicity within acceptable limits.

Immune checkpoint inhibitors (ICIs) have been the most explored of the new combos. Besides direct cytotoxicity, radionuclide therapy may cause immune cell death, improve antigen presentation and modify the tumor microenvironment, offering a justification for combination with PD-1, PD-L1 and CTLA-4 inhibitors. Early phase trials in prostate cancer, neuroendocrine tumors and other solid malignancies reveal potential synergy, but strong survival data are not yet available, and the best time of combination therapy is not yet identified.

Another potential approach is the combination of radionuclide therapy with inhibitors of DNA damage response (DDR), especially PARP inhibitors. Radionuclide therapy induces DNA strand breaks and inhibition of DNA repair can lead to increased radiosensitivity, especially in tumors with homologous recombination defects such as BRCA1/2 or ATM mutations. A number of active trials are testing ^{177}Lu -PSMA with PARP inhibition in metastatic prostate cancer, however the long-term efficacy and safety remain unknown.

Targeted therapy may further boost theranostic effectiveness through enhanced target expression or radiosensitivity. For example, BRAF and MEK inhibitors have been used to restore sodium-iodide symporter expression in radioiodine-refractory differentiated thyroid cancer, resulting in renewed responsiveness to radioiodine therapy. Combinations with androgen receptor inhibitors, HER2-targeted treatments, and other molecular medicines are also being actively investigated.

Theranostics is also a useful adjunct to external beam radiation (EBRT) and surgery. EBRT is useful for local management of bulky or symptomatic lesions. Radionuclide therapy targets widespread microscopic disease depending on expression of molecular targets. Preoperative molecular imaging can aid surgical planning, and postoperative radionuclide therapy can ablate residual or metastatic illness, highlighting the relevance of theranostics in multidisciplinary cancer care.

Combination techniques are biologically well-justified but are still primarily experimental. Optimal sequencing, cumulative toxicity, customized dosimetry, and patient selection have not been established and overlapping hematologic, renal and salivary gland toxicities necessitate close monitoring. Most of the data available are from pre-clinical research or early phase clinical trials with few randomized studies showing a survival or quality of life benefit. Future advancement will depend on the use of biomarker-driven trial designs, standardization of dosimetry and prospective comparison studies that specify which patients benefit most from specific combinations while keeping an acceptable safety profile.

Table 2. Key Opportunities and Challenges in Theranostic Development

Domain	Key Opportunities	Major Challenges
 Radiopharmaceuticals	<ul style="list-style-type: none"> New targets Alpha emitters Multifunctional ligands 	<ul style="list-style-type: none"> Production and supply Complex radiochemistry Regulatory requirements
 Quantitative Imaging & Dosimetry	<ul style="list-style-type: none"> Personalized treatment Adaptive therapy Better safety 	<ul style="list-style-type: none"> Standardization Validation of dose-response Clinical implementation
 Artificial Intelligence	<ul style="list-style-type: none"> Automated analysis Predictive modeling Decision support 	<ul style="list-style-type: none"> Generalizability Interpretability Data quality and privacy
 Combination Therapy	<ul style="list-style-type: none"> Synergistic efficacy Overcome resistance Broader indications 	<ul style="list-style-type: none"> Optimal sequencing Overlapping toxicities Evidence from RCTs
 Clinical Translation	<ul style="list-style-type: none"> Wider access Cost-effective care Improved outcomes 	<ul style="list-style-type: none"> Infrastructure Workforce training Global equity

Abbreviation: RCTs, randomized controlled trials.

CLINICAL TRANSLATION: SAFETY, TOXICITY, AND BARRIERS TO IMPLEMENTATION

The transition of theranostics into ordinary oncology will hinge on efficacy and safety, defined clinical routes, a stable radionuclide supply, specialized infrastructure and equal access. Although randomized trials have demonstrated meaningful gains in survival, disease control, and quality of life for some malignancies, logistical, regulatory, and economic obstacles pose a significant barrier to broader deployment.

Toxicity and Safety

Targeted radionuclide therapy selectively delivers radiation to malignant tissue. Physiologic expression of molecular targets in normal organs always leads to off-target radiation exposure. Toxicity depends on the target biology, radionuclide properties, delivered activity, cumulative dose, pharmacokinetics and baseline organ performance.

Hematologic toxicity remained the most common side event, especially in patients with significant skeletal metastases, prior chemotherapy or limited bone marrow reserve, underscoring the significance of cautious patient selection and longitudinal monitoring. A significant limitation of peptide-based therapeutics has been renal toxicity, which has been dramatically decreased in the past by amino acid nephroprotection, improved ligand design and optimized treatment regimens. Patients with pre-existing renal impairment need individual risk assessment. Xerostomia is the main dose-limiting effect of PSMA-directed therapy, particularly with ^{225}Ac -PSMA where harm to the salivary glands can have a major impact on quality of life. Other adverse effects are generally uncommon but still need ongoing long-term monitoring and include fatigue, nausea, transient gastrointestinal symptoms, and rare therapy-related myelodysplastic syndrome or acute leukemia. Importantly, patient-reported outcomes have consistently shown that improvements in disease control are typically accompanied by meaningful benefits in quality of life, highlighting the relevance of patient-centered assessment.

Infrastructure & Workforce

Successful theranostic programs require dedicated radiopharmacy facilities, quantitative imaging systems, radiation safe treatment environments, medical physics support and multidisciplinary teams of nuclear medicine physicians, oncologists, radiologists, surgeons, radiopharmacists, medical physicists, specialist nurses and radiation safety personnel. These infrastructure and manpower needs remain substantial obstacles, especially in healthcare systems without established nuclear medicine services, stressing the need for greater training and interdisciplinary collaboration.

Radionuclide Supply and Health Policy

The growing clinical demand has exposed critical weaknesses in global radionuclide manufacturing. Many of the key isotopes (^{177}Lu , ^{68}Ga and especially ^{225}Ac) rely on limited production capacity and supply disruption remains a common hurdle to clinical growth. Investment in reactor technology, accelerator-based production and robust international supply networks will therefore be key for sustainable expansion.

Theranostic medicines are associated with high upfront costs, but their utility goes well beyond the procurement of drugs as they allow better patient selection, slow disease progression, decrease healthcare utilization, and perhaps improve quality-adjusted survival. However, reimbursement rules differ greatly among health care systems and detailed cost-effectiveness assessments are lacking. Strong economic evidence will be critical to informing decisions around reimbursement and fostering wider uptake.

CHALLENGES IN GLOBAL AND REGULATORY IMPLEMENTATION

Many existing regulatory regimes have not kept pace with rapid breakthroughs in radiopharmaceutical development. The standardization of manufacturing standards, imaging protocols, dosimetry methodologies, response criteria, and reporting standards by organizations such as the IAEA, EANM, and SNMMI is critical to ensure reproducibility across institutions and facilitate multicenter clinical trials.

One of its biggest concerns continues to be access to theranostics. Advanced molecular imaging and radionuclide therapy are centralized in high-resource centers, and the restricted infrastructure, staff shortages, regulatory complexity, treatment costs, and isotope availability continue to impede access in many low- and middle-income nations. International cooperation, regional production of radionuclides, technology transfer, workforce development and sustainable health policies will be needed to address these inequities.

Critical Perspective

Despite impressive scientific progress, the major challenge for next generation theranostics remains clinical translation. Future success will not only depend on the development of new radiopharmaceuticals, but also on the standardization of dosimetry, the strengthening of long-term safety surveillance, the assurance of a reliable supply of radionuclides, the generation of robust cost-effectiveness data, and the expansion of equitable global access. Without overcoming these operational challenges, theranostics' therapeutic impact will remain restricted, despite ongoing technological improvement.

FUTURE PERSPECTIVES: THE NEXT DECADE OF PRECISION THERANOSTICS

Theranostics, which used to be a niche application of nuclear medicine, is now a major component of precision oncology, merging molecular imaging, targeted radionuclide therapy, quantitative dosimetry, and computational medicine. The coming decade will probably bring fewer incremental enhancements to existing radiopharmaceuticals, and greater innovations that enhance personalization, extend therapeutic indications and enable worldwide application. There are some events that are especially likely to affect the future of the field.

Expansion beyond existing molecular targets

Although PSMA and somatostatin receptor theranostics have revolutionized the treatment of prostate cancer and neuroendocrine tumors, most malignancies lack approved therapeutic targets. Among the developing candidates, fibroblast activation protein (FAP) is especially interesting due to its ubiquitous expression across many epithelial malignancies and the capacity to target the tumor microenvironment, rather than malignant cells alone. Future development of radiopharmaceuticals will also include nanobodies, bispecific ligands, scaffold proteins and synthetic biomolecules with better pharmacokinetic properties. However, clinical implementation would require randomized trials demonstrating a significant benefit in survival, quality of life and cost effectiveness, not just imaging performance.

Alpha-Particle Therapy

One of the most important therapeutic developments in radionuclide therapy is alpha-emitting radionuclides. Because of their high linear energy transfer and short tissue range they are potentially able to overcome the resistance to conventional β -emitting radiopharmaceuticals, especially in little residual illness and in treatment refractory malignancies. However, challenges remain before the widespread adoption of alpha therapy, including radionuclide production, toxicity mitigation, dosimetric standardization and limited prospective clinical evidence. More biological innovation will be as crucial as expanding dependable isotope production.

Artificial Intelligence and Adaptive Personalized Dosimetry

Clinical practice may be reshaped by the move from fixed-activity administration of radionuclides to adaptive, patient-specific therapy. The integration of artificial intelligence with quantitative imaging, voxel-level dosimetry, laboratory biomarkers and clinical data may enable the dynamic adjustment of administered activity, treatment intervals and radionuclide selection throughout therapy. Although these technologies promise to improve precision, prospective validation and transparent clinical decision support systems are necessary before routine use.

Radiogenomics and Integrating Multi-Omics

In the future, treatment will likely depend on more than just which receptors are expressed. Molecular imaging in conjunction with genomic, transcriptomic, proteomic, metabolomic and radiomic data may allow for more precise prediction of radiosensitivity, therapeutic resistance and treatment response. Such multimodal techniques could provide for the first time personalized radiopharmaceutical selection and help identify patients more likely to benefit from combo therapy. However, external validation and defined analytical frameworks will be needed before general clinical application.

Combination Precision Therapies

Theranostics are increasingly expected to be used as part of integrated precision oncology rather than as a separate therapy approach. Among the combination treatments, radionuclide therapy plus immune checkpoint inhibitors seem particularly promising, since radiation may boost anti-tumor immunity through immunogenic cell death and modification of the tumor microenvironment. Since the current evidence is mostly limited to preclinical and early-phase clinical studies, further research should be directed at determining the appropriate sequencing, predictive biomarkers, and management of toxicities.

Global Clinical Practice translation

The future of theranostics will be decided not only by scientific development. Reliable production of radionuclides harmonized regulatory frameworks, standardized dosimetry, workforce development and fair access across varied health care systems will be needed for sustainable growth. Investment in isotope production, particularly for alpha emitters, alongside international collaboration and evidence-based reimbursement policies will be essential to ensure that advances in precision radionuclide therapy benefit patients globally rather than being restricted to specialized centers.

Future Prospects

The future of theranostics is the integration of molecular imaging, targeted radionuclide therapy, artificial intelligence, radiogenomics, and precision dosimetry into a continually evolving clinical ecosystem. Rather of replacing existing cancer therapies, theranostics will supplement surgery, systemic therapy, immunotherapy and external beam radiotherapy more and more, through biologically guided treatment selection. Success will ultimately rely on not only technology innovation but also on establishing enduring therapeutic benefit, cost-effectiveness and equitable worldwide deployment. If these problems are properly handled, theranostics will become one of the pillars of precision oncology in the next decade.

Table 3. Future Directions for Precision Theranostics

Priority Area	Expected Impact
 Expanded molecular targets (FAP, HER2, CXCR4, others)	<ul style="list-style-type: none"> • Treat broader range of cancers • Overcome resistance mechanisms
 Alpha-particle therapy	<ul style="list-style-type: none"> • Higher therapeutic efficacy • Effective for micrometastatic / resistant disease
 AI and multi-omics integration	<ul style="list-style-type: none"> • More precise patient selection • Real-time adaptive treatment • Digital twin-based decision support
 Personalized dosimetry	<ul style="list-style-type: none"> • Maximize tumor dose • Minimize toxicity • Improve safety and outcomes
 Rational combination strategies	<ul style="list-style-type: none"> • Synergistic efficacy with ICIs, DDR inhibitors, targeted therapy and EBRT
 Global implementation	<ul style="list-style-type: none"> • Standardization • Scalable production • Equitable access worldwide

CONCLUSION

Theranostics has revolutionized cancer by merging molecular imaging with targeted radionuclide therapy into a cohesive precision medicine framework. By connecting diagnosis, patient selection, therapy, and response evaluation via common molecular targets, cancer management has transitioned from an anatomy-centric approach to scientifically informed, personalized care. Proven applications in neuroendocrine tumors, prostate cancer, and differentiated thyroid carcinoma have shown significant enhancements in survival, disease management, and quality of life, affirming theranostics as a fundamental aspect of comprehensive cancer treatment. Simultaneously, novel targets such fibroblast activation protein (FAP), HER2, CXCR4, and GRPR suggest significant promise for broadening radionuclide therapy to encompass a greater variety of cancers.

Advancements in theranostics are progressively propelled by innovations that extend beyond the mere manufacture of radiopharmaceuticals. Customized dosimetry, artificial intelligence, quantitative imaging, radiogenomics, and alpha-particle therapy are transforming treatment strategies and facilitating more accurate, individualized radionuclide therapy. Nonetheless, considerable obstacles persist prior to the broad adoption of these advancements. Dependable radionuclide generation, uniform dosimetry, rigorous comparative clinical studies, extensive safety data, economic viability assessments, regulatory alignment, and fair worldwide accessibility are essential concerns for forthcoming research and clinical applications.

Ultimately, the trajectory of theranostics will hinge on both the identification of novel molecular targets and the effective integration of scientific breakthroughs into standard clinical practice. Through sustained interdisciplinary cooperation and the application of evidence-based practices, theranostics is set to emerge as a fundamental component of precision oncology, establishing a system where molecular profiling directly informs personalized cancer therapies and enhances results for a growing patient demographic.

Declaration on Ethical AI use

Artificial intelligence-assisted techniques were employed just for language improvement, structural organization, and editorial help. The literature selection, data interpretation, critical appraisal and all scientific conclusions were independently completed and validated by the authors using primary peer-reviewed sources. The authors are fully responsible for the accuracy, originality and integrity of the paper in accordance with current ICMJE criteria.

ACKNOWLEDGEMENTS

Not applicable.

FUNDING

This case report was not funded by any person or institution.

DECLARATION OF COMPETING INTEREST

The authors have no conflicts of interest to disclose in relation to this work.

REFERENCES

1. Strosberg J, El-Haddad G, Wolin E, Hendifar A, Yao J, Chasen B, et al. Phase 3 trial of ^{177}Lu -Dotatate for midgut neuroendocrine tumors. *N Engl J Med*. 2017;376(2):125-135. doi:10.1056/NEJMoa1607427.
2. Strosberg JR, Caplin ME, Kunz PL, Ruzsniwski PB, Bodei L, Hendifar A, et al. ^{177}Lu -Dotatate plus long-acting octreotide versus high-dose long-acting octreotide in patients with midgut neuroendocrine tumours (NETTER-1): final overall survival and long-term safety results from an open-label, randomised, controlled, phase 3 trial. *Lancet Oncol*. 2021;22(12):1752-1763. doi:10.1016/S1470-2045(21)00572-6.
3. Sartor O, de Bono J, Chi KN, Fizazi K, Herrmann K, Rahbar K, et al. Lutetium-177-PSMA-617 for metastatic castration-resistant prostate cancer. *N Engl J Med*. 2021;385(12):1091-1103.
4. Hofman MS, Emmett L, Sandhu S, Iravani A, Joshua AM, Goh JC, et al. [^{177}Lu]Lu-PSMA-617 versus cabazitaxel in patients with metastatic castration-resistant prostate cancer (TheraP): a randomised, open-label, phase 2 trial. *Lancet*. 2021;397(10276):797-804.
5. Parker C, Nilsson S, Heinrich D, Helle SI, O'Sullivan JM, Fosså SD, et al. Alpha emitter radium-223 and survival in metastatic prostate cancer. *N Engl J Med*. 2013;369(3):213-223.
6. Solnes LB, Werner RA, Jones KM, Sadaghiani MS, Bauman G, Lapa C, et al. Theranostics: Leveraging molecular imaging and therapy to impact patient management and secure the future of nuclear medicine. *J Nucl Med*. 2020;61(3):311-318.
7. Herrmann K, Giovanella L, Santos A, Oyen WJG, Lewis JS, Rahbar K, et al. Joint EANM, SNMMI and IAEA enabling guide: How to set up a theranostics centre. *J Nucl Med*. 2022;63(12):1836-1843.
8. Gillies RJ, Kinahan PE, Hricak H. Radiomics: Images are more than pictures, they are data. *Radiology*. 2016;278(2):563-577.
9. Lambin P, Rios-Velazquez E, Leijenaar R, Carvalho S, van Stiphout RGPM, Granton P, et al. Radiomics: Extracting more information from medical images using advanced feature analysis. *Eur J Cancer*. 2012;48(4):441-446.
10. Hosny A, Parmar C, Quackenbush J, Schwartz LH, Aerts HJWL. Artificial intelligence in radiology. *Nat Rev Cancer*. 2018;18(8):500-510.
11. Hope TA, Abbott A, Colucci K, Bushnell DL, Gardner L, Graham WS, et al. NANETS/SNMMI procedure standard for somatostatin receptor-based peptide receptor radionuclide therapy with ^{177}Lu -DOTATATE. *J Nucl Med*. 2019;60(7):937-943. doi:10.2967/jnumed.118.230607.
12. Hope TA, Allen-Auerbach M, Bodei L, Calais J, Dahlbom M, Dunnwald LK, et al. SNMMI procedure standard/EANM practice guideline for SSTR PET: imaging neuroendocrine tumors. *J Nucl Med*. 2023;64(2):204-210. doi:10.2967/jnumed.122.264860.
13. Bodei L, Mueller-Brand J, Baum RP, Pavel ME, Hörsch D, O'Dorisio MS, et al. The joint IAEA, EANM, and SNMMI practical guidance on peptide receptor radionuclide therapy (PRRT) in neuroendocrine tumours. *Eur J Nucl Med Mol Imaging*. 2013;40(5):800-816.
14. Gear JJ, Stokke C, Terwinghe C, Gnesin S, Sandström M, Tran-Gia J, et al. EANM enabling guide: how to improve the accessibility of clinical dosimetry. *Eur J Nucl Med Mol Imaging*. 2023;50(7):1861-1868. doi:10.1007/s00259-023-06226-z.
15. Wessels BW, Konijnenberg MW, Dale RG, Breitz HB, Cremonesi M, Meredith RF, et al. MIRD pamphlet No. 20: The effect of model assumptions on kidney dosimetry and response—implications for radionuclide therapy. *J Nucl Med*. 2008;49(11):1884-1899. doi:10.2967/jnumed.108.053173.
16. Del Prete M, Buteau FA, Arsenault F, Saighi N, Beauregard JM. Personalized ^{177}Lu -DOTATATE peptide receptor radionuclide therapy of neuroendocrine tumours: a clinical dosimetry-based approach. *Eur J Nucl Med Mol Imaging*. 2017;44(9):1490-1500.
17. Flux GD, Gleisner KS, Chiesa C, Lassmann M. The impact of PET and SPECT on dosimetry for targeted radionuclide therapy. *Z Med Phys*. 2020;30(1):47-59.
18. Lassmann M, Chiesa C, Flux G, Bardies M. EANM dosimetry committee guidance document: good practice of clinical dosimetry reporting. *Eur J Nucl Med Mol Imaging*. 2011;38(1):192-200.

19. Violet J, Jackson P, Ferdinandus J, Sandhu S, Akhurst T, Iravani A, et al. Dosimetry of ^{177}Lu -PSMA-617 in metastatic castration-resistant prostate cancer: correlations between absorbed dose and treatment response. *J Nucl Med.* 2019;60(4):517-523.
20. Sandström M, Garske-Román U, Granberg D, Johansson S, Widström C, Eriksson B, et al. Individualized dosimetry of kidney and bone marrow in patients undergoing ^{177}Lu -DOTA-octreotate treatment. *J Nucl Med.* 2013;54(1):33-41.
21. Fendler WP, Eiber M, Beheshti M, Bomanji J, Calais J, Ceci F, et al. PSMA PET/CT: joint EANM procedure guideline/SNMMI procedure standard for prostate cancer imaging 2.0. *Eur J Nucl Med Mol Imaging.* 2023;50(5):1466-1486. doi:10.1007/s00259-022-06089-w.
22. Kratochwil C, Fendler WP, Eiber M, Hofman MS, Emmett L, Calais J, et al. Joint EANM/SNMMI procedure guideline for the use of ^{177}Lu -labeled PSMA-targeted radioligand therapy (^{177}Lu -PSMA-RLT). *Eur J Nucl Med Mol Imaging.* 2023;50(9):2830-2845. doi:10.1007/s00259-023-06255-8.
23. Hofman MS, Lawrentschuk N, Francis RJ, Tang C, Vela I, Thomas P, et al. Prostate-specific membrane antigen PET-CT in patients with high-risk prostate cancer before curative-intent surgery or radiotherapy (proPSMA): a prospective, randomised, multicentre study. *Lancet.* 2020;395(10231):1208-1216.
24. Calais J, Czernin J, Cao M, Kishan AU, Hegde JV, Shaverdian N, et al. ^{68}Ga -PSMA-11 PET/CT mapping of prostate cancer biochemical recurrence after radical prostatectomy in relation to PSA level. *J Nucl Med.* 2018;59(2):230-237.
25. Giesel FL, Kratochwil C, Lindner T, Marschalek MM, Loktev A, Lehnert W, et al. ^{68}Ga -FAPI PET/CT: biodistribution and preliminary dosimetry estimate of two DOTA-containing FAP-targeting agents in patients with various cancers. *J Nucl Med.* 2019;60(3):386-392.
26. Loktev A, Lindner T, Burger EM, Altmann A, Giesel F, Kratochwil C, et al. Development of fibroblast activation protein-targeted radiotracers with improved tumour retention. *J Nucl Med.* 2019;60(10):1421-1429.
27. Lindner T, Loktev A, Altmann A, Giesel F, Kratochwil C, Debus J, et al. Development of quinoline-based theranostic ligands for the targeting of fibroblast activation protein. *J Nucl Med.* 2018;59(9):1415-1422.
28. Kratochwil C, Flechsig P, Lindner T, Abderrahim L, Altmann A, Mier W, et al. ^{68}Ga -FAPI PET/CT: tracer uptake in 28 different kinds of cancer. *J Nucl Med.* 2019;60(6):801-805.
29. Ferdinandus J, Röhrich M, Siveke JT, Heussel CP, Kauczor HU, Pahner I, et al. Clinical applications of fibroblast activation protein-targeted PET imaging: current evidence and future perspectives. *Eur J Nucl Med Mol Imaging.* 2021;48(13):4192-4207.
30. Herrmann K, Schwaiger M, Lewis JS, Solomon SB, McNeil BJ, Baumann M, et al. Radiotheranostics: a roadmap for future development. *Lancet Oncol.* 2020;21(3):e146-e156.
31. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, et al. 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer. *Thyroid.* 2016;26(1):1-133.
32. Schlumberger M, Leboulleux S. Current practice in patients with differentiated thyroid cancer. *Nat Rev Endocrinol.* 2021;17(3):176-188.
33. Dijkers ECF, Kosterink JGW, Rademaker AP, Perk LR, van Dongen GAMS, Bart J, et al. Development and characterization of clinical-grade ^{89}Zr -trastuzumab for HER2/neu immunoPET imaging. *J Nucl Med.* 2009;50(6):974-981. doi:10.2967/jnumed.108.060392.
34. Ulaner GA, Carrasquillo JA, Riedl CC, Yeh R, Hatzoglou V, Ross DS, et al. Identification of HER2-positive metastases in patients with HER2-negative primary breast cancer using HER2-targeted ^{89}Zr -pertuzumab PET/CT. *Radiology.* 2020;296(2):370-378. doi:10.1148/radiol.2020192828.
35. Galldiks N, Langen KJ, Pope WB. From the clinician's point of view – What is the status quo of positron emission tomography in patients with brain tumors? *Neuro Oncol.* 2015;17(11):1434-1444.
36. Langen KJ, Galldiks N, Hattingen E, Shah NJ. Advances in neuro-oncology imaging. *Nat Rev Neurol.* 2017;13(5):279-289.
37. Witzig TE, Gordon LI, Cabanillas F, Czuczman MS, Emmanouilides C, Joyce R, et al. Randomized controlled trial of yttrium-90-labeled ibritumomab tiuxetan radioimmunotherapy versus rituximab immunotherapy for patients with relapsed or refractory low-grade, follicular, or transformed B-cell non-Hodgkin lymphoma. *J Clin Oncol.* 2002;20(10):2453-2463.

38. Kaminski MS, Estes J, Zasadny KR, Francis IR, Ross CW, Tuck M, et al. Radioimmunotherapy with iodine-131 tositumomab for relapsed or refractory B-cell non-Hodgkin lymphoma. *N Engl J Med*. 2001;345(7):459-466.
39. Pandit-Taskar N, Modak S. Norepinephrine transporter as a target for imaging and therapy in neuroblastoma. *J Nucl Med*. 2017;58(Suppl 2):39S-53S.
40. Herrmann K, Schwaiger M, Lewis JS, Solomon SB, McNeil BJ, Baumann M, et al. Radiotheranostics: a roadmap for future development. *Lancet Oncol*. 2020;21(3):e146-e156.
41. Kratochwil C, Bruchertseifer F, Giesel FL, Weis M, Verburg FA, Mottaghy F, et al. ²²⁵Ac-PSMA-617 for PSMA-targeted alpha-radiation therapy of metastatic castration-resistant prostate cancer. *J Nucl Med*. 2016;57(12):1941-1944. doi:10.2967/jnumed.116.178673.
42. Yadav MP, Ballal S, Sahoo RK, Tripathi M, Seth A, Bal C. Efficacy and safety of ²²⁵Ac-PSMA-617 targeted alpha therapy in metastatic castration-resistant prostate cancer patients. *Theranostics*. 2020;10(20):9364-9377. doi:10.7150/thno.48107.
43. Sathekge MM, Lawal IO, Bal C, Bruchertseifer F, Ballal S, Cardaci G, et al. Actinium-225-PSMA radioligand therapy of metastatic castration-resistant prostate cancer (WARMTH Act): a multicentre, retrospective study. *Lancet Oncol*. 2024;25(2):175-183. doi:10.1016/S1470-2045(23)00638-1.
44. Morgenstern A, Apostolidis C, Kratochwil C, Sathekge M, Krolicki L, Bruchertseifer F. An overview of targeted alpha therapy with ²²⁵Ac and ²¹³Bi. *Curr Radiopharm*. 2018;11(3):200-208.
45. Sgouros G. Dosimetry, radiobiology and synthetic lethality: Radiopharmaceutical therapy with alpha-particle emitters. *Semin Nucl Med*. 2020;50(2):124-132.
46. Werner RA, Weich A, Kircher M, Solnes LB, Javadi MS, Higuchi T, et al. The theranostic concept: From molecular imaging to precision oncology. *Nat Rev Clin Oncol*. 2024.
47. Herrmann K, Schwaiger M, Lewis JS, Solomon SB, McNeil BJ, Baumann M, et al. Radiotheranostics: A roadmap for future development. *Lancet Oncol*. 2020;21(3):e146-e156.
48. Bodei L, Schöder H, Baum RP, Herrmann K, Modlin IM, Caplin M. Molecular profiling of neuroendocrine tumours: Role of theranostics in precision oncology. *Nat Rev Clin Oncol*. 2022.
49. Sathekge M, Morgenstern A. Advances in targeted alpha therapy of cancer. *Eur J Nucl Med Mol Imaging*. 2024;51(5):1205-1206. doi:10.1007/s00259-024-06658-1.
50. Haberkorn U, Giesel FL, Morgenstern A, Kratochwil C. The future of radioligand therapy: α , β , or both? *J Nucl Med*. 2017;58(Suppl 2):1017-1018.

CITE THIS ARTICLE:

- **APA (7th edition):** Bakshi, I., Anand, P., & Rawat, H. S. (2026, August 3). *Theranostics in oncology: Integrating molecular imaging and targeted radionuclide therapy for precision cancer care*. *The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2607004>
- **Harvard:** Bakshi, I., Anand, P. and Rawat, H.S., 2026. *Theranostics in oncology: Integrating molecular imaging and targeted radionuclide therapy for precision cancer care*. *The Operating Room Global Journal (TORGJ)*, 2(3). Published 3 August. Available at: <https://doi.org/10.64573/torgj2607004>
- **Vancouver:** Bakshi I, Anand P, Rawat HS. *Theranostics in oncology: Integrating molecular imaging and targeted radionuclide therapy for precision cancer care*. *The Operating Room Global Journal (TORGJ)*. 2026 Aug 3;2(3). <https://doi.org/10.64573/torgj2607004>
- **MLA (9th edition):** Bakshi, Ishaan, Prashant Anand, and Hriday Singh Rawat. "Theranostics in Oncology: Integrating Molecular Imaging and Targeted Radionuclide Therapy for Precision Cancer Care." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 3 Aug. 2026, <https://doi.org/10.64573/torgj2607004>
- **Chicago (Author-Date):** Bakshi, Ishaan, Prashant Anand, and Hriday Singh Rawat. 2026. "Theranostics in Oncology: Integrating Molecular Imaging and Targeted Radionuclide Therapy for Precision Cancer Care." *The Operating Room Global Journal (TORGJ)* 2 (3), August 3. <https://doi.org/10.64573/torgj2607004>

Knowledge and Attitude of Staff Nurses at University of Ilorin Teaching Hospital Towards Nursing Anaesthesia Programme

Authors: Racheal Olufunmilayo Oyelude^{1,5*}, Chuwang Bitrus Zi^{2,3}, Phillip A. Ojo⁴

¹ Anaesthesia Unit, Department of Nursing services, University of Ilorin Teaching Hospital, Kwara State, Nigeria.

² Department of Urban and Regional Planning, Faculty of Environmental services, University of Jos.

³ School of Post Basic Nursing Anaesthesia, Jos University Teaching Hospital. Plateau State, Nigeria.

⁴ College of Nursing sciences, University College Hospital, Ibadan. Oyo State, Nigeria.

⁵ The Operating Room Global (TORG)

DOI: <https://doi.org/10.64573/torgj2602002>

ABSTRACT

Background: Nursing anaesthesia is a specialized field of nursing practice that plays a vital role in the delivery of safe perioperative care. Despite the increasing demand for nurse anaesthetists in Nigeria, enrollment into the nursing anaesthesia programme remains low. Understanding nurses' knowledge, attitudes, and perceived barriers to enrollment is essential for developing strategies to strengthen the anaesthesia workforce.

Objective: To assess the knowledge and attitude of staff nurses towards the nursing anaesthesia programme and identify factors influencing enrollment at the University of Ilorin Teaching Hospital, Ilorin, Nigeria.

Methods: A descriptive cross-sectional study was conducted among 261 staff nurses selected using a total enumeration sampling technique. Data were collected using a structured self-administered questionnaire comprising sections on socio-demographic characteristics, knowledge, attitude, perceived barriers to enrollment, and suggested strategies for improving enrollment. Descriptive statistics were used to summarize the data, while Chi-square tests were employed to examine the relationships between age and awareness and between gender and willingness to enroll. Statistical significance was set at $p < 0.05$.

Results: Respondents demonstrated a high level of awareness of the nursing anaesthesia programme, with 92.0% correctly identifying it as a nursing specialty. Overall, 88.1% exhibited a positive attitude and willingness to enroll in the programme. Respondents perceived nursing anaesthesia as offering opportunities for professional advancement, independent and collaborative practice, and improved remuneration. Financial constraints (36.4%), lack of flexible entry pathways (24.5%), distance to training institutions (13.0%), and family-related responsibilities (11.1%) were the leading barriers to enrollment. Preference for locally available specialty programmes (54.8%) was identified as the principal reason for the low number of nurse anaesthetists. Respondents strongly supported expanding training institutions, providing financial assistance, upgrading the programme to a master's degree, and strengthening mentorship and clinical exposure as strategies for improving enrollment. A statistically significant relationship was observed between age and awareness ($\chi^2 = 30.12$, $df = 9$, $p < 0.05$), whereas no significant relationship was found between gender and willingness to enroll ($\chi^2 = 6.82$, $df = 6$, $p > 0.05$).

Conclusion: Staff nurses demonstrated high awareness and positive attitudes towards the nursing anaesthesia programme; however, enrollment remains constrained by financial, institutional, and accessibility barriers. Strengthening financial support, expanding training opportunities, improving awareness, and implementing supportive institutional policies may enhance enrollment and contribute to addressing the shortage of nurse anaesthetists in Nigeria.

Keywords: Nursing Anaesthesia Programme, Knowledge, Attitude, Enrollment, Nurse Anaesthetists, Nigeria

*Corresponding Author:

Racheal Olufunmilayo Oyelude
olufunmilayo2206@gmail.com

Declaration:

Authors' Contribution:

Racheal O. Oyelude - Conceptualisation, data collection, manuscript drafting and editing; Chuang B. Zi - Supervision, review and editing; Phillip A. Ojo - Review and editing.

Conflict of Interest: No conflict of interest.

Funding: No funding received.

Article History:

Received: 05-02-2026
 Accepted: 19-08-2026
 Available Online:
 21-08-2026

QR access this Article



INTRODUCTION

Anaesthesia services are indispensable to safe surgical care, obstetric interventions, emergency procedures, and critical care. Despite advances in healthcare delivery, the shortage of skilled anaesthesia personnel remains a major global challenge, particularly in low- and middle-income countries such as Nigeria. The growing demand for anaesthesia services continues to outpace the available workforce, and this gap is unlikely to be addressed by physician anaesthetists alone because of limited training capacity, brain drain, and the uneven distribution of specialists [14,18,19].

The shortage of anaesthesia providers is also evident at the University of Ilorin Teaching Hospital (UIH), where the demand for anaesthesia services has increased both within and outside the operating theatre. Although the hospital has a nursing workforce of approximately 750 staff nurses, fewer than ten were trained as nurse anaesthetists at the time of this study [21].

Nursing anaesthesia has emerged as a practical and sustainable strategy for addressing shortages of anaesthesia providers and improving access to safe anaesthesia services. Nevertheless, enrollment into nursing anaesthesia programmes remains low despite the increasing need for qualified personnel. This situation raises concerns about staff nurses' knowledge of the programme and their attitudes toward pursuing specialization. Previous studies have reported that inadequate awareness of the specialty, limited understanding of the roles of nurse anaesthetists, financial constraints, distance to training institutions, preference for other nursing specialties, inadequate mentorship, and insufficient institutional support may discourage nurses from enrolling in the programme [2,5,6].

This study is anchored on the Theory of Cognitive Dissonance proposed by Leon Festinger (1957) and the Theory of Operant Conditioning developed by B. F. Skinner (1938). Festinger's theory explains that individuals strive for consistency between their beliefs, attitudes, and behaviours. When new information challenges existing beliefs, individuals are motivated to modify their attitudes or behaviours to restore internal consistency. Skinner's theory, on the other hand, posits that behaviour is influenced by its consequences, with behaviours followed by positive reinforcement being more likely to be repeated. Applied to this study, increased knowledge and awareness of nursing anaesthesia may positively influence nurses' attitudes toward specialization, while institutional support such as financial sponsorship, favourable policy reforms, mentorship, clinical exposure through in-service education and clinical postings, and the transition of the nursing anaesthesia programme from a post-basic qualification to a master's degree may serve as positive reinforcers that encourage enrollment.

Against this background, this study assessed the knowledge and attitude of staff nurses at the University of Ilorin Teaching Hospital toward the nursing anaesthesia programme. Specifically, it sought to identify knowledge gaps regarding the programme, determine staff nurses' willingness to enroll in the nursing anaesthesia programme, identify factors responsible for the low enrollment of nurses into the specialty, and suggest motivating factors that could enhance participation in nursing anaesthesia training.

The findings of this study are expected to provide evidence for nurse educators, hospital administrators, policymakers, and professional nursing bodies in developing interventions to improve awareness of nursing anaesthesia, address barriers to enrollment, strengthen institutional support, and encourage specialization among nurses. Ultimately, increased participation in nursing anaesthesia programmes will contribute to strengthening the anaesthesia workforce and improving the quality, safety, and accessibility of anaesthesia services in tertiary health institutions in Nigeria [15,18].

METHODS

Research Design

A descriptive cross-sectional research design was employed to assess the knowledge and attitude of staff nurses at the University of Ilorin Teaching Hospital towards the nursing anaesthesia programme. This design was considered appropriate because it allows for the systematic collection of data from a defined population at a single point in time.

The descriptive approach enabled the researcher to obtain detailed information on existing conditions, opinions, and practices while facilitating the analysis of relationships among the study variables. It is particularly suitable for studies that seek to describe the characteristics, knowledge, and attitudes of a specific population.

Study Population

The study population comprised registered nurses working at the University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria. At the time of the study, the hospital had an estimated nursing workforce of approximately 750 registered nurses distributed across various departments, units, and clinical specialties.

This population was considered appropriate for assessing staff nurses' knowledge and attitude towards the nursing anaesthesia programme.

Sample Size Determination

The sample size for this study was determined using the Taro Yamane formula:

$$[n = \frac{N}{1 + N(e)^2}]$$

Where:

n = required sample size

N = target population (750)

e = margin of error (0.05), corresponding to a 95% confidence level

Substituting the values into the formula:

$$[n = \frac{750}{1 + 750(0.05)^2}]$$

$$[= \frac{750}{1 + 750(0.0025)}]$$

$$[= \frac{750}{2.875}]$$

$$[= 260.87 \approx 261]$$

Therefore, the minimum required sample size was 261 respondents. However, a total of 296 respondents participated in the study through the Google Forms survey, thereby exceeding the minimum sample size and improving the precision of the findings.

Sampling Technique

The study initially proposed the use of stratified random sampling. However, due to the movement restrictions and safety measures imposed during the COVID-19 pandemic, convenience and purposive sampling techniques were adopted.

The questionnaire was converted into a Google Form and distributed electronically through readily accessible online platforms. The survey link was also shared within nursing WhatsApp and Telegram groups to reach registered nurses who met the inclusion criteria.

Although this approach facilitated efficient data collection during the pandemic, it may have introduced selection bias and consequently limited the generalizability of the findings to the entire nursing population.

Instrument for Data Collection

Data were collected using a self-structured questionnaire developed from the study objectives and relevant literature. The questionnaire consisted of closed-ended questions and was divided into five sections. Section A contained four questions on the socio-demographic characteristics of the respondents. Section B consisted of five questions assessing respondents' knowledge of the nursing anaesthesia programme. Responses were measured using three options: Yes, No, and Not Sure.

Section C comprised six questions assessing respondents' attitudes and willingness to enroll in the nursing anaesthesia programme. The first three questions were measured using the response options Yes, No, and Not Sure, while the remaining three questions were measured on a four-point Likert scale of Strongly Agree, Agree, Disagree, and Strongly Disagree. The use of different response formats within the same section may have introduced some measurement inconsistency and could limit the instrument's applicability in similar studies.

Section D contained two questions assessing perceived reasons for the low enrollment of nurses in the nursing anaesthesia programme. Respondents were asked to select the factors applicable to them from the options provided. This might also contribute to poor construct and very low internal consistency because their different construct in the questions.

Section E consisted of seven questions assessing factors that could motivate nurses to enroll in the nursing anaesthesia programme. Responses were measured using a four-point Likert scale of Strongly Agree, Agree, Disagree, and Strongly Disagree.

Inclusion Criteria

The study included registered nurses who were actively working in the clinical units of the University of Ilorin Teaching Hospital during the period of data collection. Only nurses directly involved in patient care and who willingly consented to participate were included in the study.

Exclusion Criteria

Nurses working in non-clinical areas, including the School of Nursing and other academic units, were excluded from the study. Heads of departments, ward managers, and senior nursing administrators who had reached the peak of their professional careers were also excluded, as they were not the primary target population for the study.

Validity of the Research Instrument

The research instrument underwent face and content validity to ensure that it adequately measured the intended constructs. Face validity was established through the review of the questionnaire by two experts in nursing anaesthesia and nursing education, who assessed its clarity, relevance, and appropriateness.

Content validity was established through evaluation by a nurse anaesthetist and the research supervisor to ensure that the questionnaire adequately covered the study objectives and variables. Their recommendations were incorporated before the final administration of the instrument.

Reliability of the Research Instrument

The reliability of the instrument was assessed using Cronbach's Alpha to determine the internal consistency of the questionnaire items.

Although a pilot study was not conducted due to the movement restrictions associated with the COVID-19 pandemic, reliability analysis was performed using the data obtained from the main study. This provided an empirical assessment of the internal consistency of the research instrument.

Data Collection Procedure

Ethical approval was obtained from the Ethics Review Committee of the University of Ilorin Teaching Hospital before the commencement of the study.

Data were collected over a four-week period by the researcher with the assistance of two trained research assistants. Owing to the COVID-19 movement restrictions, the questionnaire was converted into a Google Form and distributed electronically through WhatsApp and Telegram platforms used by nurses working at the University of Ilorin Teaching Hospital.

Data Analysis

Data were analysed using descriptive and inferential statistics. Descriptive statistics, including frequencies, percentages, and tables, were used to summarize and present the data clearly. Inferential statistics (Chi-square test) were used to examine the relationships between selected variables, including age and awareness, as well as gender and willingness towards the nursing anaesthesia programme. Statistical significance was determined at a 5% level of significance ($p < 0.05$).

Ethical Considerations

Ethical approval was obtained from the Ethics Review Committee of the University of Ilorin Teaching Hospital, Ilorin, Kwara State. Informed consent was obtained electronically from all participants before data collection. Participation was entirely voluntary, and respondents were assured of confidentiality and anonymity. The information obtained was used solely for research purposes, and participants were treated with dignity, respect, and fairness throughout the study.

RESULTS

Response Rate

Due to the movement restrictions imposed during the COVID-19 pandemic, the originally planned method of physically distributing questionnaires was discontinued. Instead, the research instrument was converted into a Google Form and distributed electronically through WhatsApp and Telegram platforms accessible to eligible respondents.

A total of 296 responses were received during the four-week data collection period. Following data screening, 261 responses were found to be complete, non-duplicated, and suitable for analysis. This represents 88.2% of the total responses received and corresponds to the calculated sample size for the study. The remaining 35 responses (11.8%) were excluded from the analysis due to incomplete submissions and duplicate entries.

Table 1:0 Response Rate of Respondents

Description	Frequency	%age (%)
Questionnaires Retrieved	296	100
Valid questionnaire Analyzed	261	88.2
Excluded Questionnaires	35	11.8

Table 2.0 Socio- Demographic characteristics of respondents (n = 261)

Variables	Category	Frequency (n)	Percentage (%)
Age (Yrs.)	20 -29	39	14.9
	30-39	81	31.0
	40-49	93	35.6
	> 50	48	18.4
Gender	F	212	81.2
	M	43	16.5
	Not disclose	6	2.3
Marital Status	Married	235	90.0
	Single	20	7.7
	Widowed	6	2.3
Years of Service	1-10yrs	71	27.2
	11-20yrs	115	44.1
	21-30yrs	57	21.8
	31-35yrs	18	6.9

The socio-demographic characteristics of the respondents were analysed based on age, gender, marital status, and years of service.

Age Distribution

The findings showed that respondents aged 40–49 years constituted the largest proportion of the study population, accounting for 93 (35.6%) respondents. This was followed by those aged 30–39 years, who comprised 81 (31.0%) respondents. Respondents aged 50 years and above accounted for 40 (15.3%), while those aged 20–29 years constituted 39 (14.9%) of the respondents. The mean age of the respondents was 39.5 years.

Gender Distribution

The majority of the respondents were female, accounting for 212 (81.2%), while 43 (16.5%) were male. A further 6 (2.3%) respondents did not disclose their gender.

Marital Status

Most of the respondents were married, representing 235 (90.0%) of the study population. Single respondents accounted for 20 (7.7%), while 6 (2.3%) respondents were widowed.

Years of Service

With respect to years of service, the largest proportion of respondents, 115 (44.1%), had 11–20 years of service. This was followed by 71 (27.2%) respondents with 1–10 years of service, 57 (21.8%) respondents with 21–30 years of service, and 18 (6.9%) respondents with 31–35 years of service. The mean years of service among the respondents was 19.9 years.

Table 3.0. showing the response rate for knowledge (awareness) of respondents on nursing anaesthesia programme

Knowledge	Frequency (n)	Percentage (%)
Accurate knowledge	924	70.8
Inaccurate knowledge	381	29.2
Total	1305	100

A total of 1,305 responses were obtained from the five knowledge items assessing respondents' awareness of the nursing anaesthesia programme. Of these, 924 (70.8%) represented accurate knowledge, while 381 (29.2%) indicated inaccurate knowledge.

Table 3.1 Respondents knowledge on nursing anaesthesia programme

Variables	Frequency (n)	Percentage (%)	Cumulative Frequency
Anesthesia a specialty in nursing			261 (100.0)
Yes	240	92.0	240
Not Sure	12	4.6	252
No	9	3.4	261
Knowledge on existence of the course in nursing anaesthesia			
Yes	230	88.1	230
Not sure	12	4.6	242
No	19	7.3	261
Awareness On existence of post basic nursing anaesthesia programme			
Yes	235	90.1	235
Not Sure	9	3.4	244
No	17	6.5	261
A nurse anaesthetist is a nurse trained to administer anaesthesia			
Yes	203	77.8	203
Not Sure	43	16.5	246
No	15	5.7	261
A nurse anaesthetist is a nurse Who assist physician anaesthetist			
Yes	16	6.1	16
Not sure	15	5.7	31
No	230	88.1	261

The findings revealed a generally high level of awareness of the nursing anaesthesia programme among the respondents. The majority of respondents, 240 (92.0%), correctly identified nursing anaesthesia as a specialty in nursing. Similarly, 230 (88.1%) reported being aware of the availability of nursing anaesthesia courses, while 235 (90.0%) indicated awareness of post-basic nursing anaesthesia programmes.

Regarding knowledge of the role of nurse anaesthetists, 203 (77.8%) of the respondents correctly identified a nurse anaesthetist as a nurse specially trained to administer anaesthesia. However, 16 (6.1%) respondents incorrectly identified a nurse anaesthetist as a nurse who assists a physician anaesthetist. These findings suggest that, although respondents generally demonstrated a high level of awareness of the nursing anaesthesia programme, some misconceptions regarding the professional role of nurse anaesthetists still exist.

Response rate for attitude towards nursing anaesthesia programme: Table 4.0., 4.1.1 & 4.1.2 shows respondents' attitude towards nursing anaesthesia programme.

This section comprises questions designed to assess respondents' attitudes toward the nursing anaesthesia programme, particularly their willingness to enroll in the programme and their perceptions of the opportunities and career prospects associated with it. The responses provide insight into the extent to which these perceived opportunities influence respondents' willingness to pursue specialization in nursing anaesthesia.

Table 4.0. Shows response rate of attitude towards nursing anaesthesia programme.

ATTITUDE (WILLINGNESS)	FREQUENCY (n)	PERCENTAGE (%)
Positive attitude	1380	88.1
Negative attitude	186	11.9
Total score	1566	100

A total of 1,566 responses were obtained from the attitude items assessing respondents' willingness to enroll in the nursing anaesthesia programme. Of these, 1,380 (88.1%) reflected a positive attitude, indicating respondents' willingness to enroll in the programme, while 186 (11.9%) reflected a negative attitude, indicating unwillingness to enroll.

TABLE 4.1.1. Shows respondents attitude (willingness) towards enrollment for nursing anaesthesia programme

Variables	Frequency (f)	Percentage (%)	Cumulative Frequency
Are you specialized?			
Yes	188	72%	188
No	73	28%	261
Do you think that Nursing anaesthesia programme can offer you another opportunity for specialization			
Yes	249	95.4%	249
No	8	3.1%	257
Not sure	4	1.5%	261
Do you think Nursing anaesthesia can gives you job satisfaction?			
Yes	219	84%	219
No	29	11%	248
Not sure	13	5%	261

The findings revealed that 188 (72.0%) of the respondents possessed one or more post-basic nursing specialties, while 73 (28.0%) had no post-basic nursing specialty. Furthermore, 249 (95.4%) of the respondents believed that the nursing anaesthesia programme would provide an additional opportunity for specialization, whereas 8 (3.1%) did not share this opinion and 4 (1.5%) were unsure.

Regarding job satisfaction, 219 (84.0%) of the respondents believed that the nursing anaesthesia programme could enhance job satisfaction, while 29 (11.0%) disagreed and 13 (5.0%) were uncertain.

Table 4.1.2: Opportunities that Nursing Anesthesia programme provides related the respondents willingness towards nursing anaesthesia programme

Variables	Strongly Agreed	Agreed	Strongly Disagreed	Disagreed
	N(%)	N(%)	N(%)	N(%)
Professional Advancement	207 (79.3)	51 (19.5)	2 (0.8)	1 (0.4)
Independent & Collaborative Practice	15 (5.7)	221 (84.7)	10 (3.8)	15 (5.7)
Increase in Salary & Allowance	132 (50.6)	98 (37.5)	22 (8.4)	9 (3.4)

The findings presented in Table 4.1.2 revealed that 207 (79.3%) of the respondents strongly agreed and 51 (19.5%) agreed that the nursing anaesthesia programme provides opportunities for professional advancement. In contrast, 2 (0.8%) strongly disagreed and 1 (0.4%) disagreed with this statement.

Regarding independent and collaborative practice, 15 (5.7%) of the respondents strongly agreed, while the majority, 221 (84.7%), agreed that the nursing anaesthesia programme promotes independent and collaborative practice. Conversely, 10 (3.8%) strongly disagreed and 15 (5.7%) disagreed.

Furthermore, 132 (50.6%) of the respondents strongly agreed and 98 (37.5%) agreed that the nursing anaesthesia programme could lead to increased salary and allowances. However, 22 (8.4%) strongly disagreed and 9 (3.4%) disagreed with this assertion.

Overall, the findings indicate that the majority of the respondents were already specialized in one or more post-basic nursing fields and perceived the nursing anaesthesia programme as an avenue for further specialization and improved job satisfaction.

Decision Rule for the Four-Point Likert Scale

A four-point Likert scale was used to assess respondents' attitudes towards the nursing anaesthesia programme. The response options were assigned the following scores: Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. The mean score for each questionnaire item was computed based on these assigned values.

The criterion mean was calculated as follows:

$$\left[\frac{4 + 3 + 2 + 1}{4} = 2.50 \right]$$

Therefore, a mean score of 2.50 or above was interpreted as agreement (positive perception/attitude), while a mean score below 2.50 was interpreted as disagreement (negative perception/attitude).

Table 4.1.3. Showing likert scale decision interpretation

Mean/Range	Interpretation
3.26 – 4.00	S.A (Very High)
2.51 – 3.25	A (High)
1.76 – 2.50	D (Low)
1.00 – 1.75	SD (Very Low)

The findings of this study indicate that respondents perceived the nursing anaesthesia programme as offering substantial professional and economic benefits. Specifically, respondents strongly agreed that the programme provides opportunities for professional advancement, as reflected by a mean score of 3.78. Similarly, respondents agreed that the programme promotes independent and collaborative practice, with a mean score of 2.90. In addition, respondents strongly agreed that specialization in nursing anaesthesia is associated with increased salary and allowances, as indicated by a mean score of 3.35.

The overall grand mean score of 3.34 demonstrates a highly positive perception of the opportunities and benefits associated with the nursing anaesthesia programme among the respondents.

Table 5.1 and 5.1.2 shows respondents' reasons for low enrollment to nursing anaesthesia programme

Table 5:1 Reasons for Low Enrolment to Nursing Anesthesia Programme

Variables	Frequency (F)	% Age	Cum. Frq.	Ranking
Financial Constraints	95	36.4	95	1 st
Lack of Flexible Entry Point	64	24.5	159	2 nd
Distance of Training Institution	34	13.0	193	3 rd
Family Issue	29	11.1	222	4 th
Reference for University sited Programme	13	5.0	235	5 th
Lack of Motivation	13	5.0	248	6 th
Lack of Sponsorship	8	3.1	256	7 th
Lack of Information	5	1.9	261	8 th

The findings revealed that respondents identified several barriers to enrollment in the nursing anaesthesia programme. Financial constraints emerged as the most frequently reported barrier, identified by 95 (36.4%) respondents, making it the

highest-ranked barrier. This was followed by the lack of flexible entry pathways, reported by 64 (24.5%) respondents. The distance of training institutions and family-related issues were also identified as notable barriers by 34 (13.0%) and 29 (11.1%) respondents, respectively.

Other less frequently reported barriers included lack of motivation and preference for university-based programmes, each identified by 13 (5.0%) respondents, while lack of sponsorship was reported by 8 (3.1%) respondents. The least frequently reported barrier was lack of information, identified by 5 (1.9%) respondents. Overall, the findings suggest that financial and structural factors were the predominant barriers influencing enrollment in the nursing anaesthesia programme.

Table 5.1.2: Perceived Reasons for Fewer Nurse Anesthetist

Variables	Frequency (F)	%	Rank
Preference for Locally Available programme	143	54.8	1 st
Lack of Understanding of Role & Duties of nurse anaesthetists	47	18.0	2 nd
Misinformation about nursing anaesthesia programme	38	14.6	3 rd
Lack of Interest in the programme	33	12.6	4 th
	261	100.0	-

The findings revealed that the low number of nurse anaesthetists was primarily attributed to a preference for locally available programmes, as reported by 143 (54.8%) respondents, making it the highest-ranked contributing factor. This was followed by a lack of understanding of the roles and responsibilities of nurse anaesthetists, reported by 47 (18.0%) respondents. In addition, misinformation about nursing anaesthesia was identified by 38 (14.6%) respondents, while lack of interest in the specialty was reported by 33 (12.6%) respondents. Overall, the findings suggest that preference for locally available programmes, limited awareness of the nurse anaesthetist's role, and misconceptions about the specialty were the major factors contributing to the low number of nurse anaesthetists.

Table 6.0: Shows suggestion on ways to motivate nurses toward pursuing a career in anesthesia.

Variable	Strongly Agree n (%)	Agree n (%)	Disagree n (%)	Strongly disagree n (%)
Do you think increasing the number of post basic nursing anesthesia schools will facilitate nurses' interest to anesthesia Programme	149 (57.1)	103 (39.)	6 (2.3)	3 (1.1)
Giving incentive, study leave And/or sponsorship will motivate Nurses toward pursuing a career In anesthesia	153 (58.7)	88 (33.7)	17 (6.5)	3 (1.1)
Denying of approval for nurses from going for courses where there are so many specialist nurse to go nursing anesthesia programme	55 (21.1)	79 (30.3)	106 (40.6)	21 (8.0)
Raising the qualification of post Basic nursing anesthesia to Master's degree in Nigerian will Raise interest and encourage enrollment in nursing anesthesia programme	139 (53.3)	110 (42.1)	10 (3.8)	2 (0.8)
Posting and rotation of nurses to Anesthesia department will	120 (46.0)	128 (49.0)	10 (3.8)	3 (1.1)

Motivate nurses to pursue a Career in nursing anesthesia				
Inclusion of nursing anesthesia At in-service training level will Promote interest to nursing Anesthesia programme	107 (41.0)	144 (55.2)	9 (3.4)	1 (0.4)
Mentoring of junior nurse about post basic nursing anesthesia programme will promote nursing anesthesia specialty among nursing in UITH	132 (50.6)	110 (42.1)	18 (6.9)	1 (0.4)

Likert scale interpretation

Item	Mean	Decision
Increase training schools	3.52	Strongly agree
Incentives/sponsorship	3.50	Strongly agree
Master's degree upgrading	3.45	Strongly agree
Posting to anaesthesia unit	3.40	Strongly agree
Mentorship of junior nurses	3.43	Strongly agree
In-service training inclusion	3.36	Strongly agree
Denying approval for other specialty	2.73	Agree
Grand mean = 3.34		

The findings of this study revealed strong agreement among respondents on several strategies that could improve enrollment into the nursing anaesthesia programme. The suggestion to increase the number of post-basic training schools for nurse anaesthetists (mean = 3.52) received very strong support. Provision of incentives and sponsorship (mean = 3.50) was also highly supported. The suggestion to upgrade the nursing anaesthesia programme to MSc degree level (mean = 3.45) also received strong agreement, respondents strongly supported posting nurses to anaesthesia departments (mean = 3.40) and mentorship of junior nurses (mean = 3.43). The inclusion of nursing anaesthesia in in-service training programmes (mean = 3.36) was also strongly supported,

However, the suggestion to deny approval for specialty training to certain categories of nurses (mean = 2.73) was less supported, falling within the "Agree" range.

HYPOTHESES TESTING

HYPOTHESIS 1: H_A : There is a significant relationship between age and awareness level(knowledge) towards nursing anaesthesia programme.

Table 7.0., 7.1 & 7.2 shows data analysis for hypothesis 1 testing.

Table 7.0 showings data for hypothesis 1

Awareness level (knowledge)	01	01	02	02	03	03	04	04	05	05	Total Yes	Total No/ Not sure
	Yes	No/no t sure	Yes	No/no t sure	Yes	No/n ot sure	Yes	No/no t sure	Yes	No/n ot sure		
Age group												
20 – 29	32	7	26	13	30	9	18	21	4	33	110	83
30 – 39	80	1	78	3	81	0	70	11	5	77	314	92
40 – 49	89	4	82	11	86	7	80	13	5	90	342	125

50 and above	39	9	44	4	38	10	35	13	2	45	158	81
	240	21	230	31	235	26	203	58	16	230	924	381

Table 7.1 showing continuation of data for hypothesis 1

Awareness level	Correct knowledge		Incorrect knowledge		Total
	Observed (O _a)	Expected (E _a)	Observed (O _i)	Expected (E _i)	
Age group					
20 – 29	110	136.6	83	56.3	193
30 – 39	314	287.5	92	118.5	406
40 – 49	342	330.7	125	136.3	467
50 and above	158	169.2	81	69.8	239
	924		381		1305

Table 7.2. Showing calculation for chi square statistical analysis for hypothesis 1

O _T = O _a & O _i	E _T = E _a & E _i	O-E	(O-E) ²	(O-E) ² /E
110	136.6	-26.6	707.6	5.18
314	287.5	-26.5	702.3	2.44
342	330.7	11.3	127.7	0.39
158	169.2	-11.2	125.4	0.74
83	56.3	26.7	712.9	12.7
92	118.5	-26.5	702.3	5.93
125	136.3	-11.3	127.7	0.94
81	69.8	11.2	125.4	1.80

The Chi-square statistic was calculated using the following formula:

$$[\chi^2 = \sum \frac{(O - E)^2}{E}]$$

where:

O = Observed frequency

E = Expected frequency

The calculated Chi-square (χ^2) value was 30.12.

The degree of freedom (df) was determined using the formula:

$$[df = (R - 1)(C - 1)]$$

where:

R = Number of rows

C = Number of columns

Thus,

$$[df = (4 - 1)(4 - 1) = 3 \times 3 = 9]$$

At a 0.05 level of significance, the critical Chi-square value for 9 degrees of freedom is 16.919. Since the calculated Chi-square value (30.12) is greater than the critical value (16.919), the null hypothesis was rejected, and the alternative hypothesis was accepted.

This indicates that there is a statistically significant relationship between age and the level of awareness of the nursing anaesthesia programme among staff nurses at the University of Ilorin Teaching Hospital ($\chi^2 = 30.12$, $df = 9$, $p < 0.05$).

HYPOTHESIS 2: There is a significant relationship between gender and willingness towards enrollment for nursing anaesthesia programme.

Table 8.0, 8.1 & 8.2 show data analysis for hypothesis 2 testing

Table 8.0 showing data for hypothesis 2

Attitude (willingness)	O1 Yes / SA /A	O1 No/ Not sure/ SD/ D	O2 Yes/S A/A	O2 Yes/No/ Not sure/SD /D	O3 Yes / SA /A	O3No/ Not sure/ SD/D	O4 Yes / SA /A	O4 No/ Not sure/ SD/ D	O5 Yes / SA /A	O5 No/ Not sure/ SD/ D	O6 Yes / SA /A	O6 No/ Not sure/ SD/ D
MALE	34	9	40	4	37	6	42	0	41	2	42	1
FEMALE	150	62	206	7	178	34	210	2	190	22	183	29
NOT DISCLOSED	4	2	3	1	4	2	6	1	5	1	5	1
TOTAL	188	73	249	12	219	42	258	3	236	25	230	31

Table 8.1. Showing continuation of data for hypothesis 2 testing

Willingness	Positive Attitude		Negative Attitude		Total
Gender	Observed Variable (O _p)	Expected Variable (E _p)	Observed Variable (O _n)	Expected Variable (E _n)	
Male	236	227.4	22	30.6	258
Female	1117	1121.8	156	151.2	1273
Not Disclosed	27	30.8	8	4.2	35
Total	1380		186		1566

Table 8.2. Shows chi square statistical analysis for hypothesis 2

O _t =O _p +O _n	E _t = E _p +E _n	O-E	(O-E) ²	(O-E) ² /E
236	227.4	8.6	73.96	0.32
1117	1121.8	-4.8	23.04	0.02
27	30.8	-3.8	14.44	0.47
22	30.6	-8.6	73.96	2.42
156	151.2	4.8	23.04	0.15
8	4.2	3.8	14.44	3.44

The Chi-square statistic was calculated using the following formula:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

where:

O= Observed frequency

E= Expected frequency

The calculated Chi-square (χ^2) value was 6.82.

The degree of freedom (df) was determined using the formula:

$$df = (R - 1)(C - 1)$$

where:

R = Number of rows

C= Number of columns

Thus,

$$df = (3 - 1)(4 - 1) = 2 \times 3 = 6$$

At a 0.05 level of significance, the critical Chi-square value for 6 degrees of freedom is 12.592. Since the calculated Chi-square value (6.82) is less than the critical value (12.592), the alternative hypothesis was rejected, and the null hypothesis was accepted.

Therefore, there is no statistically significant relationship between gender and willingness to enroll in the nursing anaesthesia programme among staff nurses at the University of Ilorin Teaching Hospital ($\chi^2 = 6.82$, $df = 6$, $p > 0.05$).

Standard Interpretation of Cronbach's Alpha

≥ 0.90 .	Excellent and high staking
0.80 – 0.89.	Good
0.70 – 0.79.	Acceptable
0.60 – 0.69.	Questionable
0.50 – 0.59.	Poor
< 0.50 .	Unacceptable

Reliability Analysis

Knowledge about Nursing anaesthesia programme	0.56
Attitude towards nursing anaesthesia programme.	0.65
Reasons for low enrollment of nurses into anaesthesia programme.	0.40
Suggestions	0.81

The reliability of the research instrument was assessed using Cronbach's alpha coefficient to determine the internal consistency of the questionnaire. The knowledge domain yielded a Cronbach's alpha coefficient of 0.56, indicating poor internal consistency. The attitude domain produced a coefficient of 0.65, indicating questionable internal consistency. Similarly, the domain assessing reasons for the low enrollment of nurses into the nursing anaesthesia programme yielded a coefficient of 0.40, indicating unacceptable internal consistency. In contrast, the suggestions domain demonstrated a Cronbach's alpha coefficient of 0.81, indicating good internal consistency.

DISCUSSION OF FINDINGS

This chapter discusses the findings of the study on the knowledge and attitude of staff nurses towards the nursing anaesthesia programme at the University of Ilorin Teaching Hospital, Ilorin. The discussion is presented in line with the study objectives and hypotheses. Specifically, it focuses on the socio-demographic characteristics of the respondents, their knowledge of the nursing anaesthesia programme, their attitude and willingness to enroll in the programme, perceived barriers to enrollment, strategies for improving enrollment, the hypotheses tested, and the reliability of the research instrument. The findings are discussed in relation to relevant empirical literature and the theoretical framework underpinning the study.

Socio-demographic Characteristics of the Respondents

The findings revealed that the mean age of the respondents was 39.5 years, with the largest proportion of respondents (33.3%) falling within the mid-career age group. This finding suggests that the nursing workforce at the University of Ilorin Teaching Hospital comprises predominantly experienced professionals who are at a stage in their careers where specialization and professional advancement are likely to be considered. Nurses within this age group possess substantial clinical experience, which may positively influence their readiness to pursue advanced specialty training such as nursing anaesthesia.¹

The study also revealed that the nursing workforce was predominantly female, which reflects the long-established gender distribution within the nursing profession globally. This finding is consistent with Adeleke (2010), who reported that nursing in Nigeria remains a female-dominated profession. The predominance of female nurses may have implications for career progression, particularly where family commitments, marital responsibilities, and geographical mobility influence decisions regarding enrolment into specialty programmes. Adeleke (2010) further observed that competing family responsibilities and gender-related challenges may limit opportunities for professional advancement among nurses.¹

Furthermore, approximately 90% of the respondents were married. This finding suggests that family obligations may influence decisions regarding postgraduate education and specialty training, particularly where such programmes require relocation or prolonged periods of study.^{1,19} Similar observations have been reported by Haron (2014), who identified family responsibilities as one of the factors influencing nurses' career choices and professional development.⁴

With respect to years of service, the respondents had a mean duration of service of 20.5 years, indicating that the majority were moderately to highly experienced nurses with considerable clinical exposure. Such experience may contribute to better

appreciation of specialty nursing roles and the importance of professional development. Experienced nurses are generally more capable of evaluating career opportunities based on professional autonomy, job satisfaction, and long-term career prospects.^{5,10}

Overall, the socio-demographic profile of the respondents suggests a mature and experienced nursing workforce with substantial potential for specialization. However, personal and structural factors, including marital responsibilities and accessibility of training institutions, may influence the decision to enroll in specialty programmes such as nursing anaesthesia.^{1,2}

Respondents Knowledge of nursing anaesthesia programme

This study demonstrated a high level of awareness of the nursing anaesthesia programme among staff nurses. Specifically, 92.0% of respondents correctly identified nursing anaesthesia as a recognized nursing specialty, indicating substantial awareness of the programme. Nevertheless, gaps remained in respondents' understanding of the specific roles and responsibilities of nurse anaesthetists, suggesting that general awareness does not necessarily translate into comprehensive knowledge of the specialty.

The findings are consistent with previous reports indicating that nurses are increasingly aware of specialty nursing programmes but often have limited understanding of their scope of practice and professional responsibilities.¹ Similarly, the American Association of Nurse Anesthetists emphasized that continuous professional education and role clarification are essential for strengthening nurses' understanding of the specialty and promoting professional identity.^{7,8,9} The observed knowledge gaps may therefore reflect limited exposure to structured information regarding the educational requirements, scope of practice, and career opportunities available in nursing anaesthesia.^{2,5}

The significant association observed between age and awareness further suggests that awareness of the nursing anaesthesia programme increases with professional maturity and clinical experience. Older nurses are more likely to have participated in continuing professional development activities and to have interacted with nurse anaesthetists in clinical practice, thereby increasing their awareness of the specialty. This finding is consistent with previous studies that identified professional experience as an important determinant of awareness of specialty nursing programmes and opportunities for career advancement.^{1,5}

The findings also lend support to the Theory of Cognitive Dissonance, which proposes that acquisition of new knowledge can influence attitudes and subsequent behaviour by reducing inconsistencies between existing beliefs and newly acquired information.²⁰ Consequently, improving nurses' knowledge of the nursing anaesthesia programme through continuing professional education, seminars, workshops, and institutional awareness campaigns may enhance positive perceptions of the specialty and encourage greater interest in enrollment.^{1,2}

Discussion of Hypothesis One

The first hypothesis examined the relationship between respondents' age and their level of awareness of the nursing anaesthesia programme. The Chi-square analysis demonstrated a statistically significant relationship between age and awareness among staff nurses at the University of Ilorin Teaching Hospital ($\chi^2 = 30.12$, $df = 9$, $p < 0.05$). Since the calculated Chi-square value exceeded the critical value, the null hypothesis was rejected, while the alternative hypothesis was accepted.

The finding suggests that respondents' age significantly influenced their level of awareness of the nursing anaesthesia programme. Older and more experienced nurses are likely to have had greater exposure to professional practice, continuing education activities, and interactions with nurse anaesthetists, thereby enhancing their awareness of the specialty. Conversely, younger nurses may have had fewer opportunities for such exposure.

This finding is consistent with previous studies, which reported that professional experience and years of service contribute significantly to nurses' awareness of specialty nursing programmes and opportunities for career advancement.^{1,5} The implication is that awareness programmes should target nurses across all age groups, particularly those in the early stages of their careers, to facilitate informed career decisions and encourage enrollment in the nursing anaesthesia programme.^{4,10,13-}

Respondents attitude towards nursing anaesthesia programme

Respondents demonstrated a positive attitude towards the nursing anaesthesia programme, with 88.1% expressing a favourable attitude and willingness to enroll in the programme. Furthermore, respondents perceived the programme as providing opportunities for professional advancement, greater professional autonomy through independent and collaborative practice, and improved remuneration. These findings suggest that nurses recognize nursing anaesthesia as a viable career pathway with substantial professional and economic benefits.

The positive attitude observed in this study is consistent with previous findings that nurses generally exhibit favourable attitudes towards professional development and specialization when opportunities for career advancement, job satisfaction, and professional recognition are evident.^{4,5} Similarly, improved professional autonomy and expanded clinical responsibilities have been identified as important factors that enhance nurses' motivation to pursue advanced specialty training.^{15,16} The high level of willingness to enroll observed in the present study may therefore reflect respondents' recognition of the professional and financial advantages associated with the nursing anaesthesia programme.⁶

Despite the favourable attitude, enrollment in the nursing anaesthesia programme remains relatively low, suggesting that positive attitudes alone may not translate into actual enrollment. This disparity indicates that external barriers, including financial constraints, limited training opportunities, and accessibility challenges, may hinder nurses from pursuing the programme despite their willingness. Similar observations have been reported in previous studies, which identified institutional and financial barriers as significant obstacles to professional advancement among nurses.^{2,12-15}

Hypothesis Two

The second hypothesis examined the relationship between gender and willingness to enroll in the nursing anaesthesia programme. Chi-square analysis revealed no statistically significant relationship between gender and willingness to enroll ($\chi^2 = 6.82$, $df = 6$, $p > 0.05$). Consequently, the null hypothesis was accepted, indicating that willingness to pursue the nursing anaesthesia programme did not differ significantly between male and female nurses.

This finding suggests that gender was not a determining factor in respondents' willingness to specialize in nursing anaesthesia, as both male and female nurses expressed comparable levels of interest in the programme. The favourable attitude and willingness to enroll observed among respondents appear to be influenced more by perceived professional benefits, career advancement opportunities, increased autonomy, anticipated job satisfaction, and improved remuneration than by gender. This indicates that both male and female nurses are equally receptive to pursuing the nursing anaesthesia programme when enabling conditions are available.

The finding is consistent with previous studies, which reported that career decisions among nurses are primarily influenced by professional aspirations, institutional support, and opportunities for advancement rather than gender. Although the nursing profession remains predominantly female, willingness to pursue specialty training depends more on the availability of supportive policies, financial assistance, flexible training opportunities, and institutional support than on demographic characteristics.^{1,6,12-16}

The findings also support the Theory of Operant Conditioning, which proposes that behaviour is influenced by its consequences.⁶ The positive attitudes demonstrated by respondents may be explained by the anticipated rewards associated with specialization, including professional advancement, increased autonomy, enhanced remuneration, and greater job satisfaction. These anticipated outcomes serve as positive reinforcers that can motivate nurses to pursue specialty training in nursing anaesthesia.^{6,20}

The implication of this finding is that interventions aimed at increasing enrollment in the nursing anaesthesia programme should not be gender specific. Instead, efforts should focus on addressing modifiable structural and institutional barriers, including financial constraints, limited training capacity, inadequate awareness of the specialty, and restricted access to accredited training institutions. Addressing these barriers is more likely to improve enrollment among both male and female nurses than interventions based on gender differences.^{2,12-16}

Reasons for Low Enrollment in the Nursing Anaesthesia Programme

Although respondents demonstrated a favourable attitude and willingness to enroll in the nursing anaesthesia programme, several barriers were identified that may limit actual enrollment. Financial constraints emerged as the most frequently reported barrier, followed by lack of flexible entry pathways, distance to training institutions, and family-related responsibilities. These findings suggest that economic and structural challenges are the primary factors limiting nurses' participation in the programme.^{1,2,19}

The prominence of financial constraints indicates that the cost of tuition, accommodation, transportation, and other training-related expenses may discourage nurses from pursuing specialization in nursing anaesthesia. Similar findings have been reported among nurses undertaking advanced professional education, where inadequate financial support and limited sponsorship opportunities were identified as major barriers to career progression.^{1,2} The findings also align with reports from the World Health Organization, which recognized inadequate investment in health workforce education and training as a significant challenge to strengthening the anaesthesia workforce in low-resource settings.¹²

The identification of limited entry pathways and the geographical location of training institutions further highlight the influence of institutional accessibility on enrollment decisions. Restricted availability of training centres may increase the financial and logistical burden associated with specialty education, thereby reducing participation. Comparable findings have been reported in studies demonstrating that the availability and geographical distribution of training institutions influence the production and retention of specialist nurses and anaesthesia providers.^{2,4,13,14,15} Similarly, evidence from Ghana showed that the location of nurse anaesthesia training schools significantly influenced the distribution of trained nurse anaesthetists across the country, with specialists more likely to practice in areas where training opportunities were available.¹⁹

Family-related responsibilities also emerged as an important consideration, suggesting that personal obligations may influence nurses' decisions to pursue specialty training. Balancing work commitments, family responsibilities, and academic demands may present additional challenges, particularly where programmes require relocation or prolonged periods of full-time study. Previous studies have similarly reported that personal and family responsibilities influence nurses' decisions regarding postgraduate education and professional specialization.^{1,4,5}

In addition to these barriers, respondents identified preference for locally available specialty programmes, limited understanding of the roles and responsibilities of nurse anaesthetists, misinformation about the specialty, and lack of interest as factors contributing to the low enrollment in the nursing anaesthesia programme. These findings indicate that enrollment is influenced not only by financial and structural barriers but also by knowledge and perception of the specialty. Similar observations have been reported, with career choice among nurses being influenced by programme accessibility, perceived career prospects, and understanding of specialty roles.^{4,10} Collectively, these findings suggest that improving enrollment will require interventions that address both structural barriers and educational gaps through increased investment in training capacity, financial support, and sustained professional awareness programmes.

Suggestions for Improving Enrollment in the Nursing Anaesthesia Programme

Respondents expressed strong support for several strategies aimed at improving enrollment in the nursing anaesthesia programme. The findings indicate that expanding training institutions, upgrading the programme to a master's degree, providing financial support, increasing clinical exposure to the specialty, and strengthening mentorship were perceived as effective approaches for enhancing enrollment.² These findings suggest that respondents recognized the need for institutional and policy reforms to improve access to specialty training.^{12,13}

The strong support for expanding training institutions reflects the need to improve geographical access to the programme and reduce barriers associated with the limited availability of training centres. This finding is consistent with recommendations by the World Health Organization, which emphasized the expansion of training capacity as a key strategy for strengthening the surgical and anaesthesia workforce, particularly in low- and middle-income countries.¹² Similarly, the Global Surgery 2030 Commission recommended increased investment in specialist health workforce education to improve access to safe surgical and anaesthesia services.¹³

Respondents also supported upgrading the nursing anaesthesia programme to a master's degree, suggesting that academic advancement and enhanced professional recognition could increase the attractiveness of the specialty. Higher educational qualifications are widely recognized as important drivers of career progression, professional autonomy, and leadership opportunities within the nursing profession. This finding is consistent with previous studies that reported that opportunities for academic and professional advancement positively influence nurses' decisions to pursue specialty education.^{4,14,15}

Financial assistance through scholarships, sponsorships, and institutional support was also identified as an important strategy for improving enrollment. This finding reinforces the observation that financial barriers remain a significant obstacle to specialty training and suggests that reducing the economic burden of education could increase participation in

the programme. Similar recommendations have been made by previous studies advocating increased investment in nursing education and workforce development to address shortages of specialist healthcare professionals.^{2,17,18}

Furthermore, respondents recognized clinical exposure and mentorship by practising nurse anaesthetists as important strategies for stimulating interest in the specialty. Increased exposure during clinical practice may improve understanding of the roles and responsibilities of nurse anaesthetists, thereby correct misconceptions and fostering informed career decisions. These findings support the Theory of Operant Conditioning, which proposes that behaviour is influenced by positive reinforcement.^{5,6} Institutional support, mentorship, professional recognition, and financial incentives may therefore serve as positive reinforcers that encourage nurses to pursue specialization in nursing anaesthesia.^{1,2,4,12,13} Interestingly, respondents did not support restricting access to other nursing specialty programmes as a strategy for increasing enrollment in nursing anaesthesia. This finding suggests that nurses favour policies that expand educational opportunities rather than those that limit professional choices. Consequently, interventions aimed at improving enrollment should focus on creating enabling environments through policy support, increased training opportunities, and financial assistance rather than restricting access to alternative specialties.^{2,5,11,12}

CONCLUSION

This study demonstrated that staff nurses at the University of Ilorin Teaching Hospital had a high level of awareness and a positive attitude towards the nursing anaesthesia programme. Respondents recognized the programme as an important pathway for professional advancement, increased autonomy, and improved remuneration. Despite these favourable perceptions, enrollment into the programme remains low because of financial constraints, limited training opportunities, inflexible entry pathways, geographical inaccessibility of training institutions, and misconceptions regarding the specialty. Addressing these barriers through institutional support, policy reforms, and improved access to training may enhance enrollment and contribute to the development of the nursing anaesthesia workforce in Nigeria.

IMPLICATIONS FOR NURSING PRACTICE AND POLICY

The findings have important implications for nursing education, workforce planning, and health policy. The positive attitude demonstrated by respondents indicates that nurses are receptive to specialization in nursing anaesthesia when appropriate support systems are available. Expanding training institutions, strengthening continuing professional education, improving awareness of the roles of nurse anaesthetists, and providing financial support through scholarships and sponsorship programmes may increase enrollment into the programme. These interventions could contribute to addressing the shortage of nurse anaesthetists and strengthening the capacity of the healthcare system to provide safe anaesthesia services.

STUDY LIMITATIONS

This study has some limitations that should be considered when interpreting the findings. The study was conducted in a single tertiary healthcare institution, which may limit the generalizability of the findings to other healthcare settings in Nigeria. In addition, a pilot study was not conducted before the main survey, which may have contributed to the relatively low internal consistency observed in some domains of the questionnaire, particularly the knowledge scale. Future studies should validate the instrument through pilot testing and include a larger and more diverse sample drawn from multiple institutions. The questionnaires were disseminated in Google forms via WhatsApp and telegram platform to the respondents, due to restrictive movement from COVID 19 pandemic and it may have introduced selection bias and consequently limited the generalizability of the findings to the entire nursing population. The use of different response formats within the same section introduced some measurement inconsistency and could limit the instrument's applicability in similar studies. Some sections also show poor construct in the questionnaires which contributed to the low internal consistency.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that healthcare institutions, nursing regulatory bodies, and policymakers should strengthen awareness programmes on the nursing anaesthesia specialty through continuing professional education, seminars, and workshops. Financial support mechanisms, including scholarships, sponsorships, and study leave, should be implemented to reduce barriers to specialty training. The number and geographical distribution of

nursing anaesthesia training institutions should be expanded to improve accessibility, while consideration should be given to upgrading the programme to the master's degree level to enhance professional recognition and career progression. Future research should involve multicentre studies with larger sample sizes and psychometrically validated instruments to provide more robust evidence on factors influencing enrollment in the nursing anaesthesia programme.

FUNDING

This work received no funding.

DECLARATION OF COMPETING INTEREST

The authors declare that this manuscript is original, has not been published previously in any journal or other publication, and is not currently under consideration for publication elsewhere. Furthermore, the work has not been presented at any conference, seminar, or workshop.

The authors declare that there are no conflicts of interest, financial or otherwise, related to this research. No external funding or financial grant was received for this study. The corresponding author solely funded the research and was responsible for all associated expenses.

Ethical approval for this study was obtained from the Health Research Ethics Committee of the University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria, prior to the commencement of the research.

AUTHORS' CONTRIBUTIONS

Corresponding author

Racheal O. OYELUDE is the primary author responsible for data sourcing, data collation, writing of the research work, editing and funding of this research. A Chief Nursing Officer from the Anaesthesia Unit, department of Nursing Services, University of Ilorin Teaching Hospital, Kwara state, Nigeria, was a student at School of Post Basic Nursing Anaesthesia Jos University Teaching Hospital, Plateau State Nigeria at the time of conducting this research. 2019-2021.

Second author

Chuang B. Zi was the supervising lecturer for this project, a visiting lecturer, school of post basic nursing anaesthesia, Jos University Teaching Hospital, plateau State, Nigeria. He supervised, edited and reviewed the work.

Third author

Phillip Ojo a lecturer from the college of Nursing, University College Hospital, Ibadan, Oyo State, Nigeria. He is a Registered Nurse Anaesthetist who assisted with reviewing and editing of the research work.

REFERENCES

1. Adeleke AO. The challenges of best practice and standards in nursing in Nigeria. Okada (Nigeria): Igbinedion University Press Ltd; 2010.
2. Golf T, Yunusa U, Olatunbi MI, Ahmed S, Suleiman D, Dathimi H. Appraisal of barriers and facilitators associated with advanced professional education among nurses in Adamawa State, Nigeria. *Int J Educ Res Inf Sci*. 2015;2(4):102-107.
3. Gilanie G. Knowledge and its types. Bahawalpur (Pakistan): Islamia University of Bahawalpur; 2022. Available from: <https://www.researchgate.net>. Accessed 2022 Oct.
4. Haron Y, Reichert S, Riba S. Factors influencing nursing career choices and choice of study programme. *Health Mark Q*. 2014;31(2):167-177. doi:10.1080/07359683.2014.907126.
5. Uba SC, Zi CB. Attitude of nurses towards professional development for improved service delivery at the Jos University Teaching Hospital. *Texila Int J Nurs*. 2019;5(1-2).
6. McLeod SA. Skinner: operant conditioning. *Simply Psychology*. 2018. Available from: <https://www.simplypsychology.org/operant-conditioning.html>. Accessed 2026 Jul 24.
7. American Association of Nurse Anesthetists. Scope and standards of nurse anesthetist practice. Park Ridge (IL): American Association of Nurse Anesthetists; 2013. Available from: <https://www.aana.com>
8. American Association of Nurse Anesthetists. Professional attributes of the nurse anesthetist. Park Ridge (IL): American Association of Nurse Anesthetists; 2016. Available from: <https://www.aana.com>
9. American Association of Nurse Anesthetists. What is nurse anesthesia? Park Ridge (IL): American Association of Nurse Anesthetists; 2018. Available from: <https://www.aana.com>
10. Khan FA, Hamdani GA. Factors influencing the choice of anaesthesia as a career in a developing country. *Middle East J Anaesthesiol*. 2007;19(1):149-157.

11. Fente BG, Ouserigba OE. Experience working with nurse anaesthetists as non-physician anaesthesia providers in a semi-urban Niger Delta University Teaching Hospital, Okolobiri: a review of the literature. *Niger J Med.* 2013;22(1):36-40.
12. World Health Organization. Surgical care systems strengthening: developing national surgical, obstetric and anaesthesia plans. Geneva: World Health Organization; 2017. Available from: <https://iris.who.int/handle/10665/255566>
13. Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, et al. Global surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet.* 2015;386(9993):569-624.
14. Dubowitz G, Detlefs S, McQueen KA. Global anesthesia workforce crisis: a systematic review. *Anesth Analg.* 2014;118(5):1005-1010.
15. Kempthorne P, Morris WW, Møtting-Olsen J, Gore-Booth J. Global anesthesia workforce survey. *Anesth Analg.* 2017;125(3):981-990. doi:10.1213/ANE.0000000000002258.
16. Bharati SJ, Chowdhury T, Gupta N, et al. Anaesthesia in underdeveloped world: present scenario and future challenges. *Niger Med J.* 2014;55(1):1-8. doi:10.4103/0300-1652.128146.
17. Famewo OE, Bodman RI. The choice of anaesthesia as a career by undergraduate medical students. *Middle East J Anaesthesiol.* 1985;8:179-185.
18. Fawaz MA, Hamdan-Mansour AM, Tassi A. Challenges facing nursing education in the advanced health care environment. *Int J Afr Nurs Sci.* 2018;9:105-110. doi:10.1016/j.ijans.2018.10.005.
19. Potisek MG, Hatch DM, Atito-Narh E, et al. Where are they now? Evolution of a nurse anaesthesia training school in Ghana and a survey of graduates. *Front Public Health.* 2017;5:78. doi:10.3389/fpubh.2017.00078.
20. Miller MK, Clark JD, Jehley A. Cognitive dissonance theory. In: Caution RL, Lilienfeld SO, editors. *The Encyclopaedia of Clinical Psychology.* Hoboken (NJ): Wiley;2015. Doi:10.1002/9781118625392.wbecp200.

CITE THIS ARTICLE:

- **APA (7th edition):** Oyelude, R. O., Zi, C. B., & Ojo, P. A. (2026, August 21). *Knowledge and attitude of staff nurses at University of Ilorin Teaching Hospital towards nursing anaesthesia programme. The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2602002>
- **Harvard:** Oyelude, R.O., Zi, C.B. and Ojo, P.A., 2026. *Knowledge and attitude of staff nurses at University of Ilorin Teaching Hospital towards nursing anaesthesia programme. The Operating Room Global Journal (TORGJ)*, 2(3). Published 21 August. Available at: <https://doi.org/10.64573/torgj2602002>
- **Vancouver:** Oyelude RO, Zi CB, Ojo PA. Knowledge and attitude of staff nurses at University of Ilorin Teaching Hospital towards nursing anaesthesia programme. *The Operating Room Global Journal (TORGJ)*. 2026 Aug 21;2(3). <https://doi.org/10.64573/torgj2602002>
- **MLA (9th edition):** Oyelude, Racheal Olufunmilayo, Chuwang Bitrus Zi, and Phillip A. Ojo. "Knowledge and Attitude of Staff Nurses at University of Ilorin Teaching Hospital Towards Nursing Anaesthesia Programme." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 21 Aug. 2026, <https://doi.org/10.64573/torgj2602002>
- **Chicago (Author-Date):** Oyelude, Racheal Olufunmilayo, Chuwang Bitrus Zi, and Phillip A. Ojo. 2026. "Knowledge and Attitude of Staff Nurses at University of Ilorin Teaching Hospital Towards Nursing Anaesthesia Programme." *The Operating Room Global Journal (TORGJ)* 2 (3), August 21. <https://doi.org/10.64573/torgj2602002>

Prevention And Management Of Hypotension During Spinal Anesthesia: A Narrative Review

Authors: Anas Jahangir^{1,6*}, Muhammad Hashim², Hira Khan³, Atia Ur Rehman⁴, Fatima Ashraf⁵

¹ Foundation University Islamabad, Pakistan

² Lahore Medical and Dental College, Pakistan

³ Nishtar Medical University, Multan, Pakistan

⁴ Allied Health Sciences, Rashid Latif Khan University, Lahore, Pakistan

⁵ Women University Multan

⁶ The Operating Room Global (TORG)

DOI: <https://doi.org/10.64573/torgj2606003>

ABSTRACT

Background: Spinal anesthesia is widely used in lower limb, lower abdominal, and obstetric surgery due to its rapid onset, extensive sensory and motor blockade, and good analgesic effect. The most frequent complication associated with this method is intraoperative hypotension, which occurs due to sympathetic vasomotor blockade, venous pooling, decreased venous return, and compromised cardiac compensatory response. Obstetric patients may experience decreased organ perfusion during hypotensive episodes.

Objective: The purpose of this narrative review is to present the causes, risk factors, manifestations, and interventions that have been shown to prevent and treat hypotension following spinal anesthesia.

Methods: Articles were identified through a literature search of PubMed, Scopus, and Google Scholar for the years 2015 to 2026. Keywords used were spinal anesthesia, hypotension, prevention, and management. A total of 87 articles were screened, of which 45 articles were selected for inclusion in the review.

Results: Factors associated with hypotension following spinal anesthesia can be grouped into patient-, procedure-, and drug-related factors. Patient factors include pregnancy, age, intravascular volume, and cardiac disease. Procedural factors include block height, local anesthetic dose, speed of injection, and positioning. Drug-related factors include the type of local anesthetic, vasoconstrictors, and adjuncts. Controlled crystalloid (electrolyte) fluid co-loading and early use of vasopressors, particularly phenylephrine or norepinephrine, are effective strategies for prevention. Continuous non-invasive hemodynamic monitoring can facilitate early identification of hemodynamic disturbances and support an appropriate response. The effects of spinal anesthesia-induced hypotension may be greatly reduced through appropriate management.

Conclusion: Spinal anesthesia may cause hypotension primarily due to sympathetic blockade. Recognition of relevant patient-, procedural-, and drug-related factors, together with appropriate fluid management, early vasopressor use, and hemodynamic monitoring, can support its prevention and management.

Keywords: Anesthesia, Spinal; Hypotension; Blood Pressure; Perioperative Care; Bradycardia; Hemodynamics; Patient Positioning; Fluid Therapy

*Corresponding Author:

Anas Jahangir
anas.jahangir@fui.edu.pk

Declaration:

Authors' Contribution:

See Declarations section at the end of the article.

Conflict of Interest: No conflict of interest.

Funding: No funding received.

Article History:

Received: 06-06-2026
Accepted: 20-08-2026
Available Online: 21-08-2026

QR access this Article



INTRODUCTION

Overview of spinal anesthesia

The major advantage of spinal anesthesia (SA) is that it provides an adequate sensory, motor, and sympathetic nerve block, which has led to its widespread adoption as a regional anesthesia technique. (J.-K. Lee, Park, Hyun, Hodel, & Hausmann, 2021). Spinal anesthesia has a rapid onset of action, predictable block properties, and avoids airway manipulation, making it an appealing option for surgeries performed on the lower abdomen, pelvis, perianal, and lower extremity areas.

Furthermore, spinal anesthesia has several benefits over general anesthesia, such as a reduction in postoperative pain, blood loss, and the incidence of thromboembolic complications (Schubert, Wiesmann, Wulf, & Dinges, 2023).

NICE guidelines recommend that neuraxial anesthetic be offered for cesarean section. Local anesthetics like bupivacaine, ropivacaine, or lidocaine are given into the subarachnoid space. Analgesics with a longer duration of action, like opioids (e.g., fentanyl or morphine), might be used to extend the duration of the action. The sensory blockade level needed is around T10 for vaginal delivery and T4 for cesarean delivery (Watson, Richardson, & Lucas, 2022).

Significant hemodynamic changes occur with spinal anesthesia, such as sympathetic blockade, hypotension, and bradycardia. Regional anesthesia has been found to have certain benefits over general anesthesia, such as maintenance of consciousness and spontaneous respiration during delivery, which results in fewer pulmonary complications and faster recovery after delivery (Finsterwald et al., 2018). Patients also go through the perioperative pathway quicker and discharge from the hospital earlier (Watters, Scott, Sammour, Harris, & Ludbrook, 2024).

Hypotension is most commonly defined as a decrease in systolic blood pressure (SBP) to <80% of baseline or an absolute SBP <100 mmHg (Chaithra, 2018). However, definitions vary across studies; a survey of UK obstetric anesthetists found that most consider hypotension to be an SBP <100 mmHg or <90 mmHg (Ferré et al., 2020). For the purposes of this review, we adopt the definition of SBP <80% of baseline or <100 mmHg, acknowledging the variation in definitions reported in the literature. Acute hypotension may lead to brainstem ischemia and stimulate the vomiting centers (Ferré et al., 2020).

The most common and clinically significant side effect of spinal anesthesia is hypotension. When left untreated, it may result in inadequate tissue perfusion, organ hypoxia, and ischemia. In risk groups, such as pregnant women, older people, and patients with pre-existing cardiovascular disease (CVD), even small changes in blood pressure are significant (Ferré et al., 2020). The use of obstetric anesthesia, which results in poor maternal blood pressure, can lead to poor uterine and placental blood flow, fetal distress, and acidosis. Other complications of intraoperative hypotension include cardiac ischemic events, acute kidney injury, and postsurgical cognitive impairment. So prevention and management are crucial (Pirenne, Dewinter, & Van de Velde, 2023).

Hypotension in association with spinal anesthesia is caused by sympathetic blockade, which causes venous and arterial dilation (Ferré et al., 2020). Sympathetic blockade leads to venous pooling in the lower extremities and splanchnic circulation, which decreases venous return, thus decreasing cardiac output. Loss of vasomotor tone also occurs in the arteries and decreases systemic vascular resistance. A sympathetic block can progress to cardiac accelerator fibers (T1-T4), causing bradycardia (Padberg, 2024) (Figure 1).

Spinal anesthesia also weakens the baroreceptor reflex, and therefore the responses to hypotension will be decreased. Hypotension depends on the level of the block, local anesthetic dose, type of local anesthetic, and patient factors such as age, baseline autonomic tone, and intravascular volume status (Dong et al., 2024).

Pathophysiology of Hypotension During Spinal Anesthesia

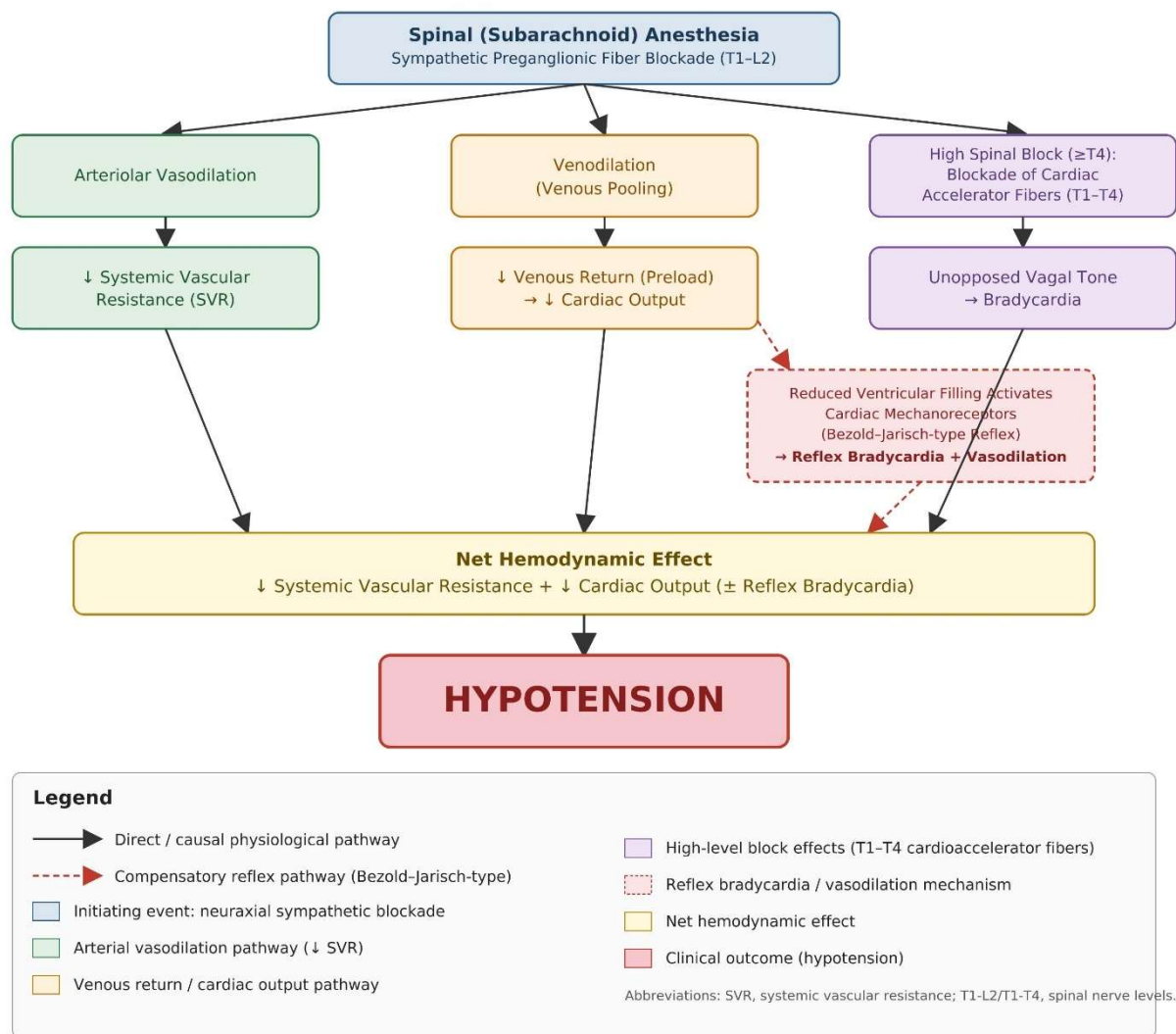


Figure 1. Mechanism of hypotension that occurs during spinal anesthesia

(Spinal anesthesia will block sympathetic nerve fibers (T1-L2), which will lead to vasodilation of the arteries and veins. This causes a decrease in systemic vascular resistance, increased venous pooling, decreased venous return (preload), and decreased stroke volume and cardiac output, leading to hypotension).

Source: Authors' original creation

METHODOLOGY

A narrative review was performed to consolidate the existing evidence for preventing and treating hypotension during spinal anesthesia. A systematic literature search was performed to identify articles published in the last five years (2015–2026) on PubMed, Scopus, and Google Scholar. The search terms utilized included combinations of the following: “spinal anesthesia”, “hypotension”, “prevention”, “management”, “vasopressors”, “fluid therapy”, and “hemodynamic monitoring” with the use of “Boolean” operators (AND, OR) as appropriate. A total of 87 records were retrieved from the database. The titles and abstracts were assessed for specific inclusion criteria. The full text of articles that may have been eligible were evaluated. In addition, by hand searching the reference lists of included articles, additional relevant articles were identified that were not included in the database search. This process provided an all-encompassing search strategy that was both comprehensive and repeatable for a narrative review.

A total of 87 articles were retrieved after searching the databases. Following title and abstract screening, 62 papers were discarded for failure to meet the criteria for inclusion (such as non-English articles, conference abstracts, opinion papers, etc., or articles not directly related to spinal anesthesia induced hypotension). The other 25 articles were assessed for full text review. Of these, 7 were omitted due to inadequate data, or due to duplication, or they did not seem to be relevant. The

number of articles retrieved from the database was 18. Another 27 articles were found by hand searching the reference lists of the included articles. There were 45 articles included in this narrative review.

LITERATURE REVIEW

Co-loading is shown to be effective in preventing spinal anesthesia-induced hypotension. A 2020 randomised controlled trial (RCT) showed that the incidence of hypotension was higher in crystalloid preloading than co-loading group. Pre-loading compared with co-loading for preventing post-spinal hypotension during cesarean section in 2024 showed a reduction in the prevalence of hypotension in co-loaded group. Saeed and colleagues found that co-loading was associated with the increased mean SBP 10 minutes ($p < 0.01$) and 15 minutes ($p < 0.01$) post induction (Saeed et al., 2024).

The use of vasopressors has undergone a considerable change in the last 20 years. Burns et al. (2001) polled consultant obstetric anesthetists in the UK and discovered that 87.1% gave fluids prior to spinal anesthesia and 95.2% only used ephedrine. In 2021, however, a review was conducted, and it was found that women undergoing cesarean section should receive prophylactic vasopressors; phenylephrine is suggested as the first-line drug (Heesen et al., 2021). In a 2019 systematic review, phenylephrine has been shown to improve maternal nausea and vomiting and to achieve better neonatal acid-base status than ephedrine (Xu, Shen, Liu, Yang, & Wang, 2019).

Ondansetron has been found to be a helpful prophylactic agent. A 2020 study titled "Intravenous ondansetron to prevent hypotension during cesarean delivery under spinal anesthesia" showed that the incidence of hypotension and the use of vasopressors were decreased after taking ondansetron as a prophylactic. A meta-analysis of 2018 confirmed ondansetron's efficacy and reported that ondansetron decreased the ED50 of phenylephrine by 26% (Xiao et al., 2020).

Mechanical interventions also help to prevent spinal anesthesia-induced hypotension. In a study published in 2024, "Effect of pneumatic leg compression on phenylephrine dose for preventing spinal-induced hypotension at cesarean delivery," pneumatically compressed legs resulted in fewer episodes of hypotension and reduced phenylephrine requirements. A 2014 RCT in elderly patients showed that prophylactic use of glycopyrrolate significantly decreased hypotension from 70% to 27% ($p=0.001$). However, a recent meta-analysis from 2018 revealed that preemptive glycopyrrolate failed to overall decrease the incidence of hypotension during cesarean delivery but did reduce the requirement for vasopressors (Xiao et al., 2020).

Evidence has been synthesized through comprehensive reviews. The literature gaps were identified in a 2017 review published in "Post-spinal anesthesia hypotension during cesarean delivery, a comprehensive review." In a 2020 review, the authors "Preventing and treating hypotension during caesarean section under spinal anesthetic: What is current evidence-based practice?" reviewed the evidence-based techniques (Hasanin, Mokhtar, Badawy, & Fouad, 2017).

MECHANISM OF HYPOTENSION IN SPINAL ANESTHESIA

Sympathetic blockade & vasodilation

Sympathetic blockade is the main cause of hypotension with spinal anesthesia. When efferent sympathetic fibers between T1 and L2 are blocked, there is a lack of vasomotor response in arterial and venous systems (Lee et al., 2017). Arteriolar dilation reduces systemic vascular resistance (SVR), which results in a fall in mean arterial pressure (MAP). Capacitance is increased, which results in blood pooling and reduced preload, in lower limb veins and splanchnic veins. Hypotension severity increases with higher spinal block levels; sympathetic blockade typically extends two to six dermatomes above the sensory block level (Taş, Kelleci, Umuroğlu, & Abdullayev, 2026).

Maternal symptoms of severe hypoperfusion include nausea, vomiting, dyspnea, and decreased cooperation. Fetal complications include low Apgar scores and umbilical cord acidosis. If the hypotension is severe, it can lead to permanent neurological damage in the child (Patel & Ninave, 2024).

Left ventricle afterload reduction leads to decreased venous return & cardiac output

Vasodilation and blood pooling reduce venous return to the right atrium. Through the Frank-Starling mechanism, decreased venous return reduces end-diastolic volume and stroke volume, proportionally decreasing cardiac output. If higher thoracic levels (T1-T4) are blocked, cardiac accelerator fibers are inhibited, causing bradycardia and further reducing cardiac output (Patel & Ninave, 2024). If untreated, this can result in cardiovascular collapse (Yu, Gu, Liao, & Feng, 2021).

Role of the baroreceptor reflex

If blood pressure drops, the baroreceptor reflex is activated, leading to an increase in HR and vasoconstriction of the peripheral circulation. However, sympathetic efferent pathways involved in this compensation are suppressed during spinal anesthesia, diminishing the body's compensatory response to hypotension (Khan & Paliwal, 2026).

In healthy parturients under spinal anesthetic, systemic vascular resistance decreases because of dilation of smaller arteries (Lertkovit & Nivatpumin, 2022). Normally, baroreceptor activation increases heart rate and stroke volume; however, if the block reaches the cervical region, reflex tachycardia is inhibited, further contributing to hypotension (Kondo, Hirose, Maeda, Yoshino, & Suzuki, 2019).

FACTORS THAT INCREASE THE RISK OF HYPOTENSION

Patient-Related Factors

Multiple patient parameters affect the probability and severity of hypotension (Masha, Lorato, Amsalu, & Markos, 2025). Compensatory ability is reduced in elderly patients due to their lower baseline sympathetic tone, decreased baroreceptor sensitivity, and limited cardiovascular reserve. The risk of hypotension is increased during pregnancy due to physiological vasodilation, redistribution of blood volume, and aortocaval compression from the enlarged uterus.

Comorbidities such as diabetes, hypertension, and cardiovascular disease affect autonomic nervous system response and vascular compliance, which can raise the risk for hypotension.

Hypovolemia or Dehydration: In hypovolemic patients, even minimal sympathetic blockade causes dramatic blood pressure changes due to reduced preload. Bradycardia and hypotension may be exacerbated in patients on beta-blockers or antihypertensives.

Procedure-Related Factors

The hemodynamic outcomes are significantly affected by technical aspects of spinal anesthesia (Finsterwald et al., 2018). Higher block levels induce more vasodilation and hypotension.

Local Anesthetic Dose: Higher volumes and doses increase sympathetic inhibition and cephalic spread (Lee et al., 2017).

Injection Speed: The speed of intrathecal injection may influence the spread and uniformity of the block, although evidence remains limited (Lee et al., 2017).

Block distribution is influenced by patient positioning such as supine or Trendelenburg position. The positioning, seated or head up, may improve venous pooling. Left uterine displacement is important to prevent aortocaval compression during pregnancy (Lee et al., 2017).

Drug-Related Factors

Local Anesthetic Type: Bupivacaine and tetracaine have a longer duration of hypotension than lidocaine because of the longer half-life and greater lipid solubility (Whizar-Lugo, Íñiguez-López, Cárdenas-Maytorena, & Ramírez-Puerta, 2020).

Increased Risk of Hypotension with Use of Adjuncts: Opioids and clonidine may enhance sympathetic and sensory block, which may lead to an increased risk of hypotension. Preoperative vasodilators or sedatives also require careful monitoring.

CLINICAL MANIFESTATIONS & DIAGNOSIS

Signs & Symptoms

Clinical presentation is characterized by nausea, vomiting, dizziness, blurring of vision, lightheadedness, or fainting. Cutaneous symptoms are cold, pale, clammy skin or delayed capillary refill. Hypotension can be accompanied by bradycardia due to the inhibitory action of cardiac accelerator fibers (T1-T4). Severe forms can lead to changes in mental state, restlessness, confusion, or even loss of consciousness. In obstetric patients, maternal hypotension can cause decreased placental blood flow, with decreased baseline fetal heart rate variability as a sign of fetal distress (Ferré et al., 2020).

Hemodynamic Monitoring

Non-invasive blood pressure (NIBP) should be checked every 2-3 minutes after spinal anesthesia. Continuous Arterial Blood Pressure (ABP) monitoring using an arterial line gives beat-to-beat information for high-risk patients. ECG is used to detect bradycardia or arrhythmia. During labor and delivery, fetal heart rate monitoring is standard (Pinsky et al., 2022).

Importance of Early Recognition

Hypotension progresses rapidly. Early detection reduces maternal and fetal morbidity and end-organ hypoperfusion by enabling timely fluid administration, vasopressor therapy, and repositioning (Ferré et al., 2020).

PREVENTION & MANAGEMENT STRATEGIES

Pre-loading & co-loading with fluids

The risk of hypotension can be decreased by administering intravenous fluids before (preloading) or during (co-loading) spinal anesthesia. Intravenous crystalloids (Ringer's Lactate, Hartmann's Solution, and Normal Saline) and colloids (Hydroxyethyl Starch and Gelatins) help to expand blood volume and increase venous return, which compensates for vasodilation caused by sympathetic blockade (Saeed et al., 2024).

Crystalloids vs Colloids

Crystalloids (Lactated Ringer's, Normal Saline) are readily available and inexpensive but are rapidly absorbed. After 20-30 minutes, only 20-25% of the crystalloid is still in the intravascular compartment. A colloid will also stay in the blood longer because it has a higher oncotic pressure, such as hydroxyethyl starch and gelatins (Shang et al., 2021). Colloids are, however, associated with a risk of anaphylaxis, coagulation problems, and renal dysfunction, so they are not used in obstetric anesthesia. The most common fluid type used is still "crystalloids."

Preloading with crystalloids is no longer recommended as it is ineffective. Colloid preloading or rapid colloid co-loading helps to significantly reduce maternal hypotension and vasopressor requirements. Crystalloid co-loading is more effective, safer, and less expensive than the use of colloid co-loading. In pre-eclampsia, fluid loading should be optimized to avoid overload (Shang et al., 2021).

Pre-load vs. Co-load

Crystalloid preloading (500-1500 mL) is of no benefit, as crystalloids rapidly redistribute. Evidence indicates that 20 mL/kg Ringer's lactate administered during spinal injection (co-load) provides greater benefit than the same volume given as a preload over 20 minutes (Hunie et al., 2022).

Generally, hemodynamic stability is maintained with crystalloid (500-1000 mL) or colloid fluids. Whether as pre-load or co-load, colloids offer versatility at any point in time. Different strategies should be used to address individual fluid requirement (Uzun Saritaş & Yelken, 2023).

Optimal Volume

The initial number of crystalloids in non-obstetric patients is usually 10-15 mL/kg with consideration of the patient's baseline hydration status and cardiovascular condition. Elderly patients and those with reduced cardiac reserve require more judicious fluid management to avoid pulmonary edema. Fluid therapy alone or in combination with pharmacologic therapy results in an optimal outcome (Salimi & Fardelmann, 2025).

Pharmacological Management

The main class of drugs used to maintain cardiac output and re-establish systemic vascular resistance (SVR) include vasopressors (O'Neill & Helwig, 2016).

Vasopressors

Ephedrine is a mixed α - and β -adrenergic agonist that causes an increase in heart rate, myocardial contractility, and peripheral vascular tone. It is given as a 5-10 mg IV bolus. Phenylephrine provides better fetal acid-base outcomes (Xu et al., 2019) and has historically been preferred in obstetric anesthesia.

Phenylephrine is a pure α -1 vasoconstricting agent. Typical doses include 50-100 mcg bolus intravenously or 25-50 mcg/min infusion. It may cause reflex bradycardia, especially with high block levels. Norepinephrine is increasingly used in obstetric anesthesia. It has a less bradycardic effect than phenylephrine due to its α 1-mediated vasoconstriction and mild β 1 agonism. Infusion rates of 2-6 μ g/min are commonly used. Recent randomized trials have demonstrated an association of norepinephrine with better maintenance of maternal cardiac output (Mohta, 2023).

Currently, phenylephrine is recommended as the vasoconstrictor of choice during hypotension induced by spinal anesthesia. Ephedrine might still be suitable in some patient groups (Mets, 2016).

Phenylephrine administered immediately after intrathecal injection is more effective in preventing hypotension than waiting until SBP drops. Variable-rate infusion provides better hemodynamic stability than fixed-rate or intermittent boluses (Meena & Sathyanarayana, 2021). Closed-loop computer-controlled infusions achieve tighter control of blood pressure than manual infusions. Norepinephrine 0.07-0.08 μ g/kg/min appears adequate to prevent spinal anesthesia-induced hypotension (Kee, Tam, Khaw, Ng, & Lee, 2017). Additional studies are required before norepinephrine can be considered superior to phenylephrine.

Anticholinergic Agents

For acute symptomatic bradycardia due to severe sympathetic blockade, atropine (0.5 mg IV) is used. Glycopyrrolate (0.2 mg IV) is the preferred drug in obstetric patients due to minimal placental transfer. These agents do not affect the level of arterial blood pressure directly (Patel, Habib, Phillips, Carvalho, & Sultan, 2018). Routine atropine prophylaxis is not advised. Atropine, at low doses (around 5 µg/kg), can have a beneficial effect on certain patients with low baseline heart rate (Pramadika et al., 2025).

Other Adjunct Agents

Ondansetron (4-8 mg IV) is a 5-HT₃ receptor blocker that antagonizes the Bezold-Jarisch reflex and therefore is useful for reducing spinal anesthesia-induced bradycardia and hypotension. This is particularly helpful when it comes to cesarean section. Intermittent bolus doses are not recommended, and continuous infusion of vasopressors is encouraged (Stampfl & DeBlieux, 2024).

Non-Pharmacological Management

Patient positioning, leg elevation, and the compression of the lower extremity improve venous return. These interventions help to decrease the severity of hypotension when combined with fluid and vasopressor therapy (Noffsinger, 2022). Combined leg elevation >30° and elastic compression are associated with a significant decrease in the incidence of post-spinal hypotension (18% vs. 53%, $P=0.004$). Leg wrapping alone effectively reduces hypotension and vasopressor requirements.

Mild Trendelenburg positioning (10-15 degrees) may increase central venous pressure but risks upward block dispersion. In pregnant women, left uterine displacement helps reduce aortocaval compression and mitigate hypotension (Lee et al., 2017). Non-pharmacological measures alone cannot fully prevent hypotension (Noffsinger, 2022):

1. Fluid co-loading
2. Prophylactic vasopressor infusion
3. Optimal patient positioning

DISCUSSION

Comparison of preventative & management strategies

Prevention and treatment for spinal anesthesia-induced hypotension require a multimodal approach. Generally, single-modality treatment is ineffective. Fluid preloading is not effective because of rapid crystalloid redistribution. Co-loading with fluids, in combination with intrathecal administration, provides intravascular expansion. Prophylactic continuous vasopressor infusion prophylaxis provides greater hemodynamic stability than reactive bolus administration. Non-pharmacological methods such as leg elevation and left uterine tilt provide supportive benefits (Noffsinger, 2022).

Most effective evidence-based approaches

Evidence is consistent with the use of combined crystalloid co-loading and IV phenylephrine infusion as standard of care in preventing hypotension during obstetric procedures under spinal anesthesia (Heesen et al., 2021). Given its favorable balance of maintaining maternal cardiac output and comparatively less reflex bradycardia, norepinephrine IV infusion is a potential first-line agent in obstetric anesthesia. The recommendation for vasopressors in non-obstetric patients (such as those with orthopedic, urologic or general surgery) depends on the underlying physiology, comorbidities, and hemodynamic goals. Results from obstetric studies might not be directly transferable to these populations and additional studies are required. However, fluid management needs to be more careful about elderly patients and for those with lower cardiac reserve to prevent pulmonary edema (Lee et al., 2017).

LIMITATIONS AND GAPS IN THE CURRENT EVIDENCE

Significant gaps remain. There is a considerable variation and trials uncertainty in optimal dosing, especially norepinephrine infusions. There are relatively few high-quality trials of elderly or high-risk cardiovascular patients. The majority of the data available are from cesarean delivery studies. The results of this review have been derived from obstetric evidence and therefore may not be directly applicable to other populations, including orthopedic, urologic, and general surgery patients and elderly and high-risk cardiac patients. Further research in these populations is needed. Long-term cognitive outcomes of intraoperative hypotension also require further research. The risk-benefit ratio of colloids remains to be determined. Individualized hemodynamic plans and real-time monitoring of cardiac output should be a topic of future research.

CONCLUSION

Spinal anesthesia is a very common regional anesthesia method because of its rapid onset, effective analgesia and avoidance of any manipulation of the airways. Hypotension (caused by sympathetic blockade, venous pooling, decreased cardiac output, and lack of compensatory mechanisms) is the most common and clinically relevant side effect (Lee et al., 2017). Understanding of procedure- and patient-related factors, adequate hydration, prompt application of vasopressors, and non-pharmacologic supportive measures are important for prevention and treatment.

Importance of prevention & individualized management

The multimodal approach of crystalloid co-loading, the use of appropriate patient positioning, and the use of vasopressors for early treatment of hypotension provides more benefit than single interventions. The unique characteristics of each patient's physiology, comorbidities, block height, and surgery type need to be taken into consideration. Older people and pregnant women should be treated as a priority, as they have less physiological reserve and are at increased risk of adverse effects associated with hypotension.

FUTURE DIRECTIONS AND CLINICAL IMPLICATIONS

The increasing number of studies on cardiac output preservation and safety could make norepinephrine a preferred first-line vasopressor. Precision medicine techniques, dynamic hemodynamic monitoring systems, and evidence outside of obstetrics are areas of research that should be explored in the future. Increased patient safety, reduced morbidity from hypotension, and improved perioperative outcomes will result from improved preventive measures.

FUNDING

This work received no funding.

DECLARATION OF COMPETING INTEREST

No conflicts of interests declared by authors.

AUTHORS' CONTRIBUTIONS

- Anas Jahangir - Conceptualisation; Literature Search; Manuscript Drafting; Review and Editing; Project Administration; Manuscript Revision.
- Muhammad Hashim - Methodology; Literature Search; Data/Article Screening; Analysis and Interpretation; Review and Editing.
- Hira Khan - Literature Search; Data/Article Screening; Manuscript Drafting; Review and Editing; Manuscript Revision.
- Atia Ur Rehman - Literature Search; Methodology; Data/Article Screening; Analysis and Interpretation; Supervision.
- Fatima Ashraf - Conceptualisation; Methodology; Analysis and Interpretation; Review and Editing.

REFERENCES

- Buren, M. A., & Cil, H. (2025). Anesthetic considerations and management of spine surgery performed under neuraxial anesthesia. *Current Anesthesiology Reports*, 15(1), 28.
- Dong, S., Wang, Q., Wang, S., Zhou, C., & Wang, H. (2024). Hypotension prediction index for the prevention of hypotension during surgery and critical care: A narrative review. *Computers in Biology and Medicine*, 170, 107995.
- Ferré, F., Martin, C., Bosch, L., Kurrek, M., Lairez, O., & Minville, V. (2020). Control of spinal anesthesia-induced hypotension in adults. *Local and regional anesthesia*, 39-46.
- Finsterwald, M., Muster, M., Farshad, M., Saporito, A., Brada, M., & Aguirre, J. A. (2018). Spinal versus general anesthesia for lumbar spine surgery in high risk patients: perioperative hemodynamic stability, complications and costs. *Journal of clinical anesthesia*, 46, 3-7.
- Hasanin, A., Mokhtar, A. M., Badawy, A. A., & Fouad, R. (2017). Post-spinal anesthesia hypotension during cesarean delivery, a review article. *Egyptian Journal of Anaesthesia*, 33(2), 189-193.
- Heesen, M., Hilber, N., Rijs, K., Rossaint, R., Girard, T., Mercier, F., & Klimek, M. (2021). A Systematic Review of Phenylephrine Versus Noradrenaline for the Management of Hypotension Associated With Neuraxial Anesthesia in Women Undergoing Cesarean Section. *Obstetric Anesthesia Digest*, 41(1), 1-2.

- Hunie, M., Wubishet, T., Fenta, E., Teshome, D., Kibret, S., Desse, T., . . . Zewdu, D. (2022). The Effect of Preloading and Co-Loading in the Prevention of Hypotension among Mothers Who Underwent Cesarean Delivery under Spinal Anesthesia: A Prospective Cohort Study. *Systematic Reviews in Pharmacy*, 13(2).
- Kee, W. D. N., Tam, Y.-H., Khaw, K. S., Ng, F. F., & Lee, S. W. (2017). Closed-loop feedback computer-controlled phenylephrine for maintenance of blood pressure during spinal anesthesia for cesarean delivery: a randomized trial comparing automated boluses versus infusion. *Anesthesia & Analgesia*, 125(1), 117-123.
- Khan, I. A., & Paliwal, N. W. (2026). Bradycardia during thoracic segmental spinal anesthesia: Beyond cardio-accelerator (T1-T4) Fiber blockade. *JCA Advances*, 100248.
- Kondo, Y., Hirose, N., Maeda, T., Yoshino, A., & Suzuki, T. (2019). Relationship between changes in regional cerebral blood volume and oxygenation and changes in cardiac output and systemic vascular resistance during spinal anesthesia in women undergoing cesarean section. *Journal of Anesthesia*, 33(5), 579-586.
- Lertkovit, S., & Nivatpumin, P. (2022). Anesthetic management of cesarean delivery of parturient with systemic lupus erythematosus associated with pulmonary arterial hypertension-A case report. *Anesthesia and Pain Medicine*, 17(3), 291-297.
- Lee, J.-K., Park, J. H., Hyun, S.-J., Hodel, D., & Hausmann, O. N. (2021). Regional anesthesia for lumbar spine surgery: can it be a standard in the future? *Neurospine*, 18(4), 733.
- Lee, J. E., George, R. B., & Habib, A. S. (2017). Spinal-induced hypotension: Incidence, mechanisms, prophylaxis, and management: Summarizing 20 years of research. *Best practice & research Clinical anaesthesiology*, 31(1), 57-68.
- Masha, T. M., Lorato, S. S., Amsalu, H., & Markos, Z. (2025). The incidence and associated factors of hypotension during spinal anesthesia at tertiary hospital: a prospective cross-sectional study. *Annals of Medicine and Surgery*, 87(12), 8136-8142.
- Mets, B. (2016). Should norepinephrine, rather than phenylephrine, be considered the primary vasopressor in anesthetic practice? *Anesthesia & Analgesia*, 122(5), 1707-1714.
- Meena, K. R., & Sathyanarayana, V. (2021). A study of phenylephrine administration for the prevention and treatment of hypotension in cesarean section during spinal anaesthesia: A randomised clinical trial.
- Mohta, M. (2023). Norepinephrine—Can it Replace Phenylephrine as the Vasopressor of Choice in Obstetric Anesthesia? (Vol. 2, pp. 1-4): Medknow.
- Noffsinger, S. R. (2022). Evidence-Based Prevention Strategies for the Management of Spinal Anesthesia-Induced Hypotension in Healthy Parturients Undergoing Elective Cesarean Delivery. *AANA journal*, 90(4).
- O'Neill, J., & Helwig, E. (2016). Postoperative management of the physiological effects of spinal anesthesia. *Journal of Perianesthesia Nursing*, 31(4), 330-339.
- Padberg, T. (2024). Cardiovascular effects of neuraxial anesthesia. In: *Anesthesia & Analgesia*, 138(4), 789-801.
- Pramadika, T., Nurcahyo, W. I., Wicaksono, S. A., Saputra, T., Manapa, C. H., & Ksatriaputra, A. (2025). Intrathecal atropine as an adjuvant in spinal anesthesia: a systematic review of efficacy and safety. *Anaesthesia, Pain & Intensive Care*, 29(7), 796.
- Patel, S., & Ninave, S. (2024). Postspinal anesthesia hypotension in caesarean delivery: a narrative review. *Cureus*, 16(4), e59232.
- Patel, S. D., Habib, A. S., Phillips, S., Carvalho, B., & Sultan, P. (2018). The effect of glycopyrrolate on the incidence of hypotension and vasopressor requirement during spinal anesthesia for cesarean delivery: a meta-analysis. *Anesthesia & Analgesia*, 126(2), 552-558.
- Pirenne, V., Dewinter, G., & Van de Velde, M. (2023). Spinal anaesthesia in obstetrics. *Best practice & research Clinical anaesthesiology*, 37(2), 101-108.
- Pinsky, M. R., Cecconi, M., Chew, M. S., De Backer, D., Douglas, I., Edwards, M., . . . Monnet, X. (2022). Effective hemodynamic monitoring. *Critical Care*, 26(1), 294.
- Saeed, M. T., Rao, A., Saeed, M. N., Alam, T., Riaz, A., & Ahmad, H. (2024). Co-Loading Versus Pre-Loading for Preventing Post-Spinal Hypotension in Caesarean Section. *Pakistan Armed Forces Medical Journal*, 74(2), 401.
- Salimi, N. K., & Fardelmann, K. L. (2025). PREGNANT PATIENT FOR NON-OBSTETRIC SURGERY. *Perioperative Medicine: A Problem-Based Learning Approach*, 345.
- Schubert, A.-K., Wiesmann, T., Wulf, H., & Dinges, H.-C. (2023). Spinal anesthesia in ambulatory surgery. *Best practice & research Clinical anaesthesiology*, 37(2), 109-121.
- Shang, Y., Li, H., Ma, J., Tan, L., Li, S., Li, P., . . . Wang, R. (2021). Colloid preloading versus crystalloid preloading to prevent hypotension after spinal anesthesia for cesarean delivery: A protocol for systematic review and meta-analysis. *Medicine*, 100(7), e24607.

- Taş, D., Kelleci, Y., Umuroğlu, T., & Abdullayev, R. (2026). Spinal Anesthesia and Regional Hemodynamic Parameters. *Journal of Ultrasound in Medicine*, 45(3), 557-568.
- UZUN SARITAŞ, P., & YELKEN, B. (2023). Comparison of the Effect of Prophylactic Ephedrin, Ringer's Lactate, and Colloid Applied During Spinal Anaesthesia on Hemodynamic Parameters in Geriatric Patients. *İzmir Tepecik Eğitim Hastanesi Dergisi*, 33(1).
- Watson, S. E., Richardson, A. L., & Lucas, D. N. (2022). Neuraxial and general anaesthesia for caesarean section. *Best practice & research Clinical anaesthesiology*, 36(1), 53-68.
- Watters, D. A., Scott, D. A., Sammour, T., Harris, B., & Ludbrook, G. L. (2024). If the peri-operative patient pathway was right, what would it look like? *ANZ Journal of Surgery*, 94(9), 1462-1470.
- Whizar-Lugo, V. M., Íñiguez-López, K. L., Cárdenas-Maytorena, A. C., & Ramírez-Puerta, C. D. (2020). Local anesthetics Topics in Local Anesthetics: IntechOpen.
- Xiao, F., Wei, C., Chang, X., Zhang, Y., Xue, L., Shen, H., . . . Chen, X. (2020). A prospective, randomized, double-blinded study of the effect of intravenous ondansetron on the effective dose in 50% of subjects of prophylactic phenylephrine infusions for preventing spinal anesthesia-induced hypotension during cesarean delivery. *Anesthesia & Analgesia*, 131(2), 564-569.
- Xu, S., Shen, X., Liu, S., Yang, J., & Wang, X. (2019). Efficacy and safety of norepinephrine versus phenylephrine for the management of maternal hypotension during cesarean delivery with spinal anesthesia: A systematic review and meta-analysis. *Medicine*, 98(5), e14331.
- Yu, C., Gu, J., Liao, Z., & Feng, S. (2021). Prediction of spinal anesthesia-induced hypotension during elective cesarean section: a systematic review of prospective observational studies. *International Journal of Obstetric Anesthesia*, 47, 103175.

CITE THIS ARTICLE:

- **APA (7th edition):** Jahangir, A., Hashim, M., Khan, H., Ur Rehman, A., & Ashraf, F. (2026, August 21). *Prevention and management of hypotension during spinal anesthesia: A narrative review. The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2606003>
- **Harvard:** Jahangir, A., Hashim, M., Khan, H., Ur Rehman, A. and Ashraf, F., 2026. *Prevention and management of hypotension during spinal anesthesia: A narrative review. The Operating Room Global Journal (TORGJ)*, 2(3). Published 21 August. Available at: <https://doi.org/10.64573/torgj2606003>
- **Vancouver:** Jahangir A, Hashim M, Khan H, Ur Rehman A, Ashraf F. Prevention and management of hypotension during spinal anesthesia: A narrative review. *The Operating Room Global Journal (TORGJ)*. 2026 Aug 21;2(3). <https://doi.org/10.64573/torgj2606003>
- **MLA (9th edition):** Jahangir, Anas, et al. "Prevention and Management of Hypotension During Spinal Anesthesia: A Narrative Review." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 21 Aug. 2026, <https://doi.org/10.64573/torgj2606003>
- **Chicago (Author-Date):** Jahangir, Anas, Muhammad Hashim, Hira Khan, Atia Ur Rehman, and Fatima Ashraf. 2026. "Prevention and Management of Hypotension During Spinal Anesthesia: A Narrative Review." *The Operating Room Global Journal (TORGJ)* 2 (3), August 21. <https://doi.org/10.64573/torgj2606003>

Artificial Intelligence For Automated Detection Of Large Vessel Occlusion: State Of The Art, Clinical Applications And Future Perspectives

Authors: Ishaan Bakshi^{1*}

¹ The Operating Room Global (TORG).

DOI: <https://doi.org/10.64573/torgj2607005>

ABSTRACT

Background: Large vessel occlusion (LVO) is a major cause of morbidity and mortality in acute ischemic stroke (AIS) and a common indication for mechanical thrombectomy. Rapid detection is critical because the benefit of treatment is highly time dependent. Artificial intelligence (AI)-based imaging systems have emerged as decision-support tools for automated LVO identification, image prioritisation, and rapid stroke-team notification.

Objective: To critically review current evidence on AI-assisted LVO detection, including diagnostic accuracy, clinical and workflow implications, commercially available platforms, barriers to implementation, and future perspectives.

Methods: This narrative review covers literature published from January 2015 to June 2026 on AI-based LVO identification using computed tomography angiography (CTA) and multimodal stroke imaging. Evidence relating to diagnostic performance, external validation, workflow impact, commercial platforms, implementation, and emerging technologies was reviewed.

Results: AI systems demonstrate high diagnostic accuracy for proximal anterior circulation LVO, with reported sensitivities of 85-97% and specificities above 90%. Clinical implementation has improved image triage, specialist notification, thrombectomy activation, and interhospital coordination. However, performance is less consistent for distal and posterior circulation occlusions, while heterogeneity in study design, imaging methods, and outcome measures limits comparisons between platforms. Additional challenges include false-positive alerts, missed occlusions, limited generalisability, algorithmic bias, explainability, regulatory oversight, interoperability, and cost.

Conclusion: AI-assisted LVO detection has the potential to improve the speed and coordination of acute stroke care, particularly for proximal anterior circulation occlusions, but should augment rather than replace clinician interpretation. Its long-term clinical value requires prospective multicentre validation, standardised comparative studies, transparent reporting, and evaluation of patient-centred outcomes.

Keywords: Artificial Intelligence; Large Vessel Occlusion; Acute Ischemic Stroke; Mechanical Thrombectomy; Computed Tomography Angiography; Stroke Imaging; Clinical Decision Support; Machine Learning.

*Corresponding Author:

Dr. Ishaan Bakshi

ishaan_bakshi@yahoo.com

Declaration:

Author's Contributions:

I. Bakshi - Conceptualisation, literature review, analysis, manuscript drafting, review and editing.

Conflict of Interest: No conflict of interest.

Funding: No funding received.

Article History:

Received: 17-07-2026

Accepted: 25-08-2026

Available Online: 27-08-2026

QR access this Article



INTRODUCTION

Acute ischemic stroke (AIS) is one of the leading causes of death and permanent disability worldwide. The most severe type is large vessel occlusion (LVO) of major intracranial arteries, such as the intracranial internal carotid artery (ICA), middle cerebral artery (MCA), basilar artery, and proximal anterior cerebral artery. LVO stroke is associated with larger infarcts, more neurological deficits, higher mortality and poorer functional outcome, as compared to non-LVO stroke. So, early diagnosis is important [10]. Mechanical thrombectomy has changed the treatment of patients with LVO. Landmark trials have demonstrated endovascular thrombectomy (EVT) to be the standard of care for anterior-circulation LVO, with additional data expanding its use for selected patients beyond typical time frames and for posterior-circulation occlusions. Since the benefit of EVT diminishes with delays in treatment, early identification and referral of LVO is important [3,4].

Computed tomography angiography (CTA) imaging is the first-line modality for the detection of arterial occlusion and for the evaluation of eligibility for EVT. However, increasing imaging volumes, limited neuroradiology knowledge, interobserver variability and the complexity of regional stroke networks may cause interpretation delays, especially in primary stroke centers and resource-constrained settings [1,5,10].

One promising answer has come in the form of deep learning, a subfield of artificial intelligence (AI). Modern artificial intelligence systems can automatically detect LVO on CTA, prioritize urgent testing, identify vascular anomalies, and immediately report to the stroke teams. Numerous commercial tools are now integrated into clinical stroke workflows to assist in real time diagnosis and triage [10,11]. Performance in controlled validation tests is promising but doesn't necessarily translate to ordinary practice. Diagnostic accuracy was affected by occlusion location and image quality, with reduced accuracy in cases of distal and posterior circulation occlusion. Differences in study design, imaging methods, reference standards and training datasets further limit the ability to compare algorithms. Challenges for widespread implementation include false-positive and false-negative results, automated bias, explainability, regulatory and medico-legal issues, interoperability, cost, and equitable access [1,7,8].

This narrative review summarizes the available evidence on AI-assisted LVO detection in AIS with particular emphasis on diagnostic performance, algorithmic techniques, workflow integration, commercial platforms and implementation problems. It highlights the drawbacks of existing systems and the future research objectives for the safe, successful, and unbiased integration of AI into acute stroke care [1,10].

METHODS

Literature search strategy

A structured literature search was conducted to identify evidence related to the use of artificial intelligence (AI) to support the detection of large vessel occlusion (LVO) in acute ischemic stroke. We searched PubMed/MEDLINE, Scopus, Web of Science, Embase, and Google Scholar for studies published in English between January 2015 and June 2026. Reference lists were searched for relevant articles and recent reviews. The search terms were combinations of artificial intelligence, machine learning, deep learning, convolutional neural network, vision transformer, large vessel occlusion, acute ischemic stroke, computed tomography angiography, CTA, mechanical thrombectomy, stroke triage, neuroradiology, workflow optimization and computer-aided diagnosis with the use of appropriate Boolean operators.

The search retrieved approximately 25 records. After removal of duplicates and screening of titles, abstracts and full texts 13 studies were included in the final narrative review.

Inclusion and exclusion criteria

Eligible publications included original research, prospective and retrospective observational studies, multi-center validation studies, randomized trials, systematic reviews, meta-analyses, clinical guidelines, consensus statements, and landmark technical reports. Studies assessing automated LVO detection on CTA or multimodal stroke imaging, diagnostic performance, external validation, workflow integration, commercial AI platforms, implementation or emerging technologies were included.

Conference abstracts without full text, case reports, non-English publications, editorials without sufficient evidence, and studies not related to acute stroke imaging or cerebrovascular occlusion were excluded. Where the study populations overlapped, the report with the most complete or the most recent information was selected.

Titles and abstracts were screened for relevance and full texts were reviewed. Special emphasis was given to multicenter validation, prospective implementation studies, systematic reviews, meta-analyses and clinical guidelines. For qualitative comparison, we retrieved diagnostic accuracy measurements (sensitivity, specificity, and area under the receiver operating characteristic curve [AUC]) and workflow outcomes.

Justification for Qualitative Synthesis

To provide a clinically focused overview of AI-assisted LVO detection, a narrative review was chosen as the methodology to address algorithm development, diagnostic performance, workflow integration, commercial platforms, implementation challenges, ethical considerations, and emerging technologies. Significant heterogeneity in AI models, patient populations,

LVO definitions, imaging protocols, validation techniques, and outcome measures precluded meaningful quantitative synthesis.

Thus, results were narratively synthesized, and systematic reviews and meta-analyses were used to contextualize diagnostic performance where relevant. The review highlights areas of agreement, areas of disagreement between studies, limitations in external validity, and the clinical importance of the outcomes reported.

Ethical Use of Artificial Intelligence

Language tools for artificial intelligence were only used for language, organization and readability improvements. The authors independently selected the literature, interpreted the data, critically analyzed and drew conclusions and approved the manuscript for submission. The authors bear full responsibility for the accuracy, integrity and originality of the manuscript. No AI was used to generate, manipulate or fabricate research data, results or references.

CLINICAL RELEVANCE OF LARGE VESSEL OCCLUSION

Large artery occlusion (LVO) comprises 20-40% of all acute ischemic strokes, but accounts for a disproportionate amount of severe disability, death, and health care burden. A sudden reduction of cerebral blood flow may be due to a significant occlusion of intracranial arteries such as the intracranial internal carotid artery (ICA), middle cerebral artery (MCA), basilar artery, vertebral artery, and proximal anterior cerebral artery. Clinical severity is determined by the location of the occlusion, the collateral circulation, systemic hemodynamics and duration of the ischemia [1,10]

Mechanical thrombectomy has revolutionized the outcomes for appropriately selected patients with LVO. Landmark trials have established endovascular thrombectomy (EVT) as the standard of care for eligible patients with anterior-circulation large vessel occlusion (LVO). Additional evidence has expanded the eligibility criteria to include selected patients beyond traditional treatment windows and to those with basilar artery occlusions. Therefore, early recognition and treatment eligibility of LVO has become a critical part of modern stroke care [3,4]

This is where neuroimaging is relevant. NCCT is useful to exclude cerebral bleeding and to assess early ischemia changes with methods such as the Alberta Stroke Program Early CT Score (ASPECTS). Computed tomography angiography (CTA) allows immediate visualization of the cerebral vasculature to identify arterial occlusion, while CT perfusion (CTP) and magnetic resonance imaging (MRI) can be used to further determine infarct core, salvageable tissue, collateral circulation and tissue viability in selected individuals [4,5]

CTA interpretation is complicated although widely used. The accuracy of diagnosis is influenced by image quality, motion artifacts, contrast timing, vascular calcification, anatomical variance, tandem lesions and reader expertise. Occlusions in the distal and posterior circulation are more challenging to detect and access to neuroradiologists, or neurointerventional specialists is generally limited outside comprehensive stroke facilities [5,7]

These challenges are magnified in hub-and-spoke stroke networks where delays in CTA interpretation, specialist consultation, patient transfer and thrombectomy team activation can increase the time to reperfusion. Thus, the necessity of technologies that can identify LVO fast and uniformly has become more crucial, laying the groundwork for AI-assisted stroke imaging systems [6].

ARTIFICIAL INTELLIGENCE IN STROKE IMAGING: BASICS

Artificial Intelligence (AI) has evolved from a basic computer aided detection to a sophisticated tool for medical picture analysis. In acute stroke care AI is already used for automatic detection of cerebral bleeding, large vessel occlusion (LVO), ASPECTS rating, perfusion analysis, collateral assessment, and calculation of the ischemic core. Among these, automated LVO identification is especially important as a rapid diagnosis directly impacts the patient's eligibility for mechanical thrombectomy [10,11]

Early computer-assisted systems relied on hand-crafted image features such as vessel diameter, intensity, morphology and geometry, and were therefore limited in their ability to detect complicated patterns. Machine learning changed this paradigm by providing algorithms to learn from annotated imaging datasets. Most today's applications of stroke imaging use supervised learning, in which models are trained on labeled images [11]. Deep learning has progressed further. CNNs have

been the dominant LVO detection solution because of their ability to learn hierarchical spatial information from CTA images. 3D CNNs are designed to handle volumetric data while preserving spatial correlations. More recently, Vision Transformers (ViTs) and hybrid CNN-transformer models have shown promise in capturing long-range image associations, while their clinical usefulness in LVO detection remains less established [11]

The regular AI pipeline consists of image pre-processing and vessel segmentation. CTA images are normalized, registered, artifact corrected and segmented prior to analysis. Arterial occlusions are subsequently identified by algorithms that analyze vascular continuity, contrast enhancement, branching patterns and hemispheric asymmetry. Modern systems incorporate these phases into automated workflows that can deliver results in clinically relevant timeframes [1,11]. The complexity of AI models is growing, and so is the need for interpretability. Explainable AI (XAI) techniques, e.g. saliency maps, Gradient-weighted Class Activation Mapping (Grad-CAM) and attention maps, can be used to highlight the regions of an image that influence the model's predictions, which may be useful for clinician assessment and error analysis. But these approaches do not fully capture the thinking of the model [10,11]

Ultimately, technical excellence alone does not guaranty a clinical benefit. The standard artificial intelligence algorithms for acute stroke must be timely and accurate across a broad spectrum of patient populations, imaging protocols, scanner types, and clinical settings. Therefore, research has gradually shifted from algorithm development to external validation and real-world clinical deployment [1,7,10].

Artificial intelligence algorithms for automatic detection of large vessel occlusion

Artificial intelligence-based detection of LVO has evolved from conventional machine learning with manually selected imaging variables to deep learning-based methods that directly analyze computed tomography angiography (CTA). Current approaches typically involve multiple steps like image pre-processing, vessel segmentation, feature extraction and classification for detecting vascular discontinuity, reduced distal contrast opacification or hemispheric asymmetry suggestive of occlusion. Convolutional neural networks (CNNs), particularly three-dimensional models, have the most research, and attention-based and hybrid CNN-transformer architectures provide promising approaches to capturing complex vascular interactions [1,8,11]. Published studies consistently demonstrate good diagnostic accuracy for proximal anterior-circulation LVO, particularly intracranial internal carotid artery (ICA) and M1 occlusions. Sensitivities of 85–97%, specificities >90% and area under the receiver operating characteristic curve (AUC) >0.90 have been reported in systematic reviews and validation studies. In several trials, AI has been on par with professional readers, supporting their role in settings where direct neuroradiology expertise is unavailable [1,7,8].

However, these data should be treated with caution. Diagnostic performance depends on the site of occlusion, image quality, patient population, reference standards, and LVO definitions. Distal medium vascular (M2–M3), tandem and posterior circulation occlusions are far more complex due to lower caliber, anatomical heterogeneity and less conspicuity. Therefore, the good accuracy reported for proximal anterior-circulation occlusions cannot be generalized to all LVOs. [1,5,8].

Comparisons to human readers also need to be put in context. AI is often compared to neuroradiologists, the subspecialists in this area, but it may be more useful for emergency physicians, general radiologists, or readers with less experience. Also, AI and physicians err differently; false negatives can lead to a delay in thrombectomy, while false positives can lead to unnecessary evaluation or transfer. Thus, evaluation should be based on the clinical implications of errors and not on diagnostic accuracy alone [1,7].

The big problem is the problem of generalization. Many of the early algorithms were developed using retrospective, single-center data, making their performance susceptible to changes in scanner type, imaging procedures, contrast timing, patient demographics, and disease prevalence. The multicenter external validation more strongly supports clinical utility, and interinstitutional variability highlights the need for local validation and ongoing post deployment surveillance [1,7,8]. New techniques such as CTA in combination with non-contrast CT, CT perfusion, MRI and clinical data are helping to identify the infarct core, collateral circulation, perfusion mismatch and eligibility for therapy. Foundation models and self-supervised learning may improve transferability and reduce dependence on large annotated datasets, but are experimental and need prospective validation [10,12].

To summarize, current evidence supports a role for artificial intelligence as a rapid and accurate adjunct to the diagnosis of proximal LVO, but performance varies across vascular territories and studies. Future research should focus on independent

validation from multiple centers, standardized reporting, head-to-head comparisons of platforms, and prospective evaluation of patient-centered outcomes [1,8].

Category	Model / Evidence	Target Population / Vascular Territory	Validation Setting	Performance Range*		AUC (ROC)	Key Interpretation
				Sensitivity	Specificity		
 Overall across studies	AI systems across validation studies (systematic reviews and cohorts)	Predominantly proximal anterior-circulation LVO (ICA, M1)	Retrospective and prospective studies; multicenter and single-center	85 – 97%	> 90%	Often > 0.90	<ul style="list-style-type: none"> Strongest performance for proximal anterior-circulation LVO. Range reflects between-study heterogeneity in design and cohorts.
 Commercial Platform (Viz.ai)	Viz.ai (CTA-based LVO detection)	Proximal anterior-circulation LVO (ICA, M1)	Multicenter observational and implementation studies	High (≈ 85 – 97%)	High (> 90%)	Reported > 0.90	<ul style="list-style-type: none"> Extensively implemented with workflow impact evidence. Performance varies with occlusion location and imaging quality.
 Commercial Platform (RapidAI)	RapidAI / RAPID CTA (CTA-based LVO detection)	Proximal anterior-circulation LVO (ICA, M1)	Multicenter observational studies; research cohorts	High (≈ 85 – 97%)	High (> 90%)	Reported > 0.90	<ul style="list-style-type: none"> Strong performance for proximal LVO. Results should be interpreted according to vascular territory.
 Commercial Platform (JLK-LVO)	JLK-LVO (CTA-based LVO detection)	Proximal anterior-circulation LVO (ICA, M1)	Multicenter and institutional validation studies	High (≈ 85 – 97%)	High (> 90%)	Reported > 0.90	<ul style="list-style-type: none"> Comparative studies report platform-specific strengths and failure patterns. Evidence primarily for proximal LVO.
 Vascular Territory (Distal / Medium)	Commercial AI systems overall	Distal / medium-vessel occlusions (M2–M3 and more distal)	Multiple retrospective and prospective studies	Lower and more variable (≈ 50 – 80%)	Variable (≈ 70 – 90%)	Lower and variable (< 0.90)	<ul style="list-style-type: none"> Smaller vessel caliber and anatomical variability reduce detection reliability. Performance consistently below that for proximal LVO.
 Vascular Territory (Posterior Circulation)	Commercial AI systems overall	Posterior-circulation LVO (vertebrobasilar and branches)	Multiple retrospective and prospective studies	Variable (≈ 50 – 85%)	Variable (≈ 70 – 90%)	Variable (< 0.90)	<ul style="list-style-type: none"> Evidence and performance less consistent than for anterior circulation. Heterogeneity in definitions and imaging protocols.
 Comparison with Human Readers	AI versus experienced neuroradiologists and radiologists	Primarily proximal anterior-circulation LVO (ICA, M1)	Direct comparison studies	Comparable in some studies	Comparable in some studies	Comparable (≈ 0.90+)	<ul style="list-style-type: none"> Performance depends on reader expertise and case complexity. AI and humans may err differently.

* Performance ranges reflect approximate values reported across studies included in recent reviews and validation cohorts.

AI, artificial intelligence; AUC, area under the receiver operating characteristic curve; CTA, computed tomography angiography; ICA, internal carotid artery; LVO, large vessel occlusion; ROC, receiver operating characteristic.

Clinical Applications and Integration into Workflow

The advantages of AI-assisted LVO detection are not confined to its diagnostic accuracy but also encompass the capability to expedite time-sensitive stroke therapy. AI tools have the potential to evaluate CT angiography (CTA) directly after acquisition and prioritize suspected LVO cases and provide clinicians with information that can help reduce delays between imaging, specialist assessment, transfer choices and mechanical thrombectomy [2,6,10].

Another important use is automatic image triage. In routine practice, urgent CTA studies often compete with other imaging, especially in times of high volume or low neuroradiology coverage. AI is able to identify LVO cases that are more likely to be true positives and prioritize these for examination, especially for smaller hospitals and centers that do not have specialists available 24/7. But AI should augment, not replace, image interpretation skills [2,6,9]. Commercial platforms are embracing integrated communications with automated picture analysis. When LVO is detected alerts can be sent at the same time to neurologists radiologists neurointerventionalists and stroke coordinators so that they can evaluate the images and plan the treatment at the same time. In hub-and-spoke networks, these systems can allow for earlier communication between referring and comprehensive stroke centers for patient transfer and preparation for thrombectomy [2,6,9].

Observational studies have suggested that AI adoption is associated with shorter CTA to notification time, thrombectomy team activation, door to groin puncture time, and in some networks, door in door out time. However, the degree of improvement varies by institution, and depends on current procedures, manpower, transfer infrastructure and system integration. Most of the research is observational, making it difficult to separate the influence of AI from broader workflow improvements [2,6,7]. Importantly, improved process metrics do not necessarily translate into improved clinical outcomes. Earlier reperfusion is associated with better recovery but there is little evidence that AI improves functional outcomes or mortality independently. Hence, future research is vital in patient-centered outcomes [2,7].

Another problem is workflow integration. False-positive alerts may lead to unwarranted picture inspection and warning fatigue, and false-negative results may delay therapy if physicians over-rely on automated outputs. Integration with PACS, RIS, EHR and communication systems is essential with well-defined institutional guidelines for successful adoption. Human supervision is still needed, particularly when AI results differ from clinical or imaging assessments. [2,9,10]. Besides, the implementation is of great economic importance. Commercial AI platforms have licensing, infrastructure, integration,

maintenance and staff training costs. Early treatment can reduce long-term impairment and health care costs. Information on cost-effectiveness according to stroke volume and health care context is limited and likely to be variable. [9,10]

AI-assisted LVO identification may improve coordination and efficiency along acute stroke pathways by automated picture processing, prioritizing, communication and transfer support. The benefits of the workflow are routinely reported but prospective studies are necessary to ascertain the effect on patient outcomes, cost-effectiveness and equitable access. [2,6,9]

Commercial AI Platforms for Automated Detection of Large Vessel Occlusion

Commercial artificial intelligence systems have helped the clinical adoption of AI-assisted LVO identification by incorporating automated image analysis into established stroke workflows. Unlike research algorithms, these systems offer real-time interpretation of CTA, worklist prioritization, automated alarms, image sharing and multidisciplinary collaboration [9].

Common platforms include Viz.ai which uses CTA-based LVO detection, automated alerts and mobile communication to accelerate image review and stroke team collaboration. Studies of implementation have shown reduced times for notification and treatment workflows RapidAI offers a multimodal platform that combines LVO detection with CT perfusion analysis and other imaging assessments needed to inform reperfusion decisions. Brainomix e-Stroke performs ASPECTS grading, LVO detection and collateral assessment and Aidoc is an automated triage and worklist prioritization system that flags suspected abnormalities for physician rapid review. Table 2 summarizes the main features of these platforms [2,9].

Performance comparisons should be taken with a grain of salt. Published studies differ widely in terms of patient population, definition of LVO, vascular regions, imaging protocol, reference standard, and outcome measures. Most are retrospective or single center with few direct independent head-to-head comparisons. Proprietary algorithms restrict transparency around model design, training data, and updates, making it difficult to compare models [1,9]. Commercial systems were most accurate for proximal anterior-circulation LVO and least consistent for distal, medium-vessel and posterior-circulation occlusions. Interchangeability between systems may be limited, and vendor-specific processing methods may potentially influence perfusion and other quantitative imaging data [1,8,9].

Successful deployment depends not only on diagnostic performance, but Real-world effectiveness depends on integration with imaging and communications systems, local stroke workflow, alert configuration, technical assistance, licensing fees and staff training. Therefore, the platform selection should be guided by local clinical needs and independent validation and not by accuracy measures alone [9]. Commercial AI platforms have moved LVO detection from experimental research to routine clinical decision support. But different testing methods and a lack of comparisons make it impossible to rank them definitively. Their relative therapeutic value has to be established by independent external validation, standardized reporting, prospective comparisons, and assessment of patient-centred and economic outcomes [2,9].

Platform	Principal stroke-imaging applications	Workflow role	Key strengths	Important limitations
Viz.ai	CTA-based LVO detection	Automated alerts, image sharing, multidisciplinary communication	Extensive workflow-oriented implementation evidence	Performance varies by occlusion location; proprietary system
RapidAI	LVO detection, CTP and multimodal imaging analysis	Imaging analysis and treatment decision support	Broad multimodal stroke assessment	Vendor-dependent processing; direct comparative evidence limited
Brainomix e-Stroke	LVO detection, ASPECTS, collateral assessment	Standardized multimodal stroke-imaging assessment	Integrates multiple imaging biomarkers	Comparative LVO-specific evidence remains heterogeneous
Aidoc	Detection and triage of suspected neurovascular emergencies	Worklist prioritization and clinical notification	Integrates AI triage into radiology workflow	Less focused on comprehensive stroke management

Abbreviations: AI, artificial intelligence; ASPECTS, Alberta Stroke Program Early CT Score; CTA, computed tomography angiography; CTP, CT perfusion; LVO, large vessel occlusion.

CHALLENGES, LIMITATIONS, AND ETHICAL ISSUES

While the diagnostic and workflow performance is promising, autonomous application AI-assisted LVO detection shows encouraging diagnostic and workflow performance, but substantial technological, clinical, ethical and regulatory hurdles remain. Current literature supports its role as a decision-support tool for clinicians rather than replacing expert interpretation, with performance dependent on occlusion characteristics, image quality, patient population and clinical context [1,8,10]. The variable precision in the vascular areas is a major problem. Most algorithms are trained and tuned on proximal anterior-circulation occlusions, especially ICA and M1 lesions. Distal, medium-vessel, posterior-circulation, and tandem occlusions are more difficult to detect. Motion artifacts, suboptimal contrast enhancement, vascular calcification and anatomic variability may further reduce the accuracy. These limitations are clinically relevant, as false-negative results could delay thrombectomy, and false-positive alerts could lead to unnecessary evaluations and alert fatigue [1,5,8].

Another big issue is generalizability. A plethora of algorithms have been developed using retrospective datasets from high-volume academic centers and may behave differently across different scanners, imaging protocols, patient groups, and health care systems. Some demographic groups or rare stroke cases may be underrepresented, which could lead to algorithmic bias. Therefore, validation studies in multiple centers, subgroup analysis and post-deployment surveillance are needed [1,7,8]. Models are still not very well explained. Saliency maps, Gradient-weighted Class Activation Mapping (Grad-CAM) and attention visualization methods improve transparency but do not fully clarify the prediction process of the deep learning models. This lack of interpretability can impact clinician trust, error investigation, and regulatory assessment [10,11].

Regulatory and medico-legal issues also remain unresolved. AI stroke imaging software is generally considered as Software as a Medical Device (SaMD). However, physicians, health care organizations or developers are at risk of erroneous or missed AI results, especially when algorithms are updated after deployment. Hence the need for clear institutional protocols, human-recorded oversight and ongoing performance evaluation [10]. There are other issues with data governance. AI-powered stroke networks require rapid sharing of imaging and clinical data between institutional, cloud-based and mobile platforms, as well as strong protections for patient privacy, cybersecurity, secure authentication and compliance with data-protection legislation [10].

Barriers to implementation are of particular relevance in LMICs where the cost of licensing, information technology infrastructure, network connectivity, technical assistance, and access to sophisticated imaging may limit uptake. Many algorithms are developed in well-resourced settings, and their performance and therapeutic impact may not easily translate to resource-limited situations [9,10].

Implementation is also influenced by human considerations. Automation bias can cause clinicians to depend too much on the AI's suggestions, while repeated false-positive alerts can erode trust in the system. But too much distrust can undermine any workflow advantages. Successful adoption requires defined responses to conflicting findings, routine performance audits, and clinical education [10]. The therapeutic value of AI-assisted detection of LVO depends not only on diagnostic accuracy but also on generalizability, transparency, safety, accountability, cost and equitable access. Combining these considerations with traditional performance measures is needed when evaluating AI-enabled stroke care. [1,8,10]

FUTURE DIRECTIONS

Next generation stroke systems with AI-help are predicted to evolve from stand-alone LVO detection to integrated decision-support platforms with imaging, clinical and process data. But advances in technology have to be matched by evidence of safety, generalizability and real patient benefit across a range of health settings [10,12]. Foundation models and self-supervised learning are promising ways to increase adaptability. Rather than training task-specific models on large annotated datasets, foundation models can learn general imaging representations and be adaptable to multiple tasks including LVO detection, vascular segmentation, ASPECTS scoring, collateral assessment, and outcome prediction. But although they promise to reduce annotation needs and increase transferability, they are yet to be proven in ordinary clinical practice [12].

Multimodal AI that integrates CTA with other imaging modalities, lab results, NIHSS scores, and EHRs could further improve decision support. Such methods may help to predict infarct progression, treatment response, hemorrhagic risk and functional outcome. The model complexity increases as well as the difficulty of bias, missing data and interpretability and

therefore prospective evaluation is needed [10,12]. Federated learning allows institutions to work together to train AI models without sharing patient-level data, which can improve model diversity and reduce privacy concerns. But there are still major challenges, including variability in imaging procedures, data quality, infrastructure and governance [12]

Generative AI and large language models may improve computer vision for automated reporting, clinical documentation, and interdisciplinary collaboration. Given the high stakes of acute stroke care, these apps will need to be thoroughly validated, with well-defined roles and ongoing human supervision [13].

Artificial intelligence can also be applied to prehospital stroke triage, integrating clinical evaluation tools, mobile technologies, wearable sensors, and portable imaging. Pre-hospital suspicion of LVO may allow direct transfer to thrombectomy-capable hospitals and avoid secondary transfer if it is outweighed by improved triage at the cost of some misclassification [10]. Future studies should be prospective, multicenter evaluations of real-world clinical effectiveness, rather than retrospective assessments of diagnostic accuracy. We need standardized reporting, independent external validation, head-to-head comparisons and evaluation in different demographics and health care systems. Outcomes should include functional recovery, mortality, safety, cost-effectiveness and equity, and diagnostic performance and workflow efficiency [1,7,8].

The future of AI in stroke treatment is bright, but it will be human-AI collaboration, not machine-only decision-making. AI should be an adjunct to clinical knowledge, improving the speed and consistency of decision making, and offering clear benefits without unacceptable diagnostic, ethical or socio-economic concerns [10,12,13].

Table 3. Current Challenges and Future Opportunities in AI-Assisted LVO Detection

Current Challenge	Clinical / Technical Implication	Future Opportunity
 Reduced performance for distal and posterior-circulation occlusions	False negatives may delay recognition of thrombectomy candidates; performance is less reliable than for proximal ICA/M1 LVO.	<ul style="list-style-type: none"> Improved architectures, multimodal imaging, and larger diverse training datasets.
 Limited external generalizability	Performance may decline across scanners, imaging protocols, institutions, and patient populations.	<ul style="list-style-type: none"> Multicenter external validation, standardized benchmarking, and postdeployment surveillance.
 Algorithmic bias	Underrepresented populations or uncommon stroke presentations may experience unequal diagnostic performance.	<ul style="list-style-type: none"> Diverse international datasets, subgroup analysis, and federated learning.
 Limited explainability	Black-box predictions may reduce clinician trust and complicate error analysis.	<ul style="list-style-type: none"> Explainable AI, uncertainty estimation, and interpretable outputs.
 False-positive alerts and automation bias	Alert fatigue, unnecessary review, or inappropriate reliance on AI may affect clinical decisions.	<ul style="list-style-type: none"> Human-in-the-loop workflows, optimized alert thresholds, clinician training, and regular auditing.
 Regulatory and medico-legal uncertainty	Responsibility for incorrect AI recommendations or missed diagnoses may be unclear.	<ul style="list-style-type: none"> Defined accountability frameworks, regulatory standards, and continuous post-market monitoring.
 Data privacy and cybersecurity	Cloud-based image sharing and communication create privacy and security risks.	<ul style="list-style-type: none"> Secure infrastructure, robust governance, privacy-preserving approaches, and federated learning.
 Cost and infrastructure requirements	Licensing, integration, maintenance, and technical support may restrict implementation, particularly in LMICs.	<ul style="list-style-type: none"> Health-economic evaluation, scalable deployment models, and resource-appropriate AI systems.
 Limited evidence for patient-centered outcomes	Workflow improvements do not necessarily demonstrate better functional recovery or survival.	<ul style="list-style-type: none"> Prospective multicenter trials assessing functional outcomes, mortality, safety, cost-effectiveness, and equity.
 Fragmented decision support	Current systems often focus on individual imaging or workflow tasks.	<ul style="list-style-type: none"> Integrated multimodal platforms combining imaging, clinical, laboratory, and potentially prehospital data.

Abbreviations: AI, artificial intelligence; ICA, internal carotid artery; LMICs, low- and middle-income countries; LVO, large vessel occlusion.

CONCLUSION

Artificial intelligence-assisted identification of large vessel occlusion has become a useful decision support tool in acute ischemic stroke. Currently the systems have a high diagnostic accuracy for proximal anterior circulation occlusions and have the ability to improve the image prioritization, specialist notification, interhospital communication and activation of thrombectomy pathways helping to reduce treatment delays.

However, AI should not replace expert clinical and radiological interpretation. However, performance for occlusions in the distal and posterior circulation is not as reliable. The reported accuracy depends on patient population, imaging protocol and validation setting. Other issues include false positive and false negative results, algorithmic bias, limited interpretability,

interoperability, regulatory and medico-legal issues, cost and unequal access. Regular reports show improvements in workflow, but evidence for an independent benefit on functional outcomes and death is sparse.

Future work should focus on prospective multicenter validation, standardization of reporting and independent comparison of commercial platforms, post-deployment surveillance and assessment of patient-centered outcomes, cost-effectiveness and equity. New technologies may enable AI to transition from image interpretation to integrated decision assistance for stroke but will require rigorous validation and ongoing clinical oversight. AI should be considered as an adjunct to expedite and streamline LVO detection, with the clinicians making the diagnosis and treatment decisions. The long-term effect will depend not only on the accuracy of the diagnosis, but on the ability to improve the quality efficiency and equity of stroke care.

FUNDING

This work received no funding.

DECLARATION OF COMPETING INTEREST

No conflicts of interests declared by the author.

REFERENCES

1. J Dantas et al. Artificial intelligence tools for large vessel occlusion detection: Systematic review and meta-analysis. *Neuroradiol* 2025;67(9):2399-2407. doi: 10.1007/s00234-025-03716-z.
2. Sarhan K, Azzam AY, Moawad HED, et al. Automated emergent large vessel occlusion detection with Viz.ai software and its impact on stroke workflow metrics and patient outcomes in stroke centers: A systematic review and meta-analysis *Transl Stroke Res.* 2025;16:2258-71. doi:10.1007/s12975-025-01354-0
3. SNIS Board of Directors. Heit JJ, Chaudhary N, Mascitelli JR, et al. Focused update of the guidelines for endovascular therapy for emergent large vessel occlusion: patients with basilar artery occlusion. *J Neurointerv Surg* 2024;16:752–756.
4. Nguyen TN et al. Mechanical thrombectomy in late presentation of anterior circulation large vessel occlusion stroke: a guideline from the Society of Vascular and Interventional Neurology Guidelines and Practice Standards Committee. *Stroke Vasc Interv Neurol* 2023;3(1). doi:10.1161/SVIN.122.000512.
5. DR Wayer et al Finding MeVO: Detecting intracranial medium-vessel occlusion on CT angiography. *Radiographics.* 2024;44(11): doi:10.1148/rg.240010.
6. Eljovich L, Dornbos D 3rd, Nickele C, et al. Artificial intelligence-based automated detection of emergent large vessel occlusion improves stroke workflow in a hub-and-spoke system of care. *J Neurointerv Surg.* 2022 Aug 1;14(8):704-8.
7. Matsoukas S, Morey J, Lock G et al Real-world prospective diagnostic test accuracy study of artificial intelligence software for detection of large vessel occlusion stroke on CT angiography *J Neurointerv Surg.* 2023;15(1):52-56.
8. Susanti L, et al. Accuracy of AI diagnostic tests for large vessel occlusion: A systematic review and meta-analysis *Neurol Res Int.* 2026;2026:5709868. doi:10.1155/2026/5709868.
9. M Dorochoicz et al. Artificial intelligence in stroke diagnosis: a scoping review of Brainomix e-Stroke, Aidoc, RapidAI and Viz.ai. *Medicina (Kaunas)* 2026;62(3):582. doi:10.3390/medicina62030582.
10. Heeralal VT et al. Artificial intelligence in stroke care: a narrative review of current applications in diagnostics, prediction and workflows. *Cureus.* 2025;17(9). doi:10.7759/cureus.93430.
11. Kousar T, Rahim MSM, S Iqbal, et al. Algorithms Using Deep Learning for Detection, Segmentation and Classification of Ischemic Stroke *Artif Intell Rev.* 2025;58:149. doi:10.1007/s10462-025-11119-8.
12. E. He et al. Foundation model for healthcare advancement: challenges, opportunities and future directions. *IEEE Rev Biomed Eng.* 2025;18:172-191. doi:10.1109/RBME.2024.3496744
13. Zhu XC, et al., Current landscape and future directions of generative large language models in stroke care: A scoping review. *J Med Internet Res.* 2025;13. doi: 10.2196/76636.

CITE THIS ARTICLE:

- **APA (7th edition):** Bakshi, I. (2026, August 27). *Artificial intelligence for automated detection of large vessel occlusion: State of the art, clinical applications and future perspectives.* *The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2607005>

- **Harvard:** Bakshi, I., 2026. *Artificial intelligence for automated detection of large vessel occlusion: State of the art, clinical applications and future perspectives.* *The Operating Room Global Journal (TORGJ)*, 2(3). Published 27 August. Available at: <https://doi.org/10.64573/torgj2607005>
- **Vancouver:** Bakshi I. Artificial intelligence for automated detection of large vessel occlusion: State of the art, clinical applications and future perspectives. *The Operating Room Global Journal (TORGJ)*. 2026 Aug 27;2(3). <https://doi.org/10.64573/torgj2607005>
- **MLA (9th edition):** Bakshi, Ishaan. "Artificial Intelligence for Automated Detection of Large Vessel Occlusion: State of the Art, Clinical Applications and Future Perspectives." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 27 Aug. 2026, <https://doi.org/10.64573/torgj2607005>
- **Chicago (Author-Date):** Bakshi, Ishaan. 2026. "Artificial Intelligence for Automated Detection of Large Vessel Occlusion: State of the Art, Clinical Applications and Future Perspectives." *The Operating Room Global Journal (TORGJ)* 2 (3), August 27. <https://doi.org/10.64573/torgj2607005>

Task Shifting And Safe Surgical Care In Rural Adamawa, Cameroon: A Cross-Sectional Provider Survey

Authors: Peter Matthew George^{1,2,3,4,5,6,8*}, Megbar Dessalegn^{7,8}

¹ Kesmonds International University, School of Health and Medical Sciences, Cameroon

² Taxila American University (TAU) Guyana

³ Central University of Nicaragua (UCN), Nicaragua

⁴ European Union of Medical Specialist (EUMS), Brussels

⁵ Department of General Surgery, Ngaoundéré Lutheran Norwegian Hospital, Ngaoundéré, Adamawa Region, Cameroon

⁶ Hospital De District St Jeanne Antide Thouret, GALAGALA-NGAOUNDAL, Adamawa Region Cameroon

⁷ Department of Surgery, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia

⁸ The Operating Room Global (TORG)

DOI: <https://doi.org/10.64573/torgj2608004>

ABSTRACT

Background/Objective: Safe surgical and anaesthesia care is essential for universal health coverage, yet rural sub-Saharan hospitals depend heavily on non-specialist providers. We assessed task-shifting practices, safety concerns and capacity-building priorities among perioperative providers in Cameroon's Adamawa Region.

Methods: In a descriptive cross-sectional survey, 20 surgical and anaesthesia providers from district and regional hospitals completed a structured questionnaire. Continuous variables were summarised as mean (standard deviation, SD) and median (range); categorical variables as frequencies and percentages; multiple-response items by separate counts, with exact binomial 95% confidence intervals (CIs) for key indicators.

Results: Mean age was 42.1 (SD 8.4) years; 16 respondents (80.0%) worked in district hospitals. Thirteen providers (65.0%; 95% CI 40.8–84.6) performed specialist-level tasks, most commonly anaesthesia administration (76.9%) and surgical procedures (61.5%). Although 12 (60.0%) reported formal task-shifting training, only 6 (30.0%) felt adequately trained; nine (45.0%) had a defined scope and nine (45.0%) received regular supervision. Fourteen respondents (70.0%; 95% CI 45.7–88.1) had witnessed adverse events related to task-shifted care, and only five (25.0%; 95% CI 8.7–49.1%) reported clearly defined referral pathways. Regular supervision and mentorship were the highest-priority intervention (75.0%).

Conclusion: Task shifting is common and perceived to improve access, but it is incompletely supported by training, supervision, equipment and referral systems. Structured task sharing with competency-based training, ongoing mentorship and verified patient-outcome monitoring is needed.

Keywords: Cameroon; capacity building; delivery of health care; rural health services; task shifting; workforce.

*Corresponding Author:

Dr. Peter Matthew George

drpmgeorge2020@gmail.com

Declaration:

Authors' Contribution:

P. M. George - study conception and design, data collection, analysis and manuscript drafting; M. Dessalegn - supervision, study design, interpretation and critical revision. Both authors approved the final manuscript.

Conflict of Interest: No conflict of interests.

Funding: No funding received.

Article History:

Received: 10-08-2026

Accepted: 25-08-2026

Available Online: 29-08-2026

QR access this Article



INTRODUCTION

Safe, timely and affordable surgical and anaesthesia care is increasingly recognised as an indispensable component of universal health coverage (UHC). Surgical conditions arise across the life course and include injuries, obstetric emergencies, congenital anomalies, infections, malignancies and acute abdominal conditions. When health systems cannot deliver essential operations promptly, otherwise treatable conditions may result in preventable death, long-term disability and catastrophic household expenditure. The Lancet Commission on Global Surgery estimated that five billion people worldwide lack access to safe, affordable surgical and anaesthesia care when needed, with the largest gaps concentrated in

low- and middle-income countries (LMICs) [1]. Subsequent modelling work has emphasised that access must be judged across timeliness, capacity, safety and affordability rather than by the mere presence of an operating theatre [2]. In 2015, World Health Assembly resolution WHA68.15 formally embedded emergency and essential surgical care and anaesthesia within UHC and urged member states to strengthen first-referral services, monitoring systems, referral pathways and the appropriate use of task sharing [3].

These issues are particularly acute in rural sub-Saharan Africa, where shortages and maldistribution of specialist surgeons, obstetricians and physician anaesthetists constrain service delivery. The Lancet Commission proposed that, by 2030, countries should aim for a workforce density of at least 20 surgical, obstetric and anaesthesia providers per 100,000 population, yet many low-income countries remain well below this threshold [1]. District hospitals are often the nearest facilities capable of performing caesarean section, emergency laparotomy, hernia repair and basic trauma procedures, yet they operate with thin and unevenly skilled workforces [4,11]. Across the region, non-physician clinicians, general medical officers and nurse anaesthetists have become an indispensable part of the perioperative workforce, frequently carrying clinical responsibility beyond their original training.

Task shifting, the rational redistribution of selected responsibilities from more highly specialised cadres to health workers with shorter or different training, within a system of competency development, supervision and accountability [5] has therefore become a pragmatic strategy for expanding access. In surgery and anaesthesia, it may involve trained general medical officers, non-physician clinicians, clinical officers, nurse anaesthetists or anaesthesia technicians delivering selected procedures under defined conditions. It is not intended to replace specialist care; rather, its safety depends on clear boundaries, training, supervision, referral mechanisms and clinical governance.

Cameroon reflects many of these challenges. A cross-sectional assessment of hospitals with high trauma burden identified substantial gaps in infrastructure, human resources, interventions, equipment and supplies relevant to emergency and essential surgical care [6]. A more recent scoping review of surgical, obstetric and anaesthesia policy in Cameroon called for stronger political prioritisation, baseline assessment and the formalisation of workforce strategies, including task shifting, within national surgical planning [7]. The Adamawa Region, in the central-eastern part of the country, combines rural geography, long referral distances and reliance on non-specialist personnel, but there is little published local evidence describing how task shifting actually functions on the ground.

Systematic reviews from sub-Saharan Africa suggest that, within carefully structured programmes, trained non-surgeon clinicians can achieve non-inferior outcomes for selected high-volume, lower-complexity procedures such as caesarean section and hernia repair [8,9]. However, the evidence is heterogeneous, procedure-specific and strongly dependent on context; it cannot be generalised to informal delegation or to anaesthesia, where data remain comparatively sparse [8]. Crucially, much of the existing literature comes from a handful of countries and rarely integrates facility readiness, provider training, supervision, referral barriers and frontline provider priorities in a single setting. Region-specific data are needed to design accountable capacity-building interventions and to move from informal task shifting driven by scarcity alone toward supported task sharing.

The aim of this study was therefore to assess existing surgical and anaesthesia task-shifting practices, perceived safety concerns and priority capacity-building needs among perioperative healthcare providers in the Adamawa Region of Cameroon. The specific objectives were to (1) describe the demographic and professional profile, workload and procedure involvement of participating providers; (2) determine the extent and nature of task-shifted responsibilities; (3) assess reported training, scope-of-practice definition, supervision and senior support; (4) identify safety challenges, adverse-event experience and referral barriers; and (5) prioritise capacity-building interventions from the provider perspective. We hypothesised that task shifting would be widespread but incompletely supported by formal governance structures.

METHODS

Study design

We conducted a descriptive cross-sectional provider survey using a structured questionnaire. The design was appropriate for establishing a provider-level baseline of reported practices, perceptions and priorities in an understudied setting. The analysed dataset comprised only de-identified, completed provider questionnaires; it did not include patient-level clinical records, facility-audit data or qualitative interview transcripts. We therefore made no causal claims about surgical morbidity, mortality or the effectiveness of any intervention, and the study is reported in line with the applicable strengthening-the-reporting principles for cross-sectional observational studies.

Setting and participants

The study was undertaken in the Adamawa Region of Cameroon, where rural geography, specialist shortages and referral constraints affect access to essential surgical and anaesthesia services. Eligible participants were healthcare providers who routinely participated in surgical or anaesthesia care, including specialist surgeons, general medical officers, non-physician clinicians, clinical officers, anaesthesia nurses, anaesthesia technicians and operating-theatre nurses. Staff without perioperative responsibilities, interns without independent clinical responsibility and short-term observers were excluded. Recruitment used an inclusive approach within accessible participating district and regional hospital services; every completed questionnaire in the supplied analysed workbook was included, giving an achieved sample of 20 providers. The number of eligible providers approached was not captured in the analysed workbook, so a response rate could not be calculated. Because the survey was exploratory, results are reported with transparent denominators and interpreted as patterns within the surveyed group rather than as population-level prevalence estimates.

Data collection and instrument

Data were collected using the structured Surgical and Anaesthesia Provider Questionnaire (Appendix). The instrument was developed for the study, drawing on WHO guidance on task shifting and safe surgery [5,16], and was organised into eight sections: demographic and professional information; facility and workload characteristics; task-shifting practices; training and capacity building; supervision and support; surgical safety and quality of care; referral and health-system support; and perceived impact and recommendations. It captured age, sex, professional cadre, qualification, clinical experience, facility level, monthly case participation, commonly performed procedures, task-shifted responsibilities, methods of skill acquisition, formal training exposure and its perceived adequacy, scope-of-practice definition, supervision type and frequency, access to senior support, surgical safety checklist use, complication documentation, witnessed adverse events, referral pathways and barriers, perceptions of health-system support and preferred capacity-building interventions. Several items allowed multiple responses; for the priority-interventions item respondents selected up to three measures they considered most likely to improve safety in their facility. The questionnaire was reviewed by the research team for face and content validity and piloted with a small group of clinicians outside the analysed sample to refine wording; no items were added or removed after pilot testing. Questionnaires were administered by trained data collectors and completed by consenting providers, then returned to the research team for double entry and consistency checks. The cleaned, de-identified dataset and an analysed frequency-distribution sheet formed the basis of this report.

Variables

Participant-profile variables included age, sex, professional cadre, qualification, years of clinical practice and years at the current facility. Service-involvement variables included facility level (district vs regional hospital), monthly case participation and procedures commonly performed or assisted. Task-shifting variables included whether the respondent performed responsibilities typically undertaken by specialists, the nature of those responsibilities, skill-acquisition methods and whether the scope of practice was formally defined. Training and supervision variables captured formal task-shifting training, its recency and perceived adequacy, supervisor type, supervision frequency and access to senior support during complications. Safety and referral variables covered checklist use, complication documentation, witnessed task-shift-related adverse events, clarity of referral pathways and referral barriers. Capacity-building variables measured perceived access benefit, health-system support and preferred interventions.

Data management and statistical analysis

Records were checked for completeness and analysed descriptively. Age, years of clinical practice and years at facility were summarised using means, standard deviations (SD), medians and ranges. Categorical variables were summarised as frequencies and percentages. For questions permitting multiple answers, each selected option was counted separately; percentages for these items therefore could sum to more than 100% and are based on the full denominator of 20 respondents unless otherwise stated. Exact binomial 95% confidence intervals (CIs) were calculated for key single-response indicators to indicate statistical uncertainty around proportions in this small sample. No inferential between-group comparisons were performed because the achieved sample was limited, the dataset lacked a comparison group and patient-level outcomes were not available. Analyses were conducted using R version 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria); the workbook was prepared in Microsoft Excel. The study was conceived within the Donabedian structure–process–outcome framework, which links the conditions of care (workforce, equipment, organisation), the processes of care (training, supervision, safety practices, referral) and patient outcomes [10].

Ethical approval

Participation was voluntary and based on written informed consent. The analysed dataset contained de-identified participant codes rather than names or direct identifiers, and results are reported in aggregate to reduce the risk of deductive identification, particularly for small professional groups. Electronic data were stored on password-protected devices accessible only to the authorised research team, and any paper records were held in locked storage. Participants retained the right to decline participation, omit items or withdraw without penalty.

Ethical review and approval were obtained from the Kesmonds Institute of Research and Innovation, Department of Research Publications and Internships, Cameroon, under the Kesmonds International Research Institute Cameroon, one of the bodies responsible for research approval in the Adamawa Region of Cameroon. The approval reference number was 0041022/SG/KIU. Appropriate administrative authorisations were obtained before participant recruitment.

RESULTS

Participant characteristics

The analysed dataset contained 20 complete provider questionnaires, all from providers who reported routine involvement in surgical or anaesthesia care. Mean age was 42.1 (SD 8.4) years (median 41.5; range 29–56). Respondents had a mean of 10.2 (SD 4.7) years of clinical practice and had worked at their current facility for a mean of 6.9 (SD 4.2) years. Thirteen (65.0%) were male, five (25.0%) female and two (10.0%) preferred not to state their sex. Sixteen (80.0%) worked in district hospitals and four (20.0%) in regional hospitals. Anaesthesia nurses were the largest cadre (6/20; 30.0%), followed by general medical officers (4/20; 20.0%), specialist surgeons and non-physician clinicians (3/20; 15.0% each), operating-theatre nurses (2/20; 10.0%), and one clinical officer and one anaesthesia technician (5.0% each) (Table 1; Figure 1).

Table 1. Demographic and professional characteristics of respondents (n = 20).

Characteristic	Category / summary	n	%
Age (years), mean (SD)	42.1 (8.4)	—	
Age (years), median (range)	41.5 (29–56)	—	
Clinical practice (years), mean (SD)	10.2 (4.7)	—	
Time at facility (years), mean (SD)	6.9 (4.2)	—	
Sex	Male	13	65.0
Sex	Female	5	25.0
Sex	Prefer not to say	2	10.0
Facility level	District hospital	16	80.0
Facility level	Regional hospital	4	20.0
Professional cadre	Anaesthesia nurse	6	30.0
Professional cadre	General medical officer	4	20.0
Professional cadre	Specialist surgeon	3	15.0
Professional cadre	Non-physician clinician	3	15.0
Professional cadre	Operating-theatre nurse	2	10.0
Professional cadre	Clinical officer	1	5.0
Professional cadre	Anaesthesia technician	1	5.0

Surgical workload and procedure involvement

Half of respondents (10/20; 50.0%) reported participating in 10–30 surgical cases per month, while seven (35.0%) participated in fewer than 10, two (10.0%) in 31–50 and one (5.0%) in more than 50. On the multiple-response procedure item, caesarean section was the most commonly selected procedure (17/20; 85.0%), followed by anaesthesia for surgery (14/20; 70.0%), minor surgical procedures (13/20; 65.0%), laparotomy and hernia repair (12/20; 60.0% each), and trauma surgery (11/20; 55.0%) (Table 2). Respondents thus contributed across obstetric, emergency and general surgical care.

Table 2. Surgical workload and procedure involvement. *Multiple-response item; percentages may sum to >100%.

Domain	Category	n	%
Monthly cases	<10	7	35.0

Monthly cases	10–30	10	50.0
Monthly cases	31–50	2	10.0
Monthly cases	>50	1	5.0
Procedure*	Caesarean section	17	85.0
Procedure*	Anaesthesia for surgery	14	70.0
Procedure*	Minor surgical procedures	13	65.0
Procedure*	Laparotomy	12	60.0
Procedure*	Hernia repair	12	60.0
Procedure*	Trauma surgery	11	55.0

Task-shifting practices, training and supervision

Thirteen providers (65.0%; 95% CI 40.8–84.6) reported performing responsibilities typically undertaken by specialists. Among these 13, anaesthesia administration was the most frequently selected shifted responsibility (10/13; 76.9%), followed by surgical procedures (8/13; 61.5%), preoperative assessment (6/13; 46.2%), postoperative management (4/13; 30.8%) and emergency decision-making (4/13; 30.8%) (Figure 2). Skill-acquisition routes were mixed: formal training programmes were reported by 13 (65.0%), short courses or workshops and on-the-job training by 11 each (55.0%), informal mentorship by 10 (50.0%) and self-learning by six (30.0%).

Although 12 respondents (60.0%; 95% CI 36.1–80.9) reported having received formal task-shifting training, only six (30.0%) felt adequately trained for their current tasks; nine (45.0%) felt partially trained and five (25.0%) inadequately trained. A formally defined scope of task-shifted practice was reported by nine (45.0%; 95% CI 23.1–68.5), was absent for seven (35.0%) and was uncertain for four (20.0%). Regular supervision was received by nine (45.0%; 95% CI 23.1–68.5), while 11 (55.0%) did not receive it; supervision frequency was monthly for six (30.0%), never for five (25.0%), rarely for four (20.0%), daily for three (15.0%) and weekly for two (10.0%). Access to senior support during complications was reported as always by seven (35.0%), sometimes by 10 (50.0%) and rarely or never by three (15.0%) (Table 3; Figure 2).

Table 3. Task-shifting, training and supervision indicators.

Indicator	Category	n	%
Performs task-shifted responsibilities	Yes	13	65.0
Performs task-shifted responsibilities	No	7	35.0
Received formal task-shifting training	Yes	12	60.0
Received formal task-shifting training	No	8	40.0
Perceived training adequacy	Adequate	6	30.0
Perceived training adequacy	Partial	9	45.0
Perceived training adequacy	Inadequate	5	25.0
Scope formally defined	Yes	9	45.0
Scope formally defined	No	7	35.0
Scope formally defined	Not sure	4	20.0
Receives regular supervision	Yes	9	45.0
Receives regular supervision	No	11	55.0
Senior support for complications	Always	7	35.0
Senior support for complications	Sometimes	10	50.0
Senior support for complications	Rarely/never	3	15.0

Safety processes, adverse events and referral arrangements

Use of the surgical safety checklist was reported as consistent by nine respondents (45.0%), intermittent by nine (45.0%) and absent by two (10.0%). Seventeen (85.0%; 95% CI 62.1–96.8) reported that perioperative complications were routinely documented, although self-reported documentation could not be verified against clinical records. Fourteen respondents (70.0%; 95% CI 45.7–88.1) had witnessed adverse events related to task-shifted care; among the 13 who personally performed shifted responsibilities, 11 (84.6%) reported such experience. This is a descriptive observation of provider experience, not a verified clinical event rate.

Referral arrangements emerged as a particular weakness. Only five respondents (25.0%; 95% CI 8.7–49.1) stated that referral pathways for complex cases were clearly defined. On the multiple-response item, transport limitations were the most frequently selected barrier (15/20; 75.0%), followed by cost to patients (13/20; 65.0%), delayed decision-making (12/20; 60.0%)

and communication gaps (8/20; 40.0%). When asked whether the health system supported safe task shifting, half (10/20; 50.0%) answered “partially,” while five (25.0%) answered “yes” and five (25.0%) “no.” Despite these concerns, 14 respondents (70.0%; 95% CI 45.7–88.1) agreed or strongly agreed that task shifting had improved access to surgical care (Table 4).

Table 4. Selected safety, referral and health-system indicators with exact 95% confidence intervals.

Indicator	n/N	%	Exact 95% CI
Performs task-shifted responsibilities	13/20	65.0	40.8–84.6
Received formal task-shifting training	12/20	60.0	36.1–80.9
Scope formally defined	9/20	45.0	23.1–68.5
Receives regular supervision	9/20	45.0	23.1–68.5
Complications routinely documented	17/20	85.0	62.1–96.8
Witnessed task-shift-related adverse events	14/20	70.0	45.7–88.1
Referral pathways clearly defined	5/20	25.0	8.7–49.1
Task shifting improved access (agree/strongly agree)	14/20	70.0	45.7–88.1

Safety challenges and capacity-building priorities

On the multiple-response item on safety challenges, equipment shortages were most frequently reported (12/20; 60.0%), followed by staff shortages (11/20; 55.0%), lack of supervision (10/20; 50.0%), inadequate training (9/20; 45.0%) and delayed referrals (9/20; 45.0%) (Table 5; Figure 3). For capacity-building, respondents selected up to three priorities. Regular supervision and mentorship ranked first (15/20; 75.0%), followed by improved equipment supply (13/20; 65.0%), strengthened referral systems (11/20; 55.0%), structured training programmes (11/20; 55.0%) and clear clinical guidelines (10/20; 50.0%) (Table 5; Figure 4).

Table 5. Reported safety challenges, referral barriers and capacity-building priorities. *Multiple-response items; percentages may sum to >100%.

Domain	Item	n	%
Safety challenge*	Equipment shortages	12	60.0
Safety challenge*	Staff shortages	11	55.0
Safety challenge*	Lack of supervision	10	50.0
Safety challenge*	Inadequate training	9	45.0
Safety challenge*	Delayed referrals	9	45.0
Referral barrier*	Transport limitations	15	75.0
Referral barrier*	Cost to patients	13	65.0
Referral barrier*	Delayed decision-making	12	60.0
Referral barrier*	Communication gaps	8	40.0
Priority intervention*	Regular supervision and mentorship	15	75.0
Priority intervention*	Improved equipment supply	13	65.0
Priority intervention*	Strengthened referral systems	11	55.0
Priority intervention*	Structured training programmes	11	55.0
Priority intervention*	Clear clinical guidelines	10	50.0

DISCUSSION

This cross-sectional survey of 20 perioperative providers in rural Adamawa found that task shifting is a common, operationally important feature of surgical and anaesthesia service delivery and is widely perceived to improve access. Almost two-thirds of respondents performed responsibilities normally associated with specialist practice, and 70% agreed that task shifting had expanded access to care. Yet these access gains were accompanied by consistent weaknesses in the supporting system: only 30% felt adequately trained, fewer than half had a formally defined scope or received regular

supervision, 70% had witnessed adverse events related to task-shifted care, and only one quarter reported clearly defined referral pathways. Providers' proposed solutions were correspondingly systemic supervision and mentorship ranked above additional training alone reinforcing the case for structured task sharing rather than unsupported redistribution of work.

Task shifting as a response to access constraints

The breadth of procedure involvement we observed caesarean section, anaesthesia, laparotomy, hernia repair, minor surgery and trauma mirrors the essential caseload of first-referral hospitals in sub-Saharan Africa and is consistent with earlier observations that surgical task shifting already functions as a de facto adaptation to workforce scarcity [4,11]. Anaesthesia was both the largest single professional group (30% of respondents) and the most frequently shifted responsibility among those performing specialist-level tasks, which is noteworthy because evidence for anaesthesia task shifting remains sparser and more conflicting than for operative delegation [8]. The predominance of caesarean section also underscores the overlap between surgical and obstetric care at district level and the importance of integrating task-sharing strategies within broader emergency obstetric and surgical system strengthening. The 70% who perceived improved access aligns with the central rationale for task sharing in WHO guidance [5] and with modelling indicating that workforce redistribution can extend the reach of essential surgery [2]. Perceived access benefit is not, however, evidence of clinical safety or effectiveness. Systematic reviews suggest that non-specialists achieve comparable outcomes for selected procedures only within structured programmes with defined caseloads, competency-based training and ongoing supervision [8,9]; they do not validate informal delegation.

Training, scope of practice and supervision

A central finding was the gap between exposure to training and confidence in it. Although 60% reported some formal task-shifting training, only 30% felt adequately prepared, and 70% reported no or only partial preparation. Formal scope definition and regular supervision each reached only 45%, and a quarter of respondents never received supervision. This matters because the literature consistently identifies clear practice boundaries, competency assessment and sustained supervision as the active ingredients that make task shifting safe [5,8,9,12]. Reviews of non-physician clinician surgery in sub-Saharan Africa have highlighted professional, regulatory, training, resource and sustainability barriers [12], and evaluations of surgical supervision models have shown that mentorship relationships build competence, help providers recognise their limits and create feedback loops for systemic problems [13]. The Adamawa findings suggest that the region should not rely on one-off workshops or informal apprenticeship. Training should be paired with documented skills assessment, written escalation criteria and continuing, structured mentorship, preferably linking district teams with specialist surgeons and anaesthetists at regional centres.

Safety processes and reported adverse events

Safety-process findings were mixed. Most respondents reported routine complication documentation, and 90% reported that the surgical safety checklist was used at least intermittently, providing a foundation for quality improvement. However, intermittent checklist use is not equivalent to reliable completion, and self-reported documentation cannot confirm completeness or accuracy; both should be audited against clinical records. The most concerning signal was that 70% of respondents, and 85% of those personally performing shifted tasks had witnessed adverse events related to task-shifted care. This item captures experience rather than a measured incidence rate and may reflect events across a career rather than a defined period; it cannot be used to infer causation. Nevertheless, it is a clear warning that frontline providers perceive avoidable harm. The WHO surgical safety checklist has been shown to reduce morbidity and mortality when implemented with genuine team engagement [14], but checklists cannot substitute for equipment, competence, supervision or referral. Structured incident reporting with standard definitions, confidential morbidity and mortality review, and patient-record audit are needed to convert this signal into actionable learning and to establish a baseline against which improvement can be measured.

Referral barriers and health-system readiness

Referral was the clearest structural weakness: three-quarters of respondents described complex-case pathways as unclear, and transport, cost and delayed decision-making were the most frequently cited barriers. This is particularly important because the safety of task shifting depends on recognising the limits of local care and escalating appropriately; a provider may be competent for selected procedures but still require dependable transport, communication and a receiving facility prepared to accept complex cases. These findings fit the "structure" component of the Donabedian framework [10]: workforce redistribution cannot fully compensate for weak equipment, staffing and referral networks. They are consistent with earlier Cameroonian facility assessments documenting infrastructure, equipment and supply gaps [6] and with regional analyses identifying referral delays as a driver of poor surgical outcomes [11]. A practical referral-improvement plan

covering named escalation contacts, receiving-facility communication, transport coordination and attention to patient costs should be considered a core component of any safe task-sharing model, not an optional add-on.

Capacity-building priorities

Notably, providers did not ask only for more training. Their top priority was regular supervision and mentorship, followed by equipment supply, strengthened referral systems, structured training and clear clinical guidelines. This ordering closely maps the problems they reported and supports a comprehensive capacity-building package rather than isolated educational interventions. It echoes WHO recommendations that task shifting be accompanied by training, regulation, quality assurance and appropriate resourcing [5], and the global movement to integrate emergency, critical and operative care within UHC [15]. From a policy perspective, the data support formal recognition of task sharing as a governed health-system strategy, with authorised responsibilities, supervision requirements, monitoring indicators and mechanisms for continuing professional development embedded in national surgical, obstetric and anaesthesia planning.

STRENGTHS AND LIMITATIONS

The study has several strengths. It addresses a documented evidence gap in rural Cameroon by combining data on task-shifting prevalence, training, supervision, safety, referral and provider priorities in a single survey, and it reports exact confidence intervals to communicate uncertainty transparently. The cadres represented anaesthesia nurses, medical officers, non-physician clinicians and surgeons reflect the perioperative teams that actually deliver care in district hospitals. Several limitations must, however, be considered. The sample was small ($n = 20$) and exploratory, and the number of eligible providers approached was not recorded, so the response rate and representativeness cannot be determined; the findings should be interpreted as patterns within the surveyed group rather than prevalence estimates for Adamawa as a whole. The dataset recorded facility level but not unique facility identifiers, precluding inter-facility comparison. Responses were self-reported and subject to recall and social-desirability bias, and multiple-response items indicate the frequency with which concerns were selected rather than their severity. Most importantly, the dataset did not include facility audits, patient records, perioperative mortality, complication rates or referral-delay durations, so the study cannot establish the clinical effectiveness or safety of task shifting. The witnessed-adverse-event finding, in particular, is a provider perception rather than a verified event rate. These limitations define a clear agenda for the next phase of research.

IMPLICATIONS FOR PRACTICE, POLICY AND FUTURE RESEARCH

For clinical practice, participating services should agree a minimum safe task-sharing package comprising written scope-of-practice guidance, procedure limits and escalation criteria, consistent checklist use, structured complication documentation and routine case review. For education, training should be competency based, assessed in supervised practice and reinforced through refresher sessions and mentorship rather than attendance certificates alone. For management, the equipment and referral findings justify a prioritised facility-readiness audit, covering oxygen, sterilisation, essential instruments, blood access and infection prevention and a practical referral-improvement plan. For policy, the survey supports formal recognition of task sharing within regional and national surgical plans, with defined responsibilities, supervision standards and quality indicators. Future research should combine facility-readiness audits with prospective patient-level data on surgical volume, referral delays, postoperative complications and perioperative mortality, ideally before and after a documented capacity-building intervention, and should expand to larger, multi-facility samples that allow comparison across hospital levels. Such work should examine how specific structural supports, defined scope, supervision frequency and equipment availability, relate to objectively measured process and outcome indicators, moving beyond provider perception to test the structure–process–outcome logic that guided this study. Implementation-science approaches, including stepped-wedge or hybrid effectiveness designs, would be well suited to evaluating the kind of multicomponent capacity-building package prioritised by respondents, while qualitative methods could illuminate the professional, regulatory and motivational factors that determine whether task sharing is accepted and sustained over time.

CONCLUSION

Task shifting is a common and, from the provider perspective, access-enhancing feature of surgical and anaesthesia care in rural Adamawa. It is, however, incompletely supported: fewer than one in three providers felt adequately trained, fewer than half had a defined scope or regular supervision, adverse events were widely witnessed, and referral pathways were usually unclear. The appropriate response is neither to abandon task shifting nor to expand it informally, but to formalise it

as structured task sharing with clearly defined responsibilities, competency-based training, reliable mentorship, functional equipment, consistent safety processes and dependable referral pathways. These findings provide a practical baseline for capacity-building interventions and for subsequent evaluation using verified clinical outcomes.

ACKNOWLEDGMENTS

The authors thank The Operating Room Global (TORG) Global Research Fellowship Programme for the academic platform and mentorship supporting this work. We are grateful to the hospital managers, surgical and anaesthesia teams, data collectors and, above all, the participating providers in the Adamawa Region whose contributions made this study possible. We also thank colleagues and family members who encouraged the work.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

ARTIFICIAL INTELLIGENCE USE DECLARATION

Artificial intelligence tools were used to support language editing, formatting, structural organization and preparation of data visualizations. The authors retained responsibility for study design, ethical conduct, source verification, dataset validation, interpretation, scientific decisions and final manuscript approval. AI tools were not used to create participant data or patient-level clinical outcomes.

FUNDING STATEMENT

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. The TORG fellowship provided mentorship and academic structure but had no role in study design, data analysis, interpretation or the decision to submit the manuscript.

DATA AVAILABILITY

The de-identified analysed dataset supporting the findings of this study is available from the corresponding author upon reasonable request, subject to applicable confidentiality and ethical constraints.

AUTHORS' CONTRIBUTIONS

Peter Matthew George conceived and designed the study, oversaw data collection, performed the descriptive analysis and drafted the manuscript. Megbar Dessalegn supervised the study, contributed to study design and interpretation, and critically revised the manuscript. Both authors approved the final version and agreed to be accountable for all aspects of the work.

REFERENCES

1. Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet*. 2015;386(9993):569–624.
2. Alkire BC, Raykar NP, Shrimel MG, Weiser TG, Bickler SW, Rose JA, et al. Global access to surgical care: a modelling study. *Lancet Glob Health*. 2015;3(6):e316–23.
3. World Health Organization. WHA68.15: Strengthening emergency and essential surgical care and anaesthesia as a component of universal health coverage. Geneva: WHO; 2015.
4. Chu K, Rosseel P, Gielis P, Ford N. Surgical task shifting in sub-Saharan Africa. *PLoS Med*. 2009;6(5):e1000078.
5. World Health Organization. Task shifting: rational redistribution of tasks among health workforce teams—global recommendations and guidelines. Geneva: WHO; 2008.
6. Kouo-Ngamby M, Juillard C, Stevens KA, Ekeke N, Bryant L, Lee J, et al. A cross-sectional survey of emergency and essential surgical care capacity among hospitals with high trauma burden in a Central African country. *BMC Health Serv Res*. 2015;15:478.
7. Agoubi L, Carvalho M, Fewer S, Oke R, Fabo B, Daya L, et al. Integrating political prioritisation into national surgical planning: a scoping review of surgical, obstetric and anaesthesia care in Cameroon. *BMJ Glob Health*. 2024;9:e014730.

8. Bognini MS, Oko CI, Kebede MA, Ifeanyichi MI, Singh D, Hargest R, et al. Assessing the impact of anaesthetic and surgical task-shifting globally: a systematic literature review. *Health Policy Plan.* 2023;38(8):960–94.
9. Ryan I, Shah KV, Barrero CE, Uamunovandu T, Ilbawi A, Swanson J. Task shifting and task sharing to strengthen the surgical workforce in sub-Saharan Africa: a systematic review of the existing literature. *World J Surg.* 2023;47(12):3070–80.
10. Donabedian A. The quality of care: how can it be assessed? *JAMA.* 1988;260(12):1743–8.
11. Kruk ME, Wladis A, Mbembati N, Ndao-Brumblay SK, Hsia RY, Galukande M, et al. Human resource and funding constraints for essential surgery in district hospitals in Africa: a retrospective cross-sectional survey. *PLoS Med.* 2010;7(3):e1000242.
12. van Heemskerken P, Broekhuizen H, Gajewski J, Brugha R, Bijlmakers L, Borgstein E. Barriers to surgery performed by non-physician clinicians in sub-Saharan Africa—a scoping review. *Hum Resour Health.* 2020;18:51.
13. Pittalis C, Brugha R, Bijlmakers L, Mwapasa G, Borgstein E, Gajewski J, et al. Evaluation of a surgical supervision model in three African countries: protocol for a prospective mixed-methods controlled pilot trial. *Pilot Feasibility Stud.* 2019;5:25.
14. Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat AHS, Dellinger EP, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med.* 2009;360(5):491–9.
15. World Health Organization. WHA76.2: Integrated emergency, critical and operative care for universal health coverage and protection from health emergencies. Geneva: WHO; 2023.
16. World Health Organization. WHO guidelines for safe surgery 2009: safe surgery saves lives. Geneva: WHO; 2009.

FIGURES

Figure 1. Professional cadre distribution of respondents (n = 20)

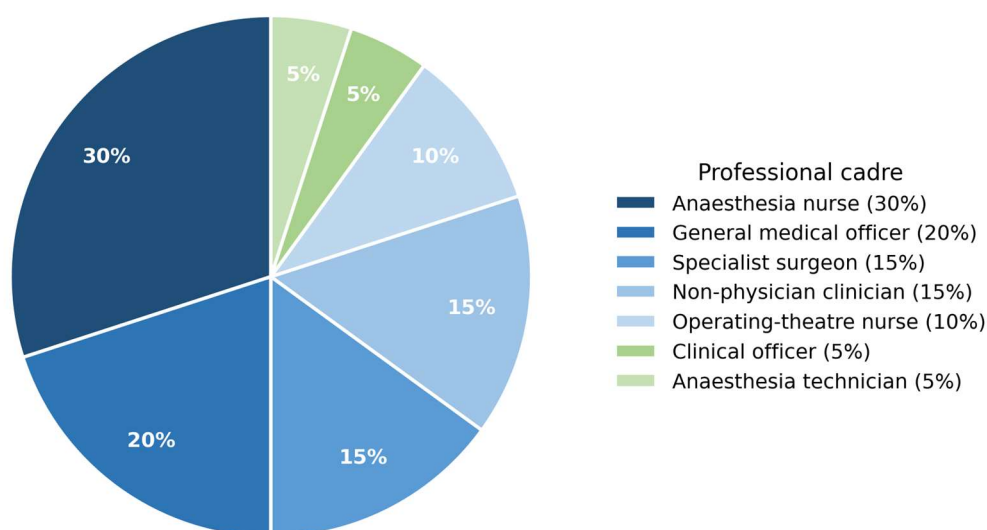


Figure 1. Professional cadre distribution of respondents (n = 20). Percentages use N = 20 as the denominator.

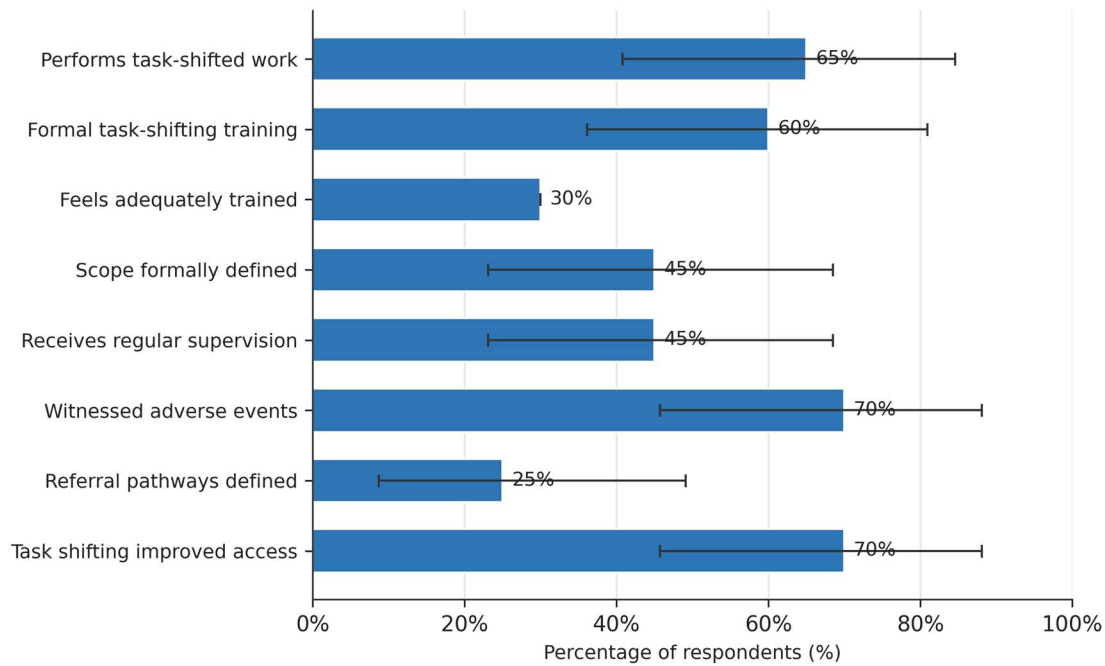
Figure 2. Selected task-shifting, safety and governance indicators (n = 20)

Figure 2. Selected task-shifting, safety and governance indicators (n = 20). Bars show the percentage of all respondents; whiskers show exact 95% confidence intervals where available (see Table 4).

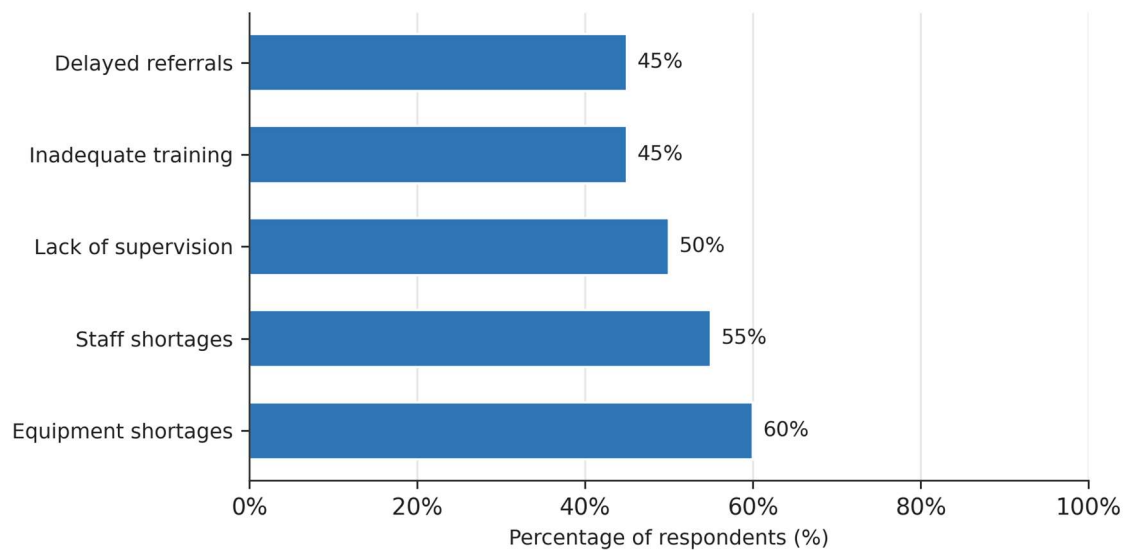
Figure 3. Reported safety challenges affecting task-shifted care (n = 20)

Figure 3. Reported safety challenges affecting task-shifted care (n = 20). Multiple responses permitted; percentages may sum to more than 100%.

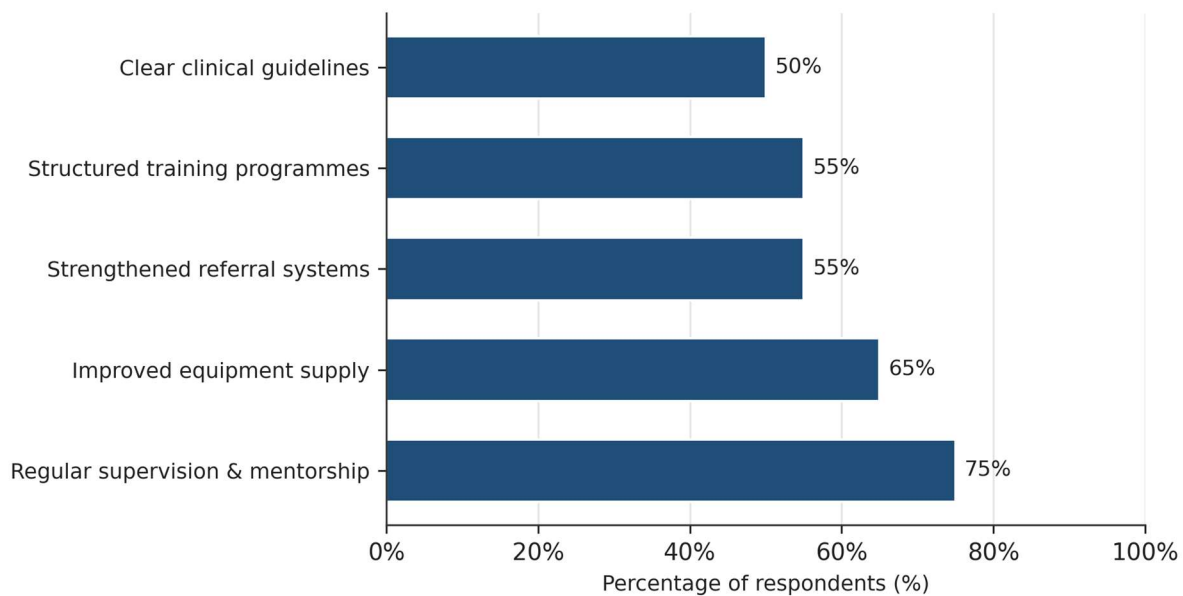
Figure 4. Priority capacity-building interventions (n = 20)

Figure 4. Priority capacity-building interventions (n = 20). Respondents selected up to three priorities; percentages may sum to more than 100%.

CITE THIS ARTICLE:

- **APA (7th edition):** George, P. M., & Dessalegn, M. (2026, August 29). *Task shifting and safe surgical care in rural Adamawa, Cameroon: A cross-sectional provider survey*. *The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2608004>
- **Harvard:** George, P.M. and Dessalegn, M., 2026. *Task shifting and safe surgical care in rural Adamawa, Cameroon: A cross-sectional provider survey*. *The Operating Room Global Journal (TORGJ)*, 2(3). Published 29 August. Available at: <https://doi.org/10.64573/torgj2608004>
- **Vancouver:** George PM, Dessalegn M. Task shifting and safe surgical care in rural Adamawa, Cameroon: A cross-sectional provider survey. *The Operating Room Global Journal (TORGJ)*. 2026 Aug 29;2(3). <https://doi.org/10.64573/torgj2608004>
- **MLA (9th edition):** George, Peter Matthew, and Megbar Dessalegn. "Task Shifting and Safe Surgical Care in Rural Adamawa, Cameroon: A Cross-Sectional Provider Survey." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 29 Aug. 2026, <https://doi.org/10.64573/torgj2608004>
- **Chicago (Author-Date):** George, Peter Matthew, and Megbar Dessalegn. 2026. "Task Shifting and Safe Surgical Care in Rural Adamawa, Cameroon: A Cross-Sectional Provider Survey." *The Operating Room Global Journal (TORGJ)* 2 (3), August 29. <https://doi.org/10.64573/torgj2608004>

Impact Of The Covid-19 Pandemic On Adult Literacy Trends In Pakistan: A Pre-Post Comparative Time-Series Analysis (2017-2024)

Authors: Muhammad Wajid Munir^{1,2,3*}, Adebisola Adenike Owokole^{3,4,5}

¹ Chaudhary Pervaiz Elahi Institute of Cardiology (CPEIC), Wazirabad, Punjab, Pakistan.

² Sialkot Medical College, Sialkot, Punjab, Pakistan

³ The Operating Room Global (TORG)

⁴ The Robotic Global Surgical Society (TROGSS)

⁵ University of Limerick (UL)

DOI: <https://doi.org/10.64573/torgj2608002>

***Corresponding Author:**

Muhammad Wajid Munir
wajidmunir65@gmail.com

Declaration:

Authors' Contribution:

MWM: Conceptualization, Methodology, Analysis, Investigation, Data Curation, Writing; AAO: Supervision, Methodology Review & Editing.

Conflict of Interest: No conflict of interests.

Funding: No funding received.

Article History:

Received: 10-08-2026
Accepted: 16-09-2026
Available Online: 21-09-2026

QR access this Article



ABSTRACT

Background: Pakistan entered the COVID-19 pandemic with substantial literacy inequalities. In 2019, the national adult literacy rate was 62.35%, compared with 72.97% among males and 51.73% among females; rural literacy was 52.18% compared with 76.54% in urban areas. School closures and limited access to remote learning occurred in a setting with marked urban–rural digital inequality.

Objective: To describe changes in adult literacy in Pakistan before, during, and after the COVID-19 pandemic using national and provincial secondary data from 2017 to 2024, with disaggregation by sex, residence, and province.

Methods: This ecological secondary-data time-series analysis used data from the Pakistan Bureau of Statistics, Pakistan Social and Living Standards Measurement Survey, UNESCO Institute for Statistics, and Ministry of Federal Education and Professional Training. Trends were examined descriptively across pre-pandemic (2017–2019), pandemic (2020–2021), and recovery (2022–2024) phases. Percentage-point changes were calculated against the 2019 baseline. The 2020 national and disaggregated values were obtained by linear interpolation because the routine PSLM round was not conducted. A descriptive sensitivity analysis compared the pre-pandemic mean with the observed 2021 value and the 2020–2021 mean; exploratory bootstrap intervals were used only to show the instability of these aggregate mean differences.

Results: National adult literacy declined from 62.35% in 2019 to 59.94% in 2021, a reduction of 2.41 percentage points. By 2024, the national rate had increased to 64.51%, 2.16 percentage points above the 2019 baseline. From 2019 to 2021, literacy declined by 2.59 percentage points among males and 2.32 percentage points among females; urban and rural literacy declined by 2.89 and 2.21 percentage points, respectively. Sindh had the largest provincial decline (–3.2 percentage points), while Balochistan remained the lowest-performing province in 2021 (40.7%).

Conclusion: Pakistan's adult literacy trajectory showed a pandemic-period decline followed by national recovery by 2024. Recovery was uneven, and substantial gender, urban–rural, and provincial inequalities remained. The findings support targeted literacy-recovery strategies while requiring cautious interpretation because the study uses aggregate secondary data and cannot establish causality.

Keywords: COVID-19, literacy trends, Pakistan, pre-post comparative analysis, education disruption, SDG 4.

INTRODUCTION

Literacy is a foundational factor of national development, shaping employment opportunities, health outcomes, and civic participation across generations. Over the two decades preceding the pandemic, Pakistan's national adult literacy rate, population aged 15 years and above rose from approximately 54% in 2009 to 62.35% in 2019, A meaningful improvement

that nonetheless concealed persistent structural inequalities. In 2019, female literacy stood at 51.73% compared with 72.97% for males, rural literacy was 52.18% against 76.54% in urban areas, and provincial rates ranged from 43.2% in Balochistan to 80.4% in the Islamabad Capital Territory (ICT). An estimated 20.3 million children of school age remained out of school in Pakistan in 2019, one of the highest absolute counts globally. Pakistan had committed to the United Nations Sustainable Development Goal 4 (SDG 4), calling for inclusive, equitable quality education for all by 2030, a trajectory already under strain before the pandemic.

When COVID-19 led to nationwide school closures in March 2020, institutions in Pakistan remained closed for between 60 and 76 weeks depending on the province. The government's primary emergency response was the Teleschool satellite-television channel. However, a Pakistan Bureau of Statistics household survey conducted in 2020 found that only approximately 36% of school-aged children had access to a television, radio, or internet-connected device at home. Rural household internet access was approximately 12%, compared with 47% in urban areas, reflecting a pronounced digital divide that severely limited the reach of substitute learning modalities.

This study addresses three evidence gaps. First, few published studies have unified national and provincial adult literacy data from 2017 to 2024 into a single harmonised time series drawing concurrently on Pakistan's major statistical sources. Second, national and provincial adult-literacy trajectories have not been described together at this temporal resolution using a consistent pre-pandemic baseline. Third, the relationship between provincial school-closure duration and literacy change has not been systematically described for Pakistan at provincial level with disaggregated data.

This study aimed to assess shifts in adult literacy patterns in Pakistan prior to and following the COVID-19 pandemic, utilizing national and provincial secondary data from 2017 to 2024, categorized by gender, urban-rural status, and province, to establish an evidence foundation for equity-centred literacy recovery strategies.

METHODOLOGY

Study Design and Setting

This is an ecological secondary-data time-series analysis employing a retrospective, descriptive, pre-post comparative observational design at the population level. The COVID-19 pandemic (March 2020 to December 2021) is treated as the index event dividing the study period into three phases: pre-pandemic (2017–2019), pandemic (2020–2024), and recovery (2022–2024).

Population, Data Sources, and Sampling

The study population comprised persons aged 15 years and above represented in Pakistan's national literacy datasets. No primary sampling was conducted. The analysis used the national adult literacy series for 2017–2024, sex- and residence-disaggregated national series, provincial estimates available at the reported survey time points, annual out-of-school estimates, and the documented digital-access and school-closure indicators. Provincial estimates were not extrapolated for years without a corresponding survey round; only reported values were retained.

Data Validity, the 2020 Gap, and Ethical Considerations

Because the routine 2020 PSLM round was not conducted because of pandemic disruption, the national and disaggregated 2020 values were estimated by linear interpolation between the corresponding 2019 and 2021 values and are marked with an asterisk in the relevant tables. These interpolated values are presented only to describe the trajectory. The final analytical series uses the 15+ adult-literacy denominator. Where a source is reported on a 10+ basis, the reproducible conversion protocol is $L(15+) = [L(10+) \times P(10+) - L(10-14) \times P(10-14)] / P(15+)$, where the population and age-specific literacy inputs are taken from the corresponding Pakistan Bureau of Statistics age-specific tables.³⁰ The protocol is documented for reproducibility; no undocumented conversion was applied to the 12 source-extraction records reproduced in Supplementary File S1. PSLM survey data were prioritised when a complete survey round was available; PBS Labour Force Survey annual bulletins provided intermediate-year information; UIS was used for source comparison and cross-validation; and MoEPT administrative data were used for out-of-school children and school-closure indicators.

Statistical Analysis

The analysis was performed using SPSS Version 26 and Microsoft Excel. Descriptive statistics characterised literacy trends across the study period and disaggregation dimensions. Percentage-point (pp) changes were calculated against the 2019 PSLM baseline, with the principal descriptive comparison defined a priori as the observed change from 2019 (62.35%) to

2021 (59.94%). Because the available annual observations are aggregate population-level estimates, the phase-specific series contain few observations, and the 2020 value is interpolated, no formal hypothesis test or standardised inferential effect size was applied.

Table 4 presents a descriptive sensitivity analysis using the pre-pandemic mean (2017–2019), the observed 2021 value, and the mean of the 2020–2021 pandemic-period values. Exploratory 95% bootstrap intervals were generated by resampling annual observations within each phase (100,000 resamples; fixed seed 2026). These intervals are presented as a sensitivity assessment of the instability of the aggregate mean difference and are not interpreted as formal population-level inferential estimates. Interpretation therefore focuses on observed trends, point-to-point percentage-point changes, and the documented limitations of the ecological design. No causal effect of COVID-19 is inferred from these descriptive comparisons.

RESULTS

National Literacy Trends

National adult literacy increased from 59.13% in 2017 to 62.35% in 2019, a pre-pandemic gain of 3.22 percentage points over two years. During the pandemic period, the national rate declined to an estimated 60.87% in 2020 (interpolated) and to 59.94% in 2021, based on the PSLM 2020–21 survey. The observed reduction from the 2019 baseline to 2021 was 2.41 percentage points. Recovery was observed from 2022 onwards (61.23%), continuing through 2023 (63.18%) and reaching 64.51% by 2024, 2.16 percentage points above the 2019 baseline. For scale only, applying the 2.41-percentage-point difference to the approximately 133.5 million people aged 15 years and above in the PBS Labour Force Survey 2020–21 produces a population-equivalent difference of approximately 3.2 million. This is a mathematical illustration of the rate difference, not an estimate of individuals who became illiterate; the aggregate data cannot identify individual-level transitions.

Table 1. National and disaggregated adult literacy rates in Pakistan, 2017–2024 (%)

Year	National	Male	Female	Urban	Rural	From 2019 (pp)	Phase
2017	59.13	70.21	48.09	74.32	49.26	–2.22	Pre-COVID
2018	60.44	71.38	49.52	75.11	50.43	–1.91	Pre-COVID
2019	62.35	72.97	51.73	76.54	52.18	Baseline	Pre-COVID
2020*	60.87	71.42	50.27	74.88	50.84	–1.48	Pandemic
2021	59.94	70.38	49.41	73.65	49.97	–2.41	Pandemic
2022	61.23	71.64	50.78	74.93	51.36	–1.12	Recovery
2023	63.18	73.11	53.22	76.87	53.64	+0.83	Recovery
2024	64.51	74.23	54.78	78.02	55.11	+2.16	Recovery

* 2020 value derived by linear interpolation (no PSLM round conducted). Δ = change from 2019 baseline in percentage points. Source: PBS Labour Force Survey; PSLM 2018–19, 2020–21, 2022–23; UIS Pakistan dataset 2024.

Gender-Disaggregated and Urban–Rural Findings

From 2019 to 2021, male literacy declined by 2.59 percentage points (from 72.97% to 70.38%), while female literacy declined by 2.32 percentage points (from 51.73% to 49.41%). Although the absolute point decline was marginally larger for males, the female decline originated from a substantially lower baseline: the relative reduction was 4.49% for females ($2.32 / 51.73 \times 100$) compared with 3.55% for males ($2.59 / 72.97 \times 100$), representing a proportionally greater impact on the group with lower initial attainment. The gender gap stood at 21.24 percentage points in 2019 and narrowed to 19.45 percentage points by 2024. From 2022 onwards, female literacy recovered more strongly (+3.05 pp above the 2019 baseline by 2024) than male literacy (+1.26 pp). This pattern is consistent with the possible influence of targeted female education programming during the recovery period; however, the observational design of this study does not permit direct attribution to specific interventions, and alternative explanations cannot be excluded.

Urban literacy declined by 2.89 percentage points (from 76.54% to 73.65%) and rural literacy declined by 2.21 percentage points (from 52.18% to 49.97%) from 2019 to 2021. Although the absolute point decline was larger in urban areas, rural regions, where household internet access was approximately 12% in 2020 compared with 47% in urban areas², had substantially less access to digital substitute learning. This structural difference is consistent with rural populations experiencing disproportionate educational disruption per unit of school closure time relative to their baseline attainment, though the ecological design does not permit causal attribution.

Table 2. Gender and urban–rural literacy gaps, 2017–2024

Year	Male (%)	Female (%)	Gender gap (pp)	Urban (%)	Rural (%)	Urban–rural gap (pp)
2017	70.21	48.09	22.12	74.32	49.26	25.06
2019	72.97	51.73	21.24	76.54	52.18	24.36
2021	70.38	49.41	20.97	73.65	49.97	23.68
2024	74.23	54.78	19.45	78.02	55.11	22.91

pp = percentage points. Gender gap = male minus female; urban–rural gap = urban minus rural. Source: PSLM Survey 2017–2024.

Provincial Analysis

Provincial trajectories varied substantially across the study period. Punjab, which entered the pandemic with the highest provincial literacy rate (65.2% in 2019), experienced 68 weeks of school closure, declined by 2.1 percentage points (to 63.1% in 2021), and recovered to 67.4% by 2024 (+2.2 pp above 2019). KPK showed the smallest pandemic-period decline of any province (–1.3 pp, from 54.8% to 53.5%); one plausible contributing factor identified in prior literature is the province's pre-pandemic investments in digital learning infrastructure,²² though this hypothesis was not directly tested in this study and should not be treated as an established finding. Sindh recorded the largest absolute pandemic-period decline (–3.2 pp, from 57.4% to 54.2%), recovering to only 58.1% by 2024 (+0.7 pp), the weakest provincial recovery trajectory.

Sindh's post-2021 pattern is likely compounded by the 2022 Pakistan floods, which according to government and UNICEF reports damaged or destroyed approximately 17,000 schools and displaced approximately 7.9 million people.^{3,22} This study's design cannot statistically separate the COVID-19 contribution from the flood effect in Sindh, an acknowledged limitation. Balochistan, beginning from Pakistan's lowest provincial baseline (43.2% in 2019) and experiencing the longest closures (76 weeks), declined to 40.7% in 2021 and recovered to only 44.6% by 2024 (+1.4 pp), consistent with a trajectory of near-stagnation from a critically low starting point. ICT declined by 1.6 pp (to 78.8%) and recovered to 82.3% by 2024 (+1.9 pp). The association between provincial closure duration and literacy change is noted as a descriptive, exploratory observation only; with five provincial data points, any apparent correlation is substantially underpowered and should not be interpreted as a robust empirical relationship.

Table 3. Provincial literacy rates and school-closure duration, 2017–2024

Province	2017 (%)	2019 (%)	2021 (%)	2024 (%)	Closure (weeks)	2019→2021 (pp)	2019→2024 (pp)
Punjab	62.4	65.2	63.1	67.4	68	–2.1	+2.2
Sindh	54.1	57.4	54.2	58.1	72	–3.2	+0.7
KPK	52.3	54.8	53.5	56.9	65	–1.3	+2.1
Balochistan	40.8	43.2	40.7	44.6	76	–2.5	+1.4
ICT	77.6	80.4	78.8	82.3	60	–1.6	+1.9

KPK = Khyber Pakhtunkhwa; ICT = Islamabad Capital Territory. Source: PBS, PSLM, MoEPT 2017–2024; MoEPT school reopening records.

Descriptive Pre-Post Comparison and Out-of-School Children

The primary comparison was descriptive. National adult literacy declined from 62.35% in 2019 to 59.94% in 2021, a reduction of 2.41 percentage points. Across the disaggregated series, male literacy declined by 2.59 percentage points, female literacy by 2.32 percentage points, urban literacy by 2.89 percentage points, and rural literacy by 2.21 percentage points over the same interval. By 2024, national literacy had increased to 64.51%, while the gender and urban–rural gaps remained substantial. Estimated out-of-school children increased from 20.3 million in 2019 to a pandemic-period peak of 26.2 million in 2021 (+5.9 million; approximately 29% above baseline) before declining to 19.9 million by 2024.

Table 4. Descriptive summary of observed literacy changes, 2019–2024

Indicator	Pre-COVID mean (2017–2019, %)	2021 observed (%)	Pandemic sensitivity mean (2020–2021, %)	Mean difference (pp)	Exploratory bootstrap 95% CI (pp)
National literacy	60.64	59.94	60.41	–0.24	–1.95 to +1.30
Male literacy	71.52	70.38	70.90	–0.62	–2.07 to +0.82
Female literacy	49.78	49.41	49.84	+0.06	–1.89 to +1.75
Urban literacy	75.32	73.65	74.27	–1.06	–2.41 to +0.30
Rural literacy	50.62	49.97	50.41	–0.22	–1.78 to +1.19

pp = percentage points. The sensitivity mean is the arithmetic mean of the 2020 and 2021 aggregate estimates. Exploratory bootstrap intervals use 100,000 resamples of annual observations within each phase (fixed seed 2026); because the number of annual observations is very small, these intervals are not treated as formal inferential confidence intervals. Source: Tables 1–3 and cited PBS/PSLM records.

DISCUSSION

This study provides harmonised descriptive time-series evidence that Pakistan's national adult literacy rate declined during the pandemic period and that the recovery observed by 2024 was uneven across demographic and geographic strata. The principal observed comparison was a 2.41–percentage-point reduction from 2019 to 2021. Because the data are aggregate, the 2020 value is interpolated, and the number of annual observations is small, the findings are interpreted as temporal changes rather than causal effects of COVID-19.

The national rate reached 64.51% by 2024, 2.16 percentage points above the 2019 percentage baseline. The population-equivalent calculation presented in the Results section is illustrative only and should not be interpreted as evidence that a specific number of adults became illiterate. Because the denominator changes over time and the analysis does not estimate individual-level transitions, the study focuses on literacy-rate trajectories rather than counts of newly illiterate adults.

The gender findings show that both male and female literacy declined between 2019 and 2021, with a larger absolute percentage-point decline among males but a larger proportional decline relative to baseline among females. The gender gap narrowed from 21.24 percentage points in 2019 to 19.45 percentage points in 2024. This descriptive pattern does not establish the influence of any specific education intervention, and alternative explanations cannot be excluded.

The provincial findings have direct policy relevance. Balochistan entered the pandemic with the lowest provincial literacy rate (43.2% in 2019), declined to 40.7% in 2021, and recovered to 44.6% by 2024. Sindh recorded the largest observed pandemic-period decline (–3.2 percentage points) and recovered to 58.1% by 2024, only 0.7 percentage points above its 2019 level. The 2022 floods provide an important concurrent explanation to consider in interpreting Sindh's recovery, but this study cannot statistically separate flood-related effects from pandemic-related effects. The relationship between school-closure duration and literacy change is treated as descriptive and exploratory only.

IMPLICATIONS

These findings suggest several areas of potential policy relevance, while recognising that policy effectiveness was not tested. The uneven provincial recovery supports consideration of targeted education-recovery resources for areas with the lowest

literacy levels. The documented urban–rural digital-access gap supports prioritising rural connectivity within education and digital-infrastructure planning. The persistent gender gap supports continued gender-responsive education strategies, including attention to female-teacher availability in underserved settings. Future research should use district-level longitudinal data and designs capable of separating pandemic-related disruption from other shocks such as the 2022 floods.

Beyond educational policy, the findings are relevant to health-system planning because literacy is related to access to health information and effective use of health services. These implications are derived from the existing literature rather than measured outcomes of this study; no direct health-literacy outcome was analysed.

LIMITATIONS

This study has several limitations. First, the ecological secondary-data design permits identification of temporal patterns but cannot establish causality. Concurrent factors, including the 2022 Pakistan floods, macroeconomic conditions, political instability, changes in survey methodology, and population growth, cannot be individually isolated. Second, the number of annual observations is small, and the routine 2020 PSLM round was not conducted; therefore, the 2020 value is interpolated and is used only for trajectory description. Third, earlier UIS records with a 10+ denominator were not converted to 15+ in the final analytical series because the supplied source records do not provide a reproducible conversion formula. Fourth, secondary data may be retrospectively revised by originating agencies. Fifth, adult literacy is a lagging population indicator and does not directly measure contemporaneous school-age learning loss. Sixth, provincial estimates may have larger uncertainty than national estimates, particularly in Balochistan.

CONCLUSION

Adult literacy in Pakistan declined from 62.35% in 2019 to 59.94% in 2021, an observed reduction of 2.41 percentage points during the pandemic period. The decline was evident across sex and residence categories and varied substantially by province. By 2024, national literacy had recovered to 64.51%, but gender, urban–rural, and provincial inequalities remained. These findings describe a marked disruption followed by uneven recovery; they do not establish a causal effect of COVID-19.

ACKNOWLEDGEMENTS

The authors acknowledge The Operating Room Global (TORG) Global Research Fellowship Programme for providing the mentorship framework under which this study was conducted. The Pakistan Bureau of Statistics, the UNESCO Institute for Statistics, and the Ministry of Federal Education and Professional Training are acknowledged for maintaining the public statistical infrastructure used in this analysis.

AUTHOR CONTRIBUTIONS (CREDIT)

Muhammad Wajid Munir: Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing – Review & Editing, Project Administration.

Prof. Adebisola Adenike Owokole: Supervision, Methodology (review), Writing - Review & Editing.

CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

FUNDING STATEMENT

This work received no specific funding. The study was conducted under the TORG Global Research Fellowship (Mentorship Track).

DATA AVAILABILITY

All data analysed in this study are derived from publicly available secondary sources, including the Pakistan Bureau of Statistics, PSLM Survey, UNESCO Institute for Statistics, and Ministry of Federal Education and Professional Training publications. A source-extraction table documenting the records available in the study documentation, including year,

source, variable, original reported value, age denominator where documented, adjustment status, final analytical value, and whether the observation was observed or interpolated, is provided as Supplementary File S1. The complete harmonised dataset and source-level audit trail are available from the corresponding author upon reasonable request. No individual-level participant data were accessed.

ETHICAL APPROVAL

A secondary-data ethics determination was made under the TORG Global Research Fellowship institutional governance framework (Reference: TORG-RF-2025-002; 20 March 2026), confirming that this aggregate secondary-data study with no primary human-participant involvement does not require formal research ethics committee review under the applicable governance policy. This determination was issued by the TORG Global Research Fellowship programme; it is not an independent research ethics committee exemption.

ARTIFICIAL INTELLIGENCE USE DECLARATION

AI tools (Claude, Anthropic) were used to support language editing, formatting, and structural reorganisation of this manuscript. All research design, data interpretation, statistical analysis, and conclusions are the original intellectual work of the authors. This declaration is made in accordance with TORGJ editorial policy on AI use in submitted manuscripts.

REFERENCES

1. Becker GS. Human capital: a theoretical and empirical analysis, with special reference to education. 3rd ed. Chicago: University of Chicago Press; 1994.
2. Pakistan Bureau of Statistics. Household survey on access to digital technologies and ICT 2020. Islamabad: PBS; 2021.
3. UNICEF Pakistan. Situation analysis of children and women in Pakistan 2022. Islamabad: UNICEF; 2022.
4. Pakistan Bureau of Statistics. Pakistan Social and Living Standards Measurement Survey 2018-19. Islamabad: Government of Pakistan; 2020.
5. Hanushek EA, Woessmann L. The economic impacts of learning losses. OECD Education Working Papers No 225. Paris: OECD Publishing; 2020.
6. Unterhalter E, Howell C. Unaligned connections or productive pedagogies? Teacher education for gender equality in South Asia. *Global Social Education*. 2021;19(3):287–300.
7. UNESCO. Education: from disruption to recovery. Global Education Monitoring Report. Paris: UNESCO; 2021. Available from: <https://www.unesco.org/en/covid-19/education-disruption-recovery>
8. Engzell P, Frey A, Verhagen MD. Learning loss due to school closures during the COVID-19 pandemic. *Proc Natl Acad Sci*. 2021;118(17):e2022376118. doi:10.1073/pnas.2022376118
9. Azevedo JP, Hasan A, Goldemberg D, Iqbal SA, Geven K. Simulating the potential impacts of COVID-19 school closures on schooling and learning outcomes: a set of global estimates. Policy Research Working Paper 9284. Washington DC: World Bank; 2021.
10. Asian Development Bank. COVID-19 and education in South Asia: impacts, responses and policy implications. Manila: ADB; 2021.
11. UNESCO. Gender and education: COVID-19 impact monitoring in South Asia. Paris: UNESCO; 2020.
12. Pakistan Institute of Education. Pakistan Education Statistics 2021-22. Islamabad: Ministry of Federal Education and Professional Training; 2023.
13. Pakistan Institute of Education. Pakistan Education Statistics 2022-23. Islamabad: Ministry of Federal Education and Professional Training; 2024.
14. Pakistan Bureau of Statistics. Pakistan Social and Living Standards Measurement Survey 2020-21. Islamabad: PBS; 2022.
15. World Bank. Pakistan development update: building resilience for recovery. Washington DC: World Bank; 2022.
16. Sabates R, Carter E, Stern JMB. Using educational transitions to estimate learning loss due to COVID-19 school closures: the case of Complementary Basic Education in Ghana. *Int J Educ Dev*. 2021;82:102377. doi:10.1016/j.ijedudev.2021.102377.
17. Kickbusch I, Pelikan JM, Apfel F, Tsouros AD. Health literacy: the solid facts. Copenhagen: WHO Regional Office for Europe; 2021.
18. UNESCO Institute for Statistics. Pakistan education profile database 2017-2024. Paris: UIS; 2024.

19. World Bank. World development report 2018: learning to realize education's promise. Washington DC: World Bank; 2018.
20. Government of Pakistan. Pakistan Economic Survey 2023-24. Islamabad: Ministry of Finance; 2024.
21. Ministry of Federal Education and Professional Training. District education performance index report 2022-23. Islamabad: Government of Pakistan; 2023.
22. Ministry of Federal Education and Professional Training. National education response and resilience plan for COVID-19. Islamabad: Government of Pakistan; 2022.
23. Marmot M, Allen J, Goldblatt P, Herd E, Morrison J. Build back fairer: the COVID-19 Marmot review. London: Institute of Health Equity; 2021.
24. OECD. Education at a glance 2023: OECD indicators. Paris: OECD Publishing; 2023.
25. Rose P, Sabates R, Alcott B, Ilie S. Overcoming inequalities within countries to achieve global convergence in learning. *Int J Educ Dev.* 2021;80:102333.
26. Government of Pakistan. National Education Policy 2017-2025. Islamabad: Ministry of Federal Education and Professional Training; 2017.
27. Pakistan Bureau of Statistics. Pakistan Social and Living Standards Measurement Survey 2022-23. Islamabad: Government of Pakistan; 2024.
28. UNESCO Institute for Statistics. Glossary: literacy rate, adult total (% of people ages 15 and above). Paris: UIS; 2024. Available from: <http://uis.unesco.org/en/glossary-term/literacy-rate-adult-total> [Accessed: April 2026].
29. Pakistan Bureau of Statistics. Labour Force Survey 2020-21. Islamabad: Government of Pakistan; 2022.
30. Pakistan Bureau of Statistics. Population and Housing Census 2017: Table 12, Population (10 years and above) by literacy, sex, age group and rural/urban. Islamabad: Government of Pakistan; 2017.

CITE THIS ARTICLE:

- **APA (7th edition):** Munir, M. W., & Owokole, A. A. (2026, September 21). *Impact of the COVID-19 pandemic on adult literacy trends in Pakistan: A pre-post comparative time-series analysis (2017–2024)*. *The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2608002>
- **Harvard:** Munir, M.W. and Owokole, A.A., 2026. *Impact of the COVID-19 pandemic on adult literacy trends in Pakistan: A pre-post comparative time-series analysis (2017–2024)*. *The Operating Room Global Journal (TORGJ)*, 2(3). Published 21 September. Available at: <https://doi.org/10.64573/torgj2608002>
- **Vancouver:** Munir MW, Owokole AA. Impact of the COVID-19 pandemic on adult literacy trends in Pakistan: A pre-post comparative time-series analysis (2017–2024). *The Operating Room Global Journal (TORGJ)*. 2026 Sep 21;2(3). <https://doi.org/10.64573/torgj2608002>
- **MLA (9th edition):** Munir, Muhammad Wajid, and Adebisola Adenike Owokole. 2026. "Impact of the COVID-19 Pandemic on Adult Literacy Trends in Pakistan: A Pre-Post Comparative Time-Series Analysis (2017–2024)." *The Operating Room Global Journal (TORGJ)* 2 (3), September 21. <https://doi.org/10.64573/torgj2608002>
- **Chicago (Author-Date):** Munir, Muhammad Wajid, and Adebisola Adenike Owokole. 2026. "Impact of the COVID-19 Pandemic on Adult Literacy Trends in Pakistan: A Pre-Post Comparative Time-Series Analysis (2017–2024)." *The Operating Room Global Journal (TORGJ)* 2 (3), September 21. <https://doi.org/10.64573/torgj2608002>

Early Postoperative Recovery Outcomes Of Minimally Invasive Versus Conventional Cardiac Surgery In Adult Patients In Pakistan: A Retrospective Cohort Study (2025-2026)

Authors: Fatima Jaweria^{1,6*}, Myada A. Ibrahim^{2,6}, Zia Un Nisa³, Saman Aziz⁴, Muhammad Muzammil Ramzan⁵

¹ Ibadat International University, Islamabad, Pakistan

² University of Global Health Equity (UGHE), Rwanda

³ National Institute of Health, Islamabad, Pakistan

⁴ Riphah International University, Islamabad, Pakistan

⁵ Farooq Teaching Hospital

⁶ The Operating Room Global (TORG).

DOI: <https://doi.org/10.64573/torgj2608007>

*Corresponding Author:

Fatima Jaweria
fatimajaweria25@gmail.com

Declaration:

Authors' Contributions:

See Contributions section.

Conflict of Interest: None

Funding: No funding received.

Article History:

Received: 26-08-2026
Accepted: 19-09-2026
Available Online: 25-09-2026

QR access this Article



ABSTRACT

Background: Cardiac surgery is indicated when medical therapy fails to control myocardial ischemia, ventricular dysfunction, or hemodynamic instability. Conventional full sternotomy carries substantial perioperative trauma, while minimally invasive cardiac surgery (MICS) aims to reduce access-related morbidity, though evidence from Pakistan remains limited. This study compared early postoperative recovery and examined factors associated with prolonged ventilation and short intensive care unit (ICU) stay after MICS versus conventional surgery.

Methods: In this retrospective cohort study, records of 98 adults (49 conventional, 49 MICS) undergoing coronary or valvular surgery at a single tertiary center in Pakistan (November 2025–May 2026) were analyzed using the Mann–Whitney U test, chi-square or Fisher's exact test, and multivariable binary logistic regression to examine factors associated with prolonged ventilation and identify independent predictors of short ICU stay.

Results: MICS was associated with significantly shorter ventilation time, ICU stay and lower intra-aortic balloon pump (IABP) use (6.1% vs 22.4%; $p=0.040$). Inotropic support and re-exploration favored MICS without reaching significance (re-exploration: $p=0.090$). Surgical approach was the only independent predictor of short ICU stay (adjusted odds ratio [AOR] 7.47, 95% CI 2.28–24.55, $p=0.001$) and approached significance for prolonged ventilation (AOR 8.59, 95% CI 1.00–73.88, $p=0.050$); sex, diabetes, and hypertension were not significant in either model.

Conclusion: MICS was associated with faster early recovery than conventional surgery in this Pakistani cohort, despite higher BMI and longer operative time. Given the retrospective design, these findings reflect association rather than causation and support prospective evaluation of MICS in Pakistani tertiary centers.

Keywords: Minimally Invasive Surgical Procedures; Cardiac Surgical Procedures; Postoperative Care; Intensive Care Units; Intra-Aortic Balloon Pumping

INTRODUCTION

Cardiovascular disease (CVD) remains the leading cause of death and disability worldwide, responsible for an estimated 19.2 million deaths and 626 million prevalent cases in 2023, with the greatest age-standardized burden concentrated in low and low-middle sociodemographic-index countries ¹. Rising exposure to modifiable risk factors, population growth, and aging are projected to push global cardiovascular deaths to 35.6 million annually by 2050^{2,3}. Coronary artery disease and valvular heart disease, the two principal indications for cardiac surgery, are managed surgically by coronary artery bypass

grafting (CABG) or valve repair/replacement when medical therapy alone cannot adequately control myocardial ischemia, ventricular dysfunction, or hemodynamic compromise.

Conventional cardiac surgery, performed through a full median sternotomy, provides excellent surgical exposure but is associated with substantial tissue trauma, blood loss, prolonged ventilation, extended intensive care unit (ICU) stay, delayed mobilization, and sternal wound complications. Minimally invasive cardiac surgery (MICS) encompassing mini-thoracotomy, partial sternotomy, thoracoscopic, robotic-assisted, and minimally invasive extracorporeal circulation techniques aims to reduce these access-related effects while preserving procedural safety and efficacy ⁴. Meta-analytic evidence broadly supports reduced blood loss and transfusion, shorter ventilation and ICU stay, and earlier mobilization with MICS ^{4,5,6}, but findings are not uniform: some large, randomized syntheses report no significant difference in ventilation time, reintervention, or mortality ⁷, and evidence on inotropic support, intra-aortic balloon pump (IABP) requirement, and re-exploration for bleeding remains sparse and inconsistently reported across studies ^{8,9}.

Pragmatic measures of early postoperative recovery were mechanical ventilation duration and stay in the ICU. To evaluate the level of inotropic support and IABP use following surgery, they were added as well as re-exploration for bleeding as a clinically relevant postoperative complication that could extend the need for ventilation and ICU care. These outcomes are affected by patient characteristics, complexity of the procedure, peri-operative management and institutional practice and may not be interpreted as causative differences between surgical groups ^{10,11}. These latter three outcomes have been reported particularly inconsistently: the largest randomized synthesis of minimally invasive extracorporeal circulation found no overall reduction in inotrope or IABP requirement ⁹, whereas a large single-center coronary bypass cohort reported significantly lower postoperative IABP use after minimally invasive surgery ¹², and appropriate prophylactic IABP support in selected high-risk patients has itself been described as beneficial rather than indicative of inferior care ¹³. Comparing these outcomes together, rather than in isolation, was intended to provide a more coherent picture of early recovery than existing single-endpoint studies ¹⁴.

By reducing mechanical ventilation times, hospital and ICU stays and the cost of hospitalization, minimally invasive cardiac surgery is more efficient of recovery than sternotomy, despite the higher upfront procedural costs ¹⁵. In Pakistan, where MICS remains less widely practiced and ICU capacity is a limited and costly resource, prolonged postoperative recovery has direct implications for bed availability, cost, and access to timely surgical care for other patients¹⁶. International findings, generated largely under standardized enhanced-recovery pathways, may not generalize to Pakistani patient profiles, perioperative practices, or resource constraints, and locally generated evidence comparing early recovery across both surgical approaches is lacking.

This study therefore aimed to compare early postoperative recovery outcomes such as ventilation time, ICU stay, inotropic and IABP requirement, and re-exploration for bleeding between adult patients undergoing MICS and conventional cardiac surgery at a single tertiary-care cardiac center in Pakistan, and to examine factors associated with prolonged ventilation and to identify independent predictors of short ICU stay after adjusting for sex, diabetes mellitus, and hypertension. We hypothesized that MICS would be associated with more favorable early recovery across these domains than conventional surgery.

METHODOLOGY

Study Design and Setting

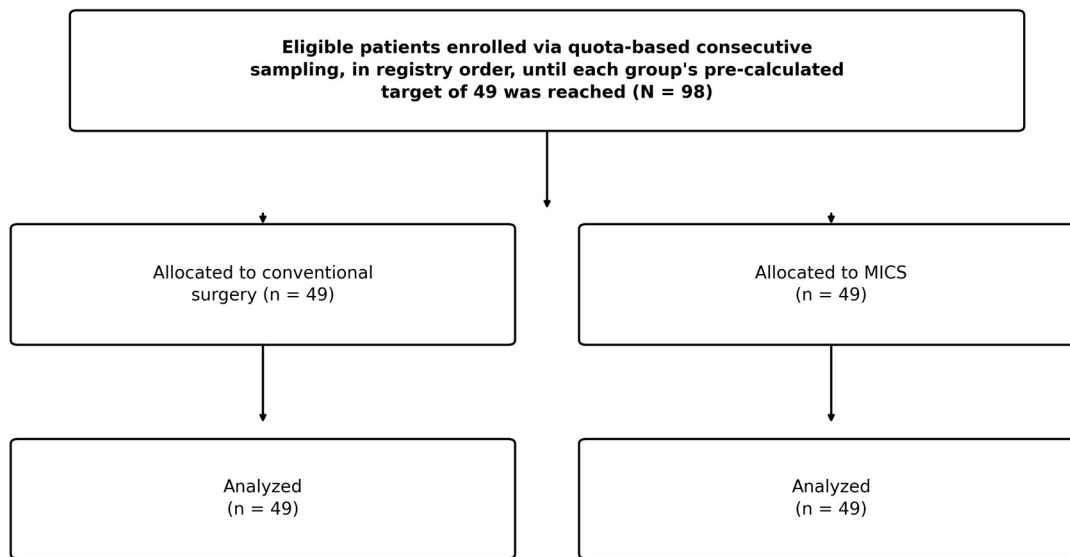
This study used a quantitative, retrospective cohort design to compare early postoperative recovery outcomes between adult patients who underwent MICS and those who underwent conventional cardiac surgery at a single tertiary-care cardiac center in Pakistan. The participating hospital is a high-volume, urban referral center for complex cardiac disease with a dedicated cardiothoracic surgical unit, an intensive care unit, and standardized postoperative monitoring protocols, and it offers both conventional and minimally invasive surgical services. Data were drawn from the clinical records of patients operated on at this single center between November 2025 and May 2026.

Participants

Eligible participants were adults (≥ 18 years) who underwent CABG or valve surgery via conventional (median sternotomy) or minimally invasive access and were subsequently admitted to the ICU with documented recovery parameters. Patients were excluded if they underwent emergency or redo cardiac surgery, combined cardiac and major non-cardiac procedures, had incomplete postoperative outcome data, or died intraoperatively. Non-probability, consecutive sampling was used

within each surgical-approach group: eligible patients were enrolled in the order they appeared in the hospital registry until the pre-calculated target of 49 patients per group (see Sample size) was reached in that group, yielding a final cohort of 49 conventional and 49 MICS patients. This quota-based consecutive approach, rather than open-ended enrollment of every eligible patient identified during the study period, accounts for the exact 1:1 balance between groups. Because counts of patients assessed beyond each group's quota cutoff were not separately logged during retrospective data extraction, the participant flow diagram (Figure 1) reports the totals that could be reliably verified from source records, patients enrolled up to the pre-calculated quota, and allocated to and analyzed in each surgical-approach group rather than a full assessed-for-eligibility and reason-coded exclusion breakdown.

Figure 1. Participant flow diagram



Verified counts of eligible patients enrolled via quota-based consecutive sampling and the numbers allocated to and analyzed in the conventional and MICS groups. Recruitment continued within each group, in registry order, until the pre-calculated quota of 49 patients per group was reached; a per-reason breakdown of patients assessed and not enrolled is not presented, as these counts were not separately recorded during retrospective chart review (see STROBE checklist, items 6b and 13a–13b).

Sample size

The required sample size was calculated in OpenEpi (version 3) using the sample size formula for comparing two means, based on expected means and standard deviations for a key continuous early-recovery outcome drawn from prior comparative literature 17, with a two-sided confidence level of 95%, power of 80%, and 1:1 allocation. This yielded a minimum requirement of 49 patients per group (total N = 98: 49 conventional, 49 MICS). Recruitment proceeded via consecutive sampling within each surgical-approach group separately, in registry order, until this per-group quota of 49 was reached, which is why the final cohort splits exactly 1:1 between approaches rather than reflecting the full, unequal number of eligible patients identified during the study period. This calculation was powered specifically for the primary continuous recovery outcome; it was not intended, and should not be interpreted, as providing adequate power for every binary secondary outcome or multivariable model reported in this study.

Data collection

Data were extracted using a structured, investigator-developed proforma from operative notes, anesthesia records, ICU charts, postoperative progress notes, and perfusion/hemodynamic records. Variables comprised demographic data (age, sex), clinical data (diagnosis, procedure type, surgical approach), intraoperative variables (cardiopulmonary bypass [CPB] use and duration, operative duration, estimated blood loss, transfusion, IABP use, temperature-management strategy), intra- and postoperative complications, and the outcome variables of interest such as ventilation time, ICU stay duration, inotropic

support requirement, IABP requirement, and re-exploration. Content validity was established through literature-based instrument design and review by the research mentor and an experienced cardiac surgeon; reliability was supported by extraction from objective clinical records and independent double-checking of a subsample against source documents. Data were anonymized at extraction using unique study codes, double-entered into a password-protected electronic database, and checked for completeness and internal consistency, with discrepancies verified against source records.

Statistical analysis

Analyses were performed in IBM SPSS Statistics version 26.0. Normality of continuous variables was assessed with the Shapiro–Wilk test; normally distributed variables are presented as mean $\pm$ standard deviation and non-normally distributed variables as median (interquartile range, IQR). Categorical variables are presented as frequencies and percentages. Between-group comparisons used the independent-samples t-test or Mann–Whitney U test for continuous variables, as appropriate, and the chi-square test for categorical variables with adequate expected cell counts; Fisher's exact test was used for categorical outcomes with low event frequency (IABP use and re-exploration). Effect sizes (r for Mann–Whitney comparisons) were calculated and interpreted using Cohen's benchmarks.

Two multivariable binary logistic regression models (enter method) were built to identify independent predictors of prolonged ventilation (>48 hours) and short ICU stay (<3 days); both outcomes were coded as binary variables (1 = outcome present, 0 = outcome absent), and both models were adjusted for sex, diabetes mellitus, hypertension, and surgical approach. For categorical predictors, the reference category was male (for sex), diabetes mellitus present (for diabetes mellitus), hypertension present (for hypertension), and MICS (for surgical approach); adjusted odds ratios therefore express the odds of the outcome for female vs male, no diabetes vs diabetes, no hypertension vs hypertension, and conventional vs MICS, respectively. Model fit was assessed with the Hosmer–Lemeshow test and Cox & Snell/Nagelkerke R^2 . Statistical significance was set at $p < 0.05$; p -values close to this threshold (including $p = 0.05$) are reported and interpreted as continuous evidence of association rather than classified strictly as "significant" or "not significant."

Ethical considerations

Ethical approval was obtained from the Institutional Review Board of The Operating Room Global (TORG-IRB; approval reference TORG-IRB/2026/032501; protocol ID TORG-IRB-20260325-01) on 06 May 2026, and the study was conducted in accordance with the Declaration of Helsinki and applicable national guidelines for biomedical research in Pakistan. It was a retrospective review of clinical records generated during routine care between November 2025 and May 2026, no prospective data collection, patient contact, or change to clinical management occurred at any point; retrospective abstraction of the relevant medical records began only after IRB approval, and no data were analyzed prior to that date. All direct identifiers were removed at extraction, and each participant was assigned a unique, non-identifying study code; data were stored on a password-protected, encrypted device in accordance with institutional and national data-protection regulations.

RESULTS

Demographical characteristics

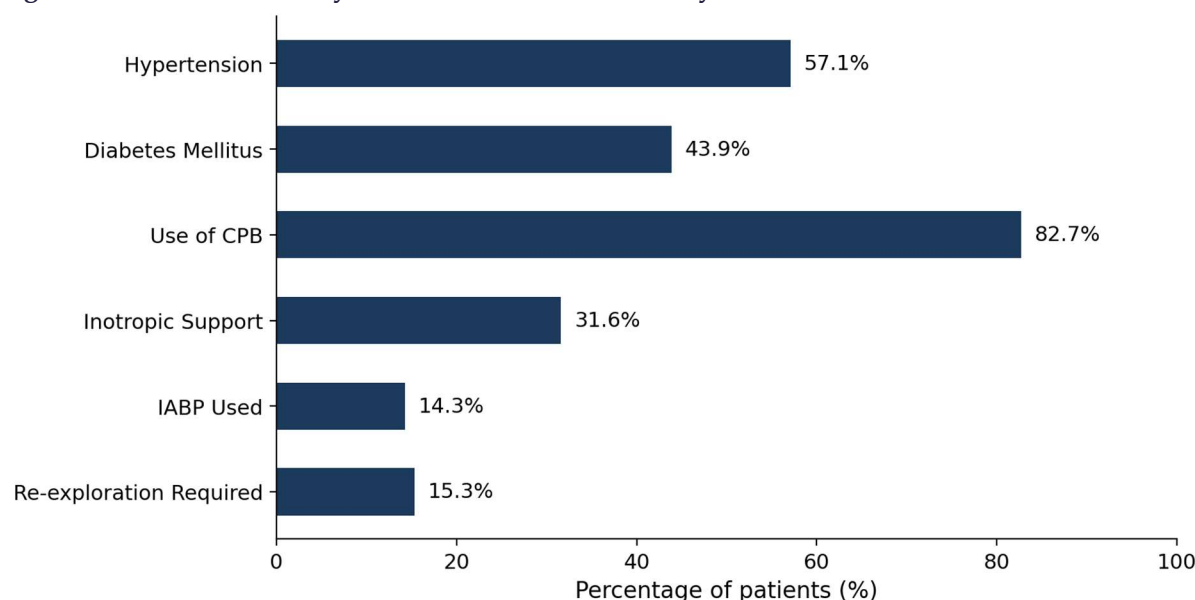
Ninety-eight adult patients were included: 49 (50.0%) underwent conventional surgery and 49 (50.0%) underwent MICS. The cohort comprised 64 males (65.3%) and 34 females (34.7%), with an even split between coronary artery disease (49, 50.0%) and valvular heart disease (49, 50.0%), and between CABG (49, 50.0%) and valve surgery (49, 50.0%). Hypertension was present in 56 patients (57.1%) and diabetes mellitus in 43 (43.9%). Overall clinical characteristics are summarized in Table 1 and Figure 2.

Table 1. Baseline demographic and clinical characteristics of the study cohort (N = 98)

Variable	Value (N = 98)
Age, years, mean $\pm$ SD	55.45 $\pm$ 8.65
Sex, male, n (%)	64 (65.3)
Sex, female, n (%)	34 (34.7)
Body mass index, kg/m ² , mean $\pm$ SD	26.07 $\pm$ 2.88
Ejection fraction, %, mean $\pm$ SD	53.11 $\pm$ 8.30
Diagnosis – coronary artery disease, n (%)	49 (50.0)
Diagnosis – valvular heart disease, n (%)	49 (50.0)
Procedure – CABG, n (%)	49 (50.0)

Procedure – valve surgery, n (%)	49 (50.0)
Surgical approach – conventional, n (%)	49 (50.0)
Surgical approach – MICS, n (%)	49 (50.0)
Hypertension, n (%)	56 (57.1)
Diabetes mellitus, n (%)	43 (43.9)
Operative duration, min, mean $\pm$ SD	201.65 $\pm$ 43.50
Cardiopulmonary bypass time, min, mean $\pm$ SD	76.40 $\pm$ 43.63
Estimated blood loss, mL, mean $\pm$ SD	385.30 $\pm$ 143.03
Intraoperative fluid balance, mL, mean $\pm$ SD	1688.02 $\pm$ 496.14
Intraoperative complications, n (%)	18 (18.4)
Bleeding, n (%)	8 (8.2)
Arrhythmia, n (%)	6 (6.1)
Hemodynamic instability, n (%)	4 (4.1)
Postoperative inotropic support, n (%)	31 (31.6)
Postoperative IABP requirement, n (%)	14 (14.3)
Postoperative re-exploration, n (%)	15 (15.3)

Figure 2. Distribution of key clinical variables in the study cohort (N = 98)



Percentage of patients in the overall cohort (N = 98) with hypertension, diabetes mellitus, use of cardiopulmonary bypass (CPB), postoperative inotropic support, intra-aortic balloon pump (IABP) use, and re-exploration.

Table 2 shows the conventional and MICS groups comparable in age, preoperative ejection fraction, and CPB time. However, the MICS group had a significantly higher body mass index (BMI) (26.74 ± 3.01 vs 25.38 ± 2.60 kg/m², $p = 0.019$) and longer operative duration (222.65 ± 42.05 vs 180.65 ± 33.98 minutes, $p = 0.001$), whereas the conventional group had significantly greater estimated blood loss (465.92 ± 136.23 vs 302.67 ± 94.05 mL, $p < 0.001$) and intraoperative fluid balance (median 1844.00 [IQR 684.00] vs 1392.00 [IQR 420.50] mL, $p = 0.001$).

Table 2. Baseline and perioperative characteristics by surgical approach (N = 98)

Parameter	Conventional (n = 49)	MICS (n = 49)	p-value
Age, years, mean $\pm$ SD	55.71 $\pm$ 9.60	55.18 $\pm$ 7.67	0.763
Body mass index, kg/m ² , mean $\pm$ SD	25.38 $\pm$ 2.60	26.74 $\pm$ 3.01	0.019
Ejection fraction, %, mean $\pm$ SD	51.84 $\pm$ 8.38	54.40 $\pm$ 8.09	0.129
Operative duration, min, mean $\pm$ SD	180.65 $\pm$ 33.98	222.65 $\pm$ 42.05	0.001

Estimated blood loss, mL, mean $\pm$ SD	465.92 $\pm$ 136.23	302.67 $\pm$ 94.05	<0.001
CPB time, min, median (IQR)	82.00 (49.00)	92.00 (71.00)	0.157
Intraoperative fluid balance, mL, median (IQR)	1844.00 (684.00)	1392.00 (420.50)	0.001

Note. Values are mean $\pm$ SD, except CPB time and intraoperative fluid balance, which are reported as median (IQR) owing to non-normal distribution. *p*-values are from independent samples *t*-tests for normally distributed variables and Mann–Whitney *U* tests for non-normally distributed variables.

Intraoperatively, complications occurred in 18 patients (18.4%): bleeding (8, 8.2%), arrhythmia (6, 6.1%), and hemodynamic instability (4, 4.1%). Postoperatively, 31 patients (31.6%) required inotropic support, 14 (14.3%) required IABP, and 15 (15.3%) required re-exploration.

Postoperative recovery outcomes by surgical approach

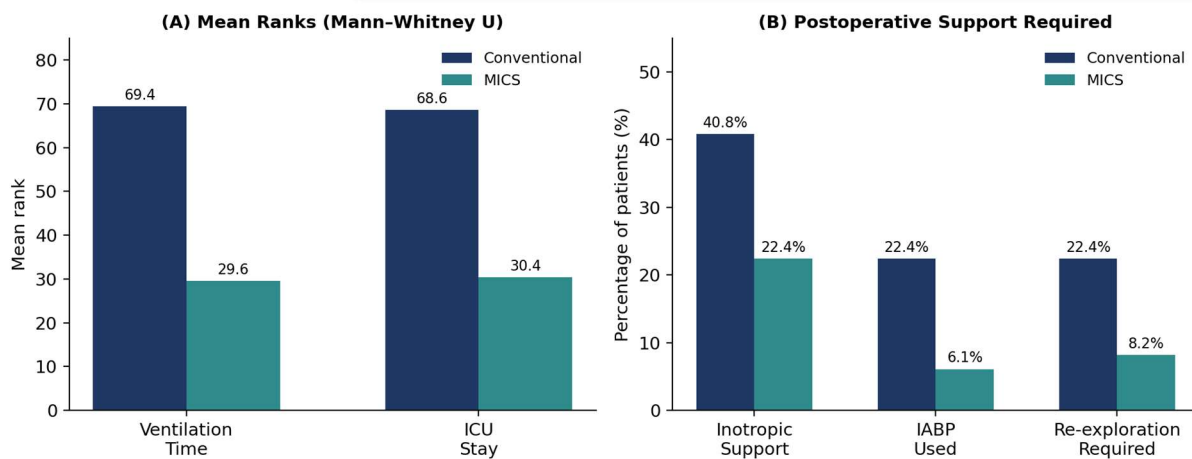
Ventilation time and ICU stay were both non-normally distributed (Shapiro–Wilk $p < 0.001$ and $p = 0.006$, respectively) and were therefore compared using the Mann–Whitney *U* test. MICS was associated with significantly shorter ventilation time (mean rank 29.61 vs 69.39; $U = 226.00$, $Z = -6.925$, $p < 0.001$, $r = 0.42$) and significantly shorter ICU stay (mean rank 30.37 vs 68.63; $U = 263.00$, $Z = -6.664$, $p < 0.001$, $r = 0.65$) than conventional surgery, representing with large effects (Table 3, Figure 3A).

Postoperative support requirements followed a broadly consistent pattern (Table 3, Figure 3B). Because IABP use and re-exploration were both low-frequency outcomes, group differences for these two variables were evaluated with Fisher's exact test. IABP use was significantly less frequent after MICS (3/49, 6.1%) than after conventional surgery (11/49, 22.4%; Fisher's exact $p = 0.040$). Re-exploration for bleeding was also less frequent after MICS (4/49, 8.2%) than after conventional surgery (11/49, 22.4%), but this difference did not reach statistical significance (Fisher's exact $p = 0.090$). Inotropic support (11/49, 22.4% vs 20/49, 40.8%; $\chi^2(1) = 3.822$, $p = 0.051$) showed the same direction of benefit without reaching significance. Effect sizes (0.20–0.23) indicated small-to-modest associations for these three comparisons, consistent with a pattern of directionally favorable but not uniformly statistically significant differences.

Table 3. Early postoperative recovery outcomes by surgical approach (N = 98)

Outcome	Conventional (n = 49)	MICS (n = 49)	Test statistic	p-value
Ventilation time, mean rank	69.39	29.61	$U = 226.00$, $Z = -6.925$, $r = 0.42$	<0.001
ICU stay, mean rank	68.63	30.37	$U = 263.00$, $Z = -6.664$, $r = 0.65$	<0.001
Inotropic support, n (%)	20 (40.8)	11 (22.4)	$\chi^2(1) = 3.822$	0.051
IABP use, n (%)	11 (22.4)	3 (6.1)	Fisher's exact test	0.040
Re-exploration, n (%)	11 (22.4)	4 (8.2)	Fisher's exact test	0.090

Figure 3. Postoperative outcomes by surgical approach



(A) Mean ranks for ventilation time and ICU stay (Mann-Whitney U test); lower mean rank indicates shorter duration. (B) Percentage of patients requiring inotropic support, IABP, or re-exploration, by surgical approach (conventional vs MICS).

Multivariable Analysis of Factors Associated with Prolonged Ventilation and Short ICU Stay

Two multivariable logistic regression models, adjusted for sex, diabetes mellitus, hypertension, and surgical approach, were fitted for prolonged ventilation (>48 hours) and short ICU stay (<3 days) (Table 4 and Figure 3). The model for prolonged ventilation was not statistically significant overall (omnibus $\chi^2 = 6.404$, $df = 4$, $p = 0.171$; Nagelkerke $R^2 = 0.146$) but showed adequate fit (Hosmer-Lemeshow $\chi^2 = 10.288$, $p = 0.245$). At the default 0.50 classification cutoff, the model correctly classified 91.8% of cases, but sensitivity was 0%, specificity was 100%, and negative predictive value (NPV) was 91.8%; positive predictive value (PPV) was not estimable because no cases were classified as prolonged ventilation. After adjustment, conventional surgical approach showed an association with higher odds of prolonged ventilation; however, the estimate was imprecise (AOR = 8.59, 95% CI 1.00–73.88, $p = 0.050$), and the overall model was not statistically significant. Sex (AOR = 0.72, 95% CI 0.12–4.34, $p = 0.724$), diabetes mellitus (AOR = 0.64, 95% CI 0.14–2.98, $p = 0.569$), and hypertension (AOR = 1.52, 95% CI 0.32–7.22, $p = 0.598$) were also not significant predictors.

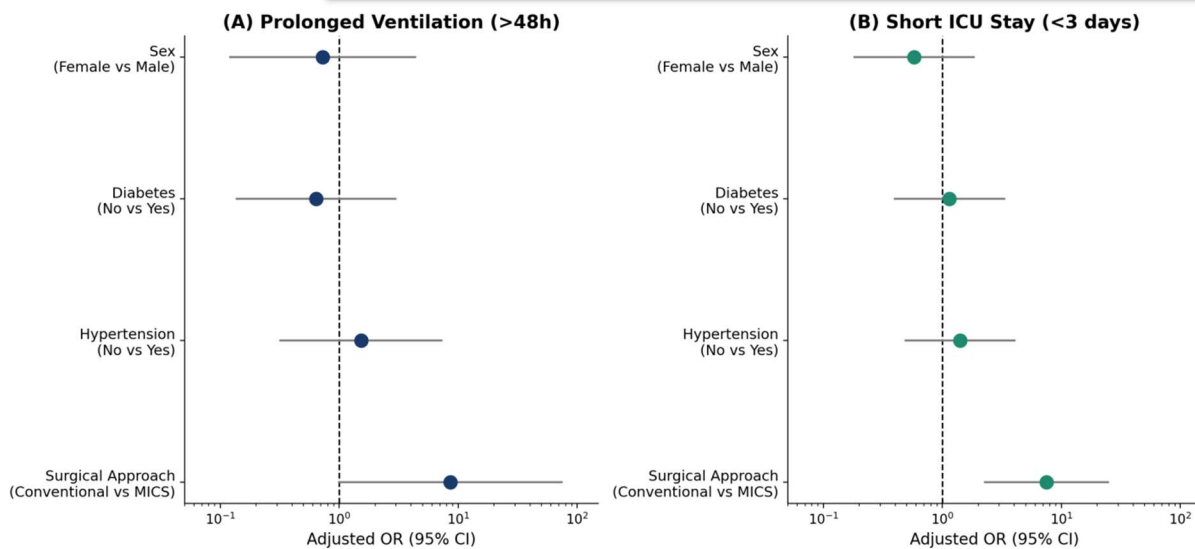
The model for short ICU stay was statistically significant (omnibus $\chi^2 = 15.319$, $df = 4$, $p = 0.004$; Nagelkerke $R^2 = 0.218$), with good fit (Hosmer-Lemeshow $\chi^2 = 5.863$, $p = 0.663$). At the default 0.50 classification cutoff, it correctly classified 76.5% of cases, but sensitivity was 0%, specificity was 100%, and NPV was 76.5%; PPV was not estimable because no cases were classified as having a short ICU stay. Surgical approach was the only significant independent predictor (AOR = 7.47, 95% CI 2.28–24.55, $p = 0.001$); sex (AOR = 0.58, 95% CI 0.18–1.83, $p = 0.350$), diabetes mellitus (AOR = 1.14, 95% CI 0.40–3.30, $p = 0.803$), and hypertension (AOR = 1.41, 95% CI 0.49–4.02, $p = 0.526$) were not significantly associated with ICU stay duration. Because short ICU stay (<3 days) reflects earlier not delayed recovery, a higher AOR for this outcome indicates a greater likelihood of the faster-recovery outcome, not a greater risk of a complication.

Table 4 Multivariable logistic regression analysis for predictors of prolonged ventilation and short ICU stay

Predictor (reference group)	Prolonged ventilation (>48 h) AOR (95% CI), p	Short ICU stay (<3 days) AOR (95% CI), p
Sex (female vs male)	0.72 (0.12–4.34), $p = 0.724$	0.58 (0.18–1.83), $p = 0.350$
Diabetes mellitus (no vs yes)	0.64 (0.14–2.98), $p = 0.569$	1.14 (0.40–3.30), $p = 0.803$
Hypertension (no vs yes)	1.52 (0.32–7.22), $p = 0.598$	1.41 (0.49–4.02), $p = 0.526$
Surgical approach (conventional vs MICS)	8.59 (1.00–73.88), $p = 0.050$	7.47 (2.28–24.55), $p = 0.001$

Note. AOR = adjusted odds ratio; CI = confidence interval. Both outcomes were coded as binary (1 = outcome present, 0 = outcome absent). Reference categories: male (sex), diabetes mellitus present (diabetes mellitus), hypertension present (hypertension), and MICS (surgical approach). Models adjusted for sex, diabetes mellitus, hypertension, and surgical approach (enter method).

Figure 3 Adjusted odds ratios for predictors of prolonged ventilation and short ICU stay



Adjusted odds ratios (95% confidence interval, log scale) from multivariable logistic regression for (A) prolonged ventilation (>48 h) and (B) short ICU stay (<3 days). The dashed vertical line marks an odds ratio of 1 (no effect); estimates whose confidence interval crosses this line are not statistically significant.

DISCUSSION

This retrospective cohort study compared early postoperative recovery between MICS and conventional cardiac surgery in 98 Pakistani adults. Consistent with our hypothesis, MICS was associated with significantly shorter ventilation time and ICU stay and significantly lower IABP use, while inotropic support and re-exploration showed the same direction of benefit without reaching conventional significance. After adjustment for sex, diabetes mellitus, and hypertension, surgical approach remained the only independent predictor of short ICU stay and approached significance for prolonged ventilation.

The reduction in ventilation time with MICS ($r = 0.42$) aligns with observational and single-center evidence reporting earlier extubation with minimally invasive or enhanced-recovery pathways^{15,18,19}. It contrasts, however, with the two largest randomized syntheses in the field, which found no significant difference in ventilation time^{7,20}. A plausible explanation is that these meta-analyses pooled predominantly isolated valve procedures performed within standardized, protocol-driven pathways, where extubation timing is governed more by institutional fast-track protocols than by incision size, whereas the present study combined CABG and valve surgery at a single Pakistani center without a uniform enhanced-recovery or zero-ICU pathway, so differences attributable to surgical trauma itself may remain more visible.

The reduction in ICU stay (large effect, $r = 0.65$) was the most robust finding of this study and the outcome most consistently supported across the literature, including the largest randomized synthesis⁷ and observational and matched studies^{15,19}. This convergence across study designs, settings, and procedure types is consistent with reduced ICU dependency being an association with MICS rather than an artifact of case selection, and is compatible with a surgical stress and recovery model in which reduced access trauma is linked to faster physiological stabilization; as with all findings in this retrospective cohort, however, this remains an association rather than evidence of a causal mechanism.

The significantly lower rate of IABP use after MICS (6.1% vs 22.4%) replicates findings from a large coronary bypass cohort in which minimally invasive off-pump surgery was associated with lower postoperative IABP use, even after propensity matching, attributed partly to greater operative efficiency¹². This contrasts with the largest randomized synthesis of minimally invasive extracorporeal circulation, which found no overall reduction in IABP or inotrope requirement⁹, a discrepancy that likely reflects a difference in comparator: that synthesis evaluated perfusion strategy (minimally invasive extracorporeal circulation versus conventional bypass) rather than surgical access route, whereas the present study, like Lei et al.¹², compared surgical approach directly, capturing the combined effect of smaller incisions and reduced operative trauma on hemodynamic stability. It is also worth noting that prophylactic or adjunctive IABP use in selected high-risk patients may itself reflect appropriate support rather than inferior care¹³, underscoring the importance of interpreting group differences in IABP use as a marker of perioperative course rather than of quality.

In the adjusted regression models, surgical approach was the only significant independent predictor of short ICU stay and approached significance for prolonged ventilation, while sex, diabetes mellitus, and hypertension were not significant in either model (Table 4). This differs somewhat from studies emphasizing patient-level risk factors, such as ejection fraction or comorbidity burden, as primary drivers of delayed recovery, and suggests that in this cohort, technique-related factors outweighed the baseline patient characteristics measured. The relatively modest, explained variance (Nagelkerke R^2 14.6–21.8%) indicates that unmeasured intraoperative variables such as operative time, blood loss, transfusion, and perfusion strategy likely account for additional variance not captured by this model.

An important contextual finding is that the MICS group had a significantly higher mean BMI and longer operative duration than the conventional group, factors typically associated with greater technical difficulty and, if anything, expected to disadvantage the MICS group. Despite this less favorable profile, the MICS group still showed significantly lower blood loss, shorter ventilation and ICU stay, and lower IABP use. This pattern is compatible with the observed differences being associated with surgical approach rather than a more favorable baseline risk profile, although, given the retrospective, non-randomized design, residual confounding by unmeasured variables cannot be excluded and a causal relationship cannot be established. This is broadly consistent with reports of preserved recovery benefit with minimally invasive approaches despite comparable or higher baseline risk^{18,21}.

This study's principal strength is its integrated assessment of five recovery domains within a single comparative cohort powered for its primary continuous recovery outcomes, generated from routine clinical practice at a Pakistani tertiary-care center, a setting largely absent from the existing comparative literature, which is dominated by high-income-country data^{7,14}. Several limitations should nonetheless be considered. The retrospective cohort design with non-probability, consecutive sampling limits control of confounding and precludes firm causal inference. While the sample size was adequate for the primary continuous outcomes, it was likely underpowered for the lower-base-rate binary outcomes (inotropic support, re-exploration). The regression models explained only 14.6–21.8% of outcome variance, indicating that unmeasured intraoperative factors were not captured. Only early postoperative recovery was assessed; longer-term outcomes such as functional recovery, readmission, and quality of life were outside the scope of this study¹⁴. Finally, as data were drawn exclusively from a single Pakistani tertiary-care center, findings may not generalize to other centers, lower-throughput settings, or non-tertiary settings. The high apparent classification accuracy should therefore be interpreted cautiously: at the 0.50 cutoff, both models classified all observations into the majority (negative) outcome category, yielding 0% sensitivity despite the reported overall accuracy.

Several recommendations follow from these findings for practice, policy, education, and future research. Multidisciplinary case selection and postoperative monitoring protocols that account for surgical approach should be considered when determining an appropriate patient population for cardiac surgical teams pursuing MICS for coronary artery disease or valvular heart disease^{19,21}. Hospital administrators and health policymakers should consider introducing MICS within tertiary cardiac centers as a viable strategy to reduce critical-care burden, provided there is capacity to invest in surgeon training, compatible perfusion equipment, and ICU resource planning²². In education, structured training and simulation-based credentialing programs for trainees and practicing surgeons are needed to support the safe adoption of minimally invasive approaches, alongside ongoing professional education on realistic, evidence-based recovery expectations. Future research should prioritize larger, multicenter, prospective studies with standardized enhanced-recovery protocols to confirm the borderline findings for inotropic support and re-exploration, incorporate unmeasured intraoperative factors such as blood loss, transfusion, and perfusion strategy into multivariable models, and extend follow-up beyond the immediate postoperative period to capture functional recovery, readmission, and quality of life¹⁴. Cost-effectiveness analyses comparing MICS with conventional approaches within Pakistani healthcare settings would further strengthen the evidence base for future policy decisions.

CONCLUSION

In this Pakistani cohort of 98 adults treated at a single tertiary-care cardiac center, minimally invasive cardiac surgery was associated with significantly shorter ventilation time and ICU stay and significantly lower IABP requirement than conventional surgery, with inotropic support showing the same non-significant direction of benefit and re-exploration showing a similar but weaker directional pattern that did not reach statistical significance (Fisher's exact $p = 0.090$). Surgical approach was the only independent predictor of short ICU stay after adjustment for sex, diabetes mellitus, and hypertension, and this association persisted despite a less favorable baseline profile (higher BMI) in the MICS group. As this was a retrospective, single-center observational study, these findings should be interpreted as an association rather than proof of

a causal benefit of MICS. They provide context-specific, hypothesis-generating evidence, largely consistent with international data, in support of the continued and cautious adoption of minimally invasive approaches in Pakistani tertiary cardiac centers, while highlighting the need for larger, prospective, multicenter studies to confirm effects on inotropic support and re-exploration and to evaluate longer-term outcomes.

ACKNOWLEDGMENTS

The authors thank The Operating Room Global (TORG) for the opportunity provided through the Global Research Fellowship Program, and the tertiary-care cardiac center in Pakistan that granted access to the medical records used in this study.

DECLARATIONS

Conflict of Interest

The authors declare no conflicts of interest relevant to the content of this manuscript.

Use of Artificial Intelligence

During the preparation of this manuscript, the authors used an AI-based language model (Claude, Anthropic) to assist with drafting, restructuring, and formatting the manuscript from the authors' original dissertation data and analysis, and to reformat the reference list. The AI tool was not used to collect, generate, analyze, or interpret study data or results; all data, statistical results, and scientific interpretations originate from the authors' own research. The authors reviewed and edited the AI-assisted content and take full responsibility for the accuracy, integrity, and originality of the final manuscript.

AUTHOR CONTRIBUTIONS (CREDIT)

Fatima Jaweria: Project administration, Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Writing original draft. Myada A. Ibrahim: Supervision & review & editing. Zia Un Nisa: Writing, review & editing. Saman Aziz: Writing, review & editing. Muhammad Muzammil Ramzan: Writing, review & editing. All authors approved the final manuscript and take responsibility for the integrity of the work.

FUNDING STATEMENT

This work received no specific funding. The study was conducted under the TORG Global Research Fellowship (Mentorship Track).

REFERENCES

1. GBD 2023 Cardiovascular Diseases and Risks Collaborators. Global, regional, and national burden of cardiovascular diseases and risk factors in 204 countries and territories, 1990–2023. *J Am Coll Cardiol*. 2025;86(22):2167–2243. <https://doi.org/10.1016/j.jacc.2025.08.015>
2. Chong B, Jayabaskaran J, Jauhari SM, Chan SP, Goh R, Kueh M, et al. Global burden of cardiovascular diseases: projections from 2025 to 2050. *Eur J Prev Cardiol*. 2024. <https://doi.org/10.1093/eurjpc/zwae281>
3. Naeem U, Deo S, Sahebkar A, Sheikh S, Khoja A, Vaughan EM, et al. Global burden of cardiovascular disease: what should be expected in the next 25 years? *Curr Cardiol Rep*. 2026;28(1):31. <https://doi.org/10.1007/s11886-026-02355-7>
4. Vignaroli W, Pala B, Nasso G, Sechi S, Campolongo G, Speziale G, et al. Mini- and micro-invasive approaches in cardiac surgery: current techniques, outcomes, and future perspectives. *Medicina (Kaunas)*. 2026;62(1):102. <https://doi.org/10.3390/medicina62010102>
5. Eqbal A, Gupta S, Basha A, Qiu Y, Wu N, Rega F, et al. Minimally invasive mitral valve surgery versus conventional sternotomy mitral valve surgery: a systematic review and meta-analysis of 119 studies. *J Card Surg*. 2022;37:1319–27. <https://doi.org/10.1111/jocs.16314>
6. Hussain S, Swystun AG, Caputo M, Angelini G, Vohra H. A review and meta-analysis of conventional sternotomy versus minimally invasive mitral valve surgery for degenerative mitral valve disease focused on the last decade of evidence. *Perfusion*. 2023;39:988–97. <https://doi.org/10.1177/02676591231174579>
7. Hoogma D, Van Bos T, Polfliet F, Verbrugghe P, Oosterlinck W, Van Den Eynde J, et al. Effect of minimally invasive cardiac surgery on hospital length of stay: a systematic review and meta-analysis. *Acta Anaesthesiol Belg*. 2024;75(3):197–208. <https://doi.org/10.56126/75.3.52>

8. Dieberg G, Smart N, King N. Minimally invasive cardiac surgery: a systematic review and meta-analysis. *Int J Cardiol.* 2016;223:554-60. <https://doi.org/10.1016/j.ijcard.2016.08.227>
9. Anastasiadis K, Antonitsis P, Voucharas C, Apostolidou-Kiouti F, Deliopoulos A, Haidich A, et al. Minimal invasive extracorporeal circulation versus conventional cardiopulmonary bypass in cardiac surgery: a contemporary systematic review and meta-analysis. *Eur J Cardiothorac Surg.* 2025;67. <https://doi.org/10.1093/ejcts/ezaf112>
10. Fröjd V, Jeppsson A. Reexploration for bleeding and its association with mortality after cardiac surgery. *Ann Thorac Surg.* 2016;102(1):109-117. <https://doi.org/10.1016/j.athoracsur.2016.01.006>
11. Mete EMT, Bastopcu M, Acarel M. 24th hour vasoactive inotrope score is associated with poor outcome in adult cardiac surgery. *Rev Assoc Med Bras (1992).* 2023;69(5):e20221433. <https://doi.org/10.1590/1806-9282.20221433>
12. Lei Y, Li G, Mei J, Xu Y, Yang Z, Qu Z, et al. Minimally invasive off-pump coronary artery bypass grafting is associated with reduced postoperative intra-aortic balloon pump use. *J Thorac Dis.* 2026;18. <https://doi.org/10.21037/jtd-2026-1-0314>
13. KraleV A, Kalisnik JM, Bauer A, Sirch J, Fittkau M, Fischlein T. Impact of prophylactic intra-aortic balloon pump on early outcomes in patients with severe left ventricular dysfunction undergoing elective coronary artery bypass grafting with cardiopulmonary bypass. *Int J Cardiol.* 2023;385:8-15. <https://doi.org/10.1016/j.ijcard.2023.05.033>
14. Marinescu A, Oprea S, Costache VS. Does minimally invasive valve surgery improve quality of life compared to sternotomy? A systematic review. *J Clin Med.* 2025;14. <https://doi.org/10.3390/jcm14248660>
15. Tang S, Qu Y, Jiang HC, Cai H, Zhang R, Hong J, et al. Minimally invasive technique facilitates early extubation after cardiac surgery: a single-centre retrospective study. *BMC Anesthesiol.* 2024;24. <https://doi.org/10.1186/s12871-024-02710-7>
16. Martins R, Waqar U, Raza H, Memon MK, Akhtar S. Assessing risk factors for prolonged intensive care unit stay after surgery for adult congenital heart disease: a study from a lower-middle-income country. *Cureus.* 2023. <https://doi.org/10.7759/cureus.35606>
17. Nguyen TB, Nguyen TT, Luong LH, Nguyen DH, Nguyen CH, Le NT, et al. Minimally invasive versus median sternotomy for mechanical mitral valve replacement: a single-centre comparative study of treatment outcomes and quality of life. *Ital J Med.* 2025;19(2). <https://doi.org/10.4081/itjm.2025.1963>
18. Yuruk M. Comparison of immediate postoperative outcomes between minimal invasive and conventional extracorporeal circulation in adult cardiac surgery. *Cardiovasc Surg Interv.* 2025. <https://doi.org/10.5606/e-cvsi.2025.2091>
19. Pitts L, Dini M, Goecke S, Kofler M, Ott S, Stoppe C, et al. Enhanced recovery after minimally invasive cardiac surgery following a zero ICU concept: a propensity score-matched analysis. *Eur J Cardiothorac Surg.* 2024;66(6). <https://doi.org/10.1093/ejcts/ezae439>
20. Spadini FA, Lira KB, Delvaux R, Kopittke L, Anschau F, Ceron R, et al. Minimally invasive versus conventional mitral valve surgery: a systematic review and meta-analysis of randomised clinical trials. *Open Heart.* 2026;13. <https://doi.org/10.1136/openhrt-2025-003612>
21. Saad M, Gadelkarim I, Borger MA, Meineri M, Janai A, Sgouropoulou S, et al. Postoperative outcomes of minimally invasive versus conventional off-pump coronary artery bypass within an ERACS protocol: a matched analysis. *J Clin Med.* 2026;15. <https://doi.org/10.3390/jcm15010328>
22. Yang NK, Soliman F, Pepe RJ, Palte NK, Yoo J, NithikaseM S, et al. Minimally invasive approach associated with lower resource utilization after aortic and mitral valve surgery. *JTCVS Open.* 2023;15:72-80. <https://doi.org/10.1016/j.xjon.2023.06.007>

CITE THIS ARTICLE:

- **APA (7th edition):** Jaweria, F., Ibrahim, M. A., Nisa, Z. U., Aziz, S., & Ramzan, M. M. (2026, September 25). *Early postoperative recovery outcomes of minimally invasive versus conventional cardiac surgery in adult patients in Pakistan: A retrospective cohort study.* *The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2608007>
- **Harvard:** Jaweria, F., Ibrahim, M.A., Nisa, Z.U., Aziz, S. and Ramzan, M.M., 2026. *Early postoperative recovery outcomes of minimally invasive versus conventional cardiac surgery in adult patients in Pakistan: A retrospective cohort study.* *The Operating Room Global Journal (TORGJ)*, 2(3). Published 25 September. Available at: <https://doi.org/10.64573/torgj2608007>

- **Vancouver:** Jaweria F, Ibrahim MA, Nisa ZU, Aziz S, Ramzan MM. Early postoperative recovery outcomes of minimally invasive versus conventional cardiac surgery in adult patients in Pakistan: a retrospective cohort study. *The Operating Room Global Journal (TORGJ)*. 2026 Sep 25;2(3). <https://doi.org/10.64573/torgj2608007>
- **MLA (9th edition):** Jaweria, Fatima, et al. "Early Postoperative Recovery Outcomes of Minimally Invasive Versus Conventional Cardiac Surgery in Adult Patients in Pakistan: A Retrospective Cohort Study." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 25 Sept. 2026, <https://doi.org/10.64573/torgj2608007>
- **Chicago (Author-Date):** Jaweria, Fatima, Myada A. Ibrahim, Zia Un Nisa, Saman Aziz, and Muhammad Muzammil Ramzan. 2026. "Early Postoperative Recovery Outcomes of Minimally Invasive Versus Conventional Cardiac Surgery in Adult Patients in Pakistan: A Retrospective Cohort Study." *The Operating Room Global Journal (TORGJ)* 2 (3), September 25. <https://doi.org/10.64573/torgj2608007>

Diagnostic and Therapeutic Management of a Painful Thyroid Mass with Discordant Thyrotropin and Thyroid Hormone Measurements: A Case Report

Authors: Peter Matthew George^{1,2,3,4,6*}, Arda Işık⁵

¹ European Union of Medical Specialists, Brussels, Belgium

² School of Health and Medical Sciences, Kesmonds International University, Yaoundé, Cameroon

³ Department of Surgery, School of Medicine, Texila American University, Georgetown, Guyana

⁴ Department of Surgery, Hospital Protestant de Ngaoubela, Adamaoua Region, Cameroon

⁵ School of Medicine, Istanbul Medeniyet University, Istanbul, Turkey

⁶ The Operating Room Global (TORG)

DOI: <https://doi.org/10.64573/torgj2609002>

ABSTRACT

Background: Thyroid nodules presenting with elevated circulating thyroid hormones, but a non-suppressed thyrotropin (TSH) poses a diagnostic and therapeutic challenge, particularly where free-hormone assays, ultrasonography, scintigraphy, cytology, and histopathology are unavailable.

Case presentation: A 30-year-old woman presented with a painful, progressive left neck mass of one year's duration. She was clinically euthyroid. Total triiodothyronine was 4.46 nmol/L and total thyroxine 189.55 nmol/L, with a non-suppressed TSH of 0.39 mIU/L (reference 0.30–4.20 mIU/L). Mild leukopenia (white cell count $3.91 \times 10^9/L$) and a platelet count of $334 \times 10^9/L$ were noted. Thyroid ultrasonography, fine-needle aspiration, scintigraphy, free-hormone assays, and histopathology were not available at the treating facility, and the family could not fund referral histopathology. After multidisciplinary discussion, left hemithyroidectomy was performed without preoperative antithyroid drugs. The recurrent laryngeal nerve and parathyroid glands were preserved. Estimated blood loss was approximately 35 mL. There was no perioperative thyroid crisis, vocal change, or clinical hypocalcemia. At day-7 the wound healed and neck pain had been resolved. Postoperative thyroid function tests and longer-term biochemical follow-up were not obtained.

Conclusion: In this patient, clinical euthyroidism and a non-suppressed TSH, together with baseline leukopenia, supported withholding thionamides and proceeding to hemithyroidectomy for a symptomatic mass. These observations apply to the circumstances described and do not constitute a validated general management algorithm. Lack of imaging, cytology, histopathology, and postoperative thyroid function tests is a major limitation.

Keywords: thyroid nodule; hemithyroidectomy; discordant thyroid function tests; euthyroid hyperthyroxinemia; resource-limited setting; case report

*Corresponding Author:

Dr. Peter Matthew George

drpmgeorge2020@gmail.com

Declaration:

Authors' Contributions:

P.M.G: Conceptualization, clinical care, data collection and drafting; A.I: Supervision and critical revision; both authors approved the final manuscript.

Conflict of Interests: None

Funding: No funding received.

Article History:

Received: 29-08-2026

Accepted: 19-09-2026

Available Online: 29-09-2026

QR access this Article



INTRODUCTION

Thyroid nodules are common. Palpable thyroid masses are identifiable in approximately 4–7% of adults, and ultrasound-detectable nodules may be present in a much larger proportion of screened populations [1,2]. Contemporary guidelines for adult thyroid-nodule evaluation rest on clinical assessment, measurement of TSH (with free thyroxine when TSH is abnormal), high-resolution ultrasonography, and, when indicated, ultrasound-guided fine-needle aspiration (FNA) [3,4]. In usual physiology an inverse log-linear relationship exists between free thyroid hormones and pituitary TSH [5].

CC-BY 4.0 Licensed

The Operating Room Global Journal

Autonomous hypersecretion by a hyperfunctioning nodule (toxic adenoma) typically suppresses TSH, often to <0.1 mIU/L [6].

Occasionally, laboratory testing shows elevated total triiodothyronine (T3) and thyroxine (T4) with a normal, non-suppressed TSH. This pattern does not establish a single diagnosis. The differential includes euthyroid hyperthyroxinemia related to binding-protein abnormalities, the early phase of an autonomously functioning nodule before full TSH suppression, immunoassay interference (including heterophile antibodies and biotin), and, rarely, resistance to thyroid hormone [7–9]. In well-resourced settings these possibilities may be refined with free-hormone assays (preferably by equilibrium dialysis or tandem mass spectrometry), binding-protein measurement, scintigraphy, and, when indicated, genetic testing [7,8]. In many regional hospitals in sub-Saharan Africa such investigations are unavailable [10,11]. Clinicians must then weigh the theoretical risk of perioperative thyrotoxic crisis against the need to treat a symptomatic neck mass [12].

We report the evaluation and hemithyroidectomy of a young woman with a painful left thyroid mass, elevated total T3 and T4, a non-suppressed TSH, and mild leukopenia, managed in a resource-limited hospital without ultrasonography, FNA, scintigraphy, or histopathology. Possible explanations for the biochemical discordance are presented as hypotheses, not as confirmed diagnoses.

CASE PRESENTATION

Patient information

A 30-year-old woman presented to the surgical outpatient clinic of Hospital Protestant de Ngaoubela with a progressive swelling on the left side of the neck. She first noticed a small, painless lump about one year before admission. The swelling enlarged gradually. Localized dull pain then developed and prompted hospital attendance.

She reported no dyspnea, dysphagia, odynophagia, or hoarseness. She denied palpitations, heat intolerance, diaphoresis, involuntary weight loss, tremor, hyperdefecation, and emotional lability. There was no known chronic endocrine, autoimmune, or hematological disease and no previous surgery. Obstetric history was gravida 2, para 1, with Living 1. Family history was negative for goiter, thyroid cancer, and multiple endocrine neoplasia. She did not smoke or drink alcohol and reported no prior head or neck irradiation.

Clinical findings

She was alert and not in distress. Blood pressure was 109/79 mmHg, pulse 90 beats per minute (regular, normal volume), temperature 36.1 °C, and weight 61 kg. Heart sounds were normal without murmur. The chest was clear without stridor. The abdomen was soft without organomegaly. Deep-tendon reflexes were normal; there was no outstretched-hand tremor. The anterior neck showed an asymmetrical left thyroid mass, approximately 4.5×3.5 cm, firm to rubbery, mildly tender on deep palpation, and mobile with swallowing. There was no tracheal deviation, skin or muscle fixation, or palpable cervical lymphadenopathy.

Timeline

Table 1 summarizes the clinical course.

Timepoint	Event
Month -12	Patient notices a small, painless left neck lump.
Month -1	Lump enlarges; localized dull pain develops.
Day 1 (admission)	Clinical assessment: clinically euthyroid; pulse 90 bpm; stable vital signs. Laboratory tests ordered.
Day 2	Elevated total T3/T4; TSH 0.39 mIU/L (non-suppressed); mild leukopenia.
Day 3	Pre-anesthetic evaluation. Thionamides withheld because of clinical euthyroidism, non-suppressed TSH, and baseline leukopenia.
Day 4 (operation)	Left hemithyroidectomy. Recurrent laryngeal nerve and parathyroid glands preserved. Estimated blood loss ~35 mL. No thyroid crisis.
Days 4–5	Uneventful ward recovery; drain output low; clinically normocalcemic; normal voice.
Day 6	Discharge on oral analgesics; drain removed.

Day 13 (clinic)	Wound healing well; pain resolved; voice normal. Histopathology and postoperative thyroid function tests not obtained (see Limitations).
-----------------	--

Table 1. Timeline of presentation, intervention, and short-term follow-up.

Diagnostic assessment

Complete blood count (Table 2) showed a white-cell count of $3.91 \times 10^9/\text{L}$ (reference 4.00–10.00), granulocyte count $1.81 \times 10^9/\text{L}$ (reference 2.00–7.80), and platelet count $334 \times 10^9/\text{L}$ (local reference 100–300). Hemoglobin was 131 g/L.

Thyroid function tests (automated immunoassay of total hormones; Table 3) showed TSH 0.39 mIU/L (reference 0.30–4.20), total T3 4.46 nmol/L (reference 1.23–3.07), and total T4 189.55 nmol/L (reference 66.00–181.00). Free T3, free T4, thyroxine-binding globulin, thyroid autoantibodies, and heterophile-antibody or biotin interference studies were not available.

Thyroid ultrasonography, FNA cytology, and radioisotope scintigraphy were not performed because they were not available at the treating hospital and could not be funded off-site. The working clinical diagnosis was a symptomatic solitary left thyroid mass. The biochemical pattern (elevated total T3/T4 with non-suppressed TSH) was recorded as discordant and unexplained. Possible explanations, euthyroid hyperthyroxinemia, early nodular autonomy, assay interference, or (least likely on clinical grounds) thyroid-hormone resistance—could not be confirmed or excluded. Malignancy could not be excluded without cytology or histopathology.

Therapeutic intervention

On hospital day 3 the team considered whether thionamides and betablockade were required before surgery. The patient was clinically euthyroid, TSH was not suppressed, and there was baseline leukopenia. Thionamides were therefore withheld, to avoid an unnecessary agranulocytosis risk in a patient who did not have overt thyrotoxicosis [13,14]. This was a case-specific judgment, not a protocol for all discordant thyroid function tests.

On day 4, left hemithyroidectomy was performed under general anesthesia with standard monitoring. A transverse collar incision was used. The left lobe contained a firm nodular mass measuring approximately $4.5 \times 3.5 \times 3.0$ cm, without gross extracapsular invasion or adherence to the carotid sheath or trachea. The right lobe and isthmus appeared macroscopically normal. The superior thyroid vessels were ligated close to the gland. The left recurrent laryngeal nerve was identified in the tracheoesophageal groove and preserved. Both left parathyroid glands were identified and preserved with their vascular pedicles. The isthmus was divided. Estimated blood loss was approximately 35 mL. There was no intraoperative tachycardia, hypertension, or other feature of thyroid storm. A closed suction drain was placed. The patient was extubated awake with a normal voice.

The excised lobe was intended for histopathological examination. No histopathology service exists at the hospital, and the family had no funds to send the specimen to a distant laboratory. The specimen could not therefore be processed. This gap is acknowledged as a central limitation of the report.

Follow-up and outcomes

Immediate recovery was uneventful. Airway and hemodynamics were stable (blood pressure 115/75 mmHg, heart rate 82 bpm). Drain output was 15 mL in the first 24 hours. The voice was normal. There was no clinical hypocalcemia (no paresthesia; Chvostek and Trousseau signs negative). The drain was removed on postoperative day 2. She was discharged the same day on oral paracetamol and a short course of ibuprofen.

At clinic review on postoperative day 13 the cervical wound was clean and healing. Neck pain had resolved. The voice remained normal. Postoperative thyroid function tests were not obtained because of cost and laboratory constraints. Longer-term clinical or biochemical follow-up is not available. These absences are limitations and preclude any claim of biochemical cure or exclusion of later hypothyroidism or recurrent thyrotoxicosis.

Patient perspective

With written consent, the patient stated: “For a whole year, I watched the lump in my neck grow larger, and when it started to ache constantly, I became deeply worried about my health and my ability to care for my family. Learning that my blood tests were somewhat unusual added to my initial anxiety. However, the doctors explained the surgical plan clearly and reassured me. Waking up from surgery with my normal voice and realizing the constant aching pain in my neck was entirely gone was an incredible relief. I am very grateful for the smooth recovery and feel completely restored to my normal daily life.”

DISCUSSION

Discordant thyroid function tests, elevated circulating thyroid hormones with non-suppressed TSH are uncommon and require cautious interpretation [7,8,15]. Published series often describe extensive laboratory work-up that was not accessible here. Most thyroidectomies reported from sub-Saharan African hospitals are performed for compressive multinodular goiter, overt toxic adenoma with suppressed TSH, or suspected cancer [11,16,17]. Standard teaching is that overt thyrotoxicosis should be controlled medically before elective thyroidectomy to reduce the risk of thyroid storm [6,12]. That teaching applies to confirmed thyrotoxicosis. It does not automatically apply to a clinically euthyroid patient whose only abnormality is elevated total T3/T4 with TSH still within the reference interval.

Interpretation of discordant thyroid function tests

Confirmed findings in this case are limited: a symptomatic left thyroid mass; clinical euthyroidism; elevated total T3 and total T4; TSH 0.39 mIU/L (within the local reference range, near its lower limit); mild leukopenia; and an uncomplicated hemithyroidectomy with short-term symptomatic relief.

The cause of the biochemical discordance was not established. Binding-protein excess can raise total hormone concentrations while free hormone and TSH remain normal [18]. Early autonomy of a nodule can raise hormone output before TSH is fully suppressed [6,19]. Immunoassay interference can produce spurious results [9,20]. Resistance to thyroid hormone is rare and was not investigated [21]. None of these mechanisms was demonstrated in this patient. Free-hormone measurement, binding-protein assays, interference work-up, and scintigraphy would have been required to move from possibility to diagnosis. Those tests were unavailable. Statements in earlier versions of this manuscript that attributed the profile to euthyroid hyperthyroxinemia or transitional autonomy with undue certainty have therefore been withdrawn.

Hematological findings and antithyroid drugs

Mild leukopenia and a modestly raised platelet count were recorded. Their mechanisms were not investigated. Benign ethnic neutropenia is common in some African populations [22], and reactive thrombocytosis can accompany inflammation [23], but neither was proven here. The practical relevance of the blood count was limited to the decision not to start thionamides, which carry a small but well-documented risk of agranulocytosis [13,14].

Surgery in a resource-limited setting

Where ultrasonography, FNA, and scintigraphy are absent, surgery for a progressive, painful mass may be both treatment of symptoms and the only remaining diagnostic step provided the family can obtain histopathology. In this case even histopathology was unaffordable. Hemithyroidectomy relieved pain and removed the mass, with nerve and parathyroid preservation and no perioperative crisis. That outcome supports feasibility of carefully selected surgery under the conditions described. It does not show that the approach is universally safe or curative, nor that it should be used as a general algorithm [16,17,24]. Figure 1 depicts only the pathway used for this patient.

LIMITATIONS

This report has substantial limitations. (1) No thyroid ultrasound, FNA, or scintigraphy. (2) No free T3/T4, binding-protein, autoantibody, or assay-interference studies. (3) No histopathological diagnosis of the excised lobe, because the hospital has no histopathology service and the family could not fund external processing. (4) No postoperative thyroid function tests and no follow-up beyond 7 days after discharge. (5) Single-patient observation. These gaps prevent definitive classification of the nodule and of the biochemical discordance.

CONCLUSION

A clinically euthyroid woman with a painful left thyroid mass, elevated total T3 and T4, and a non-suppressed TSH underwent uneventful left hemithyroidectomy without thionamide preparation in a hospital without imaging, cytology, or histopathology. Short-term pain relief and an intact voice were achieved. The biochemical discordance remains unexplained. The management described is specific to this patient and these constraints. It should not be read as evidence that the same pathway is generally safe, curative, or guideline equivalent.

CARE checklist

This revised manuscript was checked against the CARE case-report framework: title identifies the report as a case report; keywords are provided; abstract includes background, case, and conclusions; introduction states the rationale; patient

information, clinical findings, timeline, diagnostic assessment, intervention, follow-up, and outcomes are described; the patient's perspective and informed consent are included; discussion separates confirmed findings from hypotheses and states limitations. Histopathology, advanced diagnostics, and long-term biochemical follow-up could not be reported because they were not obtained.

Patient consent

Written informed consent was obtained from the patient for publication of this case report and anonymized laboratory data. A copy of the consent form is available for review by the Editor-in-Chief on request. Identifying details have been omitted.

Ethical approval

Management and retrospective reporting complied with the Declaration of Helsinki. The Institutional Ethics and Review Board of Hospital Protestant de Ngaoubela, Cameroon, exempted formal review because this is an anonymized report of standard care without experimental intervention.

Acknowledgments

The authors thank the surgical, anesthetic, and ward staff of Hospital Protestant de Ngaoubela for their care of this patient.

Funding

No specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare no competing interests.

Use of artificial intelligence

AI-assisted tools were used only for language editing and formatting. Clinical data, interpretation, and final content were reviewed and approved by the authors. No AI tool was used for medical decision-making.

Authors' contributions

Peter Matthew George conceived the report, provided clinical care, collected data, and drafted the manuscript. Arda Işık supervised the work and critically revised the manuscript. Both authors approved the final version and agreed to be accountable for all aspects of the work.

REFERENCES

1. Dean DS, Gharib H. Epidemiology of thyroid nodules. *Best Pract Res Clin Endocrinol Metab.* 2008;22(6):901-911.
2. Durante C, Grani G, Lamartina L, Filetti S, Mandel SJ, Cooper DS. The diagnosis and management of thyroid nodules: a review. *JAMA.* 2018;319(9):914-924.
3. Haugen BR, Alexander EK, Bible KC, et al. 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer. *Thyroid.* 2016;26(1):1-133.
4. Gharib H, Papini E, Garber JR, et al. American Association of Clinical Endocrinologists, American College of Endocrinology, and Associazione Medici Endocrinologi medical guidelines for clinical practice for the diagnosis and management of thyroid nodules—2016 update. *Endocr Pract.* 2016;22(5):622-639.
5. Spencer CA, LoPresti JS, Patel A, et al. Applications of a new chemiluminometric thyrotropin assay to subnormal measurement. *J Clin Endocrinol Metab.* 1990;70(2):453-460.
6. Ross DS, Burch HB, Cooper DS, et al. 2016 American Thyroid Association guidelines for diagnosis and management of hyperthyroidism and other causes of thyrotoxicosis. *Thyroid.* 2016;26(10):1343-1421.
7. Koulouri O, Moran C, Halsall D, Chatterjee K, Gurnell M. Pitfalls in the measurement and interpretation of thyroid function tests. *Best Pract Res Clin Endocrinol Metab.* 2013;27(6):745-762.
8. Gurnell M, Halsall DJ, Chatterjee VK. What should be done when thyroid function tests do not make sense? *Endocrinol Metab Clin North Am.* 2011;40(1):155-167.
9. Favresse J, Burlacu MC, Maiter D, Gruson D. Interferences with thyroid function immunoassays: clinical implications and detection algorithm. *Endocr Rev.* 2018;39(5):830-850.
10. Ogbera AO, Kuku SF. Epidemiology of thyroid diseases in Africa. *Indian J Endocrinol Metab.* 2011;15(Suppl 2):S82-S88.

11. Chagaluka G, Gopal M. Surgical management of goiter in a resource-limited setting: a 5-year review at Queen Elizabeth Central Hospital, Malawi. *World J Surg.* 2014;38(4):879-884.
12. Chiha M, Samarasinghe S, Kabaker AS. Thyroid storm: an updated review. *J Intensive Care Med.* 2015;30(3):131-140.
13. Cooper DS. Antithyroid drugs. *N Engl J Med.* 2005;352(9):905-917.
14. Vicente N, Cardoso L, Barros L, Carrilho F. Antithyroid drug-induced agranulocytosis: state of the art on diagnosis and management. *Drugs R D.* 2017;17(1):91-96.
15. Van Uytvanghe K, Ehrenkranz J, Halsall D, et al. Thyroid stimulating hormone and thyroid hormones (triiodothyronine and thyroxine): an International Federation of Clinical Chemistry and Laboratory Medicine position statement. *Clin Chem Lab Med.* 2023;61(1):17-24. (IFCC position on thyroid hormone measurement; used here for contemporary assay context.)
16. Burch HB, Cooper DS. Management of Graves disease: a review. *JAMA.* 2015;314(23):2544-2554.
17. Agarwal A, Mishra AK. Operative management of thyroid disease in developing countries. *Nat Rev Endocrinol.* 2021;17(5):291-304.
18. Pappa T, Ferrara AM, Refetoff S. Inherited defects of thyroxine-binding proteins. *Best Pract Res Clin Endocrinol Metab.* 2015;29(5):735-747.
19. Parma J, Duprez L, Van Sande J, et al. Somatic mutations in the thyrotropin receptor gene cause hyperfunctioning thyroid adenomas. *Nature.* 1993;365(6447):649-651.
20. Li D, Radulescu A, Shrestha RT, et al. Association of biotin ingestion with performance of hormone and nonhormone assays in healthy adults. *JAMA.* 2017;318(12):1150-1160.
21. Moran C, Chatterjee K. Resistance to thyroid hormone due to defective thyroid receptor alpha. *Best Pract Res Clin Endocrinol Metab.* 2015;29(5):647-657.
22. Reich D, Nalls MA, Kao WH, et al. Reduced neutrophil count in people of African descent is due to a regulatory variant in the Duffy antigen receptor for chemokines gene. *PLoS Genet.* 2009;5(1):e1000360.
23. Schafer AI. Thrombocytosis. *N Engl J Med.* 2004;350(12):1211-1219.
24. Patel KN, Yip L, McAneny D, et al. The American Association of Endocrine Surgeons guidelines for the definitive surgical management of thyroid disease in adults. *Ann Surg.* 2020;271(3):e21-e93.

TABLES

Table 2. Complete blood count at admission

Parameter	Value	Unit	Reference	Flag
White-cell count	3.91	$\times 10^9/L$	4.00–10.00	Low
Lymphocytes (absolute)	1.22	$\times 10^9/L$	0.80–4.00	Normal
Mid cells (absolute)	0.88	$\times 10^9/L$	0.10–1.80	Normal
Granulocytes (absolute)	1.81	$\times 10^9/L$	2.00–7.80	Low
Lymphocytes	31.2	%	20.0–40.0	Normal
Mid cells	22.6	%	1.0–15.0	High
Granulocytes	46.2	%	50.0–70.0	Low
Red-cell count	4.42	$\times 10^{12}/L$	3.50–5.00	Normal
Hemoglobin	131	g/L	110–150	Normal
Hematocrit	0.417	fraction	0.370–0.470	Normal
MCV	86.6	fL	80.0–100.0	Normal
MCH	27.3	pg	27.0–34.0	Normal
MCHC	315	g/L	320–360	Low
RDW-CV	14.3	%	11.0–16.0	Normal
Platelet count	334	$\times 10^9/L$	100–300	High
Mean platelet volume	9.9	fL	6.5–12.0	Normal
Plateletcrit	3.32	mL/L	1.08–2.82	

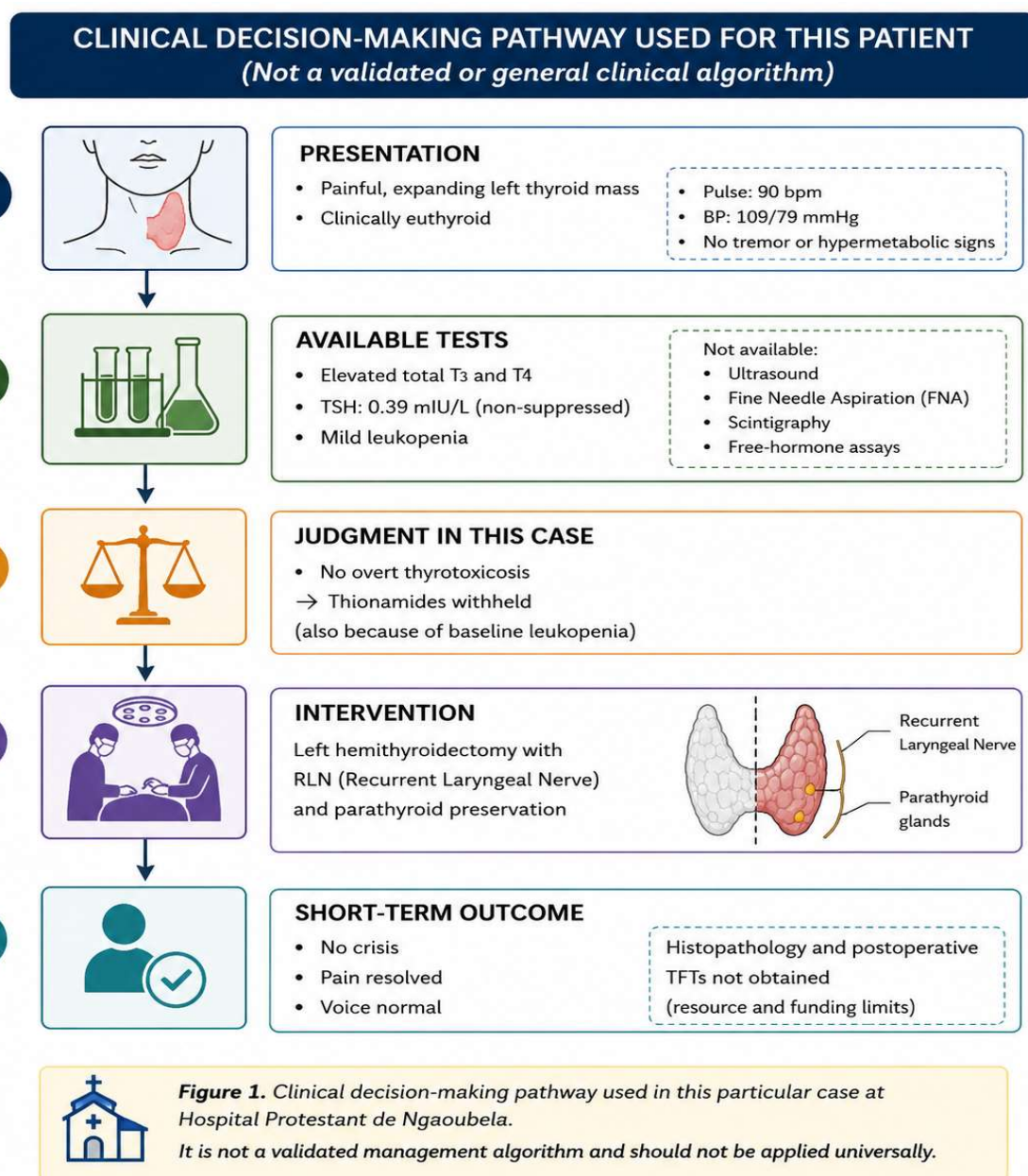
Mild leukopenia and a platelet count above the local reference interval were noted. Mechanisms were not established; the counts informed the decision to avoid thionamides.

Table 3. Thyroid function tests at admission

Parameter	Value	Unit	Reference	Interpretation
TSH	0.39	mIU/L	0.30–4.20	Within reference (near lower limit); not suppressed
Total T3	4.46	nmol/L	1.23–3.07	Elevated
Total T4	189.55	nmol/L	66.00–181.00	Elevated
Free T3 / free T4	Not measured	—	—	Unavailable
TBG / interference studies	Not performed	—	—	Unavailable

Discordant pattern: elevated total thyroid hormones with non-suppressed TSH. Cause not confirmed.

Figure 1.



CITE THIS ARTICLE:

- **APA (7th edition):** George, P. M., & Işık, A. (2026, September 29). *Diagnostic and therapeutic management of a painful thyroid mass with discordant thyrotropin and thyroid hormone measurements: A case report*. *The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2609002>
- **Harvard:** George, P.M. and Işık, A., 2026. *Diagnostic and therapeutic management of a painful thyroid mass with discordant thyrotropin and thyroid hormone measurements: A case report*. *The Operating Room Global Journal (TORGJ)*, 2(3). Published 29 September. Available at: <https://doi.org/10.64573/torgj2609002>
- **Vancouver:** George PM, Işık A. Diagnostic and therapeutic management of a painful thyroid mass with discordant thyrotropin and thyroid hormone measurements: a case report. *The Operating Room Global Journal (TORGJ)*. 2026 Sep 29;2(3). <https://doi.org/10.64573/torgj2609002>
- **MLA (9th edition):** George, Peter Matthew, and Arda Işık. "Diagnostic and Therapeutic Management of a Painful Thyroid Mass with Discordant Thyrotropin and Thyroid Hormone Measurements: A Case Report." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 29 Sept. 2026, <https://doi.org/10.64573/torgj2609002>
- **Chicago (Author-Date):** George, Peter Matthew, and Arda Işık. 2026. "Diagnostic and Therapeutic Management of a Painful Thyroid Mass with Discordant Thyrotropin and Thyroid Hormone Measurements: A Case Report." *The Operating Room Global Journal (TORGJ)* 2 (3), September 29. <https://doi.org/10.64573/torgj2609002>

THE OPERATING ROOM GLOBAL (TORG)

One-Year Research Fellowship (Mentorship Track)

MEET OUR SCIENTIFIC SESSION CHAIRS

VIRTUAL GLOBAL

RESEARCH CONGRESS 2026

Abstract Presentations, TORG Global Research Fellowship (Mentorship Track) 2025/2026 Cohort

- 4 Scientific Sessions
- 4 Sundays
- October 2026

OPEN TO THE TORG GLOBAL COMMUNITY & INTERNATIONAL AUDIENCE

SCAN QR CODE
TO REGISTER

Mr. Hailemariam Tesema Getachew

Director, The Operating Room Global Institutional Review Board (TORG-IRB); Former Vice Dean for Research & Post Graduate Studies; Lecturer and Senior Anesthetist at Dilla University Hospital Ethiopia and Partners In Health Sierra Leone.

DAY 1 • SUNDAY, 4 OCTOBER 2026 • 16:00 BST
Anaesthesia, Pain, Recovery & Patient Experience

Prof. Omokhoa Adeleye

MBBS, Cert AI, PGD, MHPM, MPH, MSc, MTD, FNIM, FRCIM, FWACP; Professor and Consultant Public Health and Community Medicine University of Benin and University of Benin Teaching Hospital (UBTH); Former Director, Centre for Artificial Intelligence Development, University of Benin; Former Deputy Chairman Medical Advisory Committee (Research & Ethics), UBTH, Benin City, Nigeria; Member, National Certification Committee for the Accreditation of Polio, Nigeria; Former Chairman, Technical Working Group on Education Ethics, National Bioethics Committee of Nigeria; Former Member, National Bioethics Committee of Nigeria; Faculty member, West African Bioethics Training Program, Ibadan, Nigeria.

DAY 2 • SUNDAY, 11 OCTOBER 2026 • 16:00 BST
Surgical Outcomes, Safety & Clinical Practice

Dr. Nikki Washington

DNP, MSN, MBA-HCM, RN, CHRN, CSCL; Director of Perioperative Services Central Valley Area, Stockton/Manteca/Madesto, Kaiser Permanente, California; Member, The Association of Perioperative Registered Nurses (AORN) Board of Directors, USA.

DAY 3 • SUNDAY, 18 OCTOBER 2026 • 16:00 BST
Perioperative Nursing, Quality Improvement & Surgical Systems

Prof. Elhadi Miskeen

Associate Professor and Head of Department, Obstetrics & Gynecology, Bisha University, Saudi Arabia; Global Research Mentor, The Operating Room Global (TORG); Associate Professor, Institute Safe Motherhood and Childhood, University of Gezira, Sudan; Faculty Lead, Obstetric & Gynecologic Surgical Education, TORG-GET.

DAY 4 • SUNDAY, 25 OCTOBER 2026 • 16:00 BST
Innovation, Evidence Synthesis & Population Health

Our Community! <https://linktr.ee/operatingroomissues>

The Largest Network of all Operating Room Professionals in One Place!

TORG CENTRE FOR EDUCATION, RESEARCH & INNOVATION.

The Operating Room Global (TORG) invites our global community and international audience to join the **Virtual Global Research Congress 2026**, featuring research presentations from fellows in the **TORG One-Year Research Fellowship (Mentorship Track), 2025/2026 Cohort**.

Across four Sundays in October 2026, fellows will present research spanning anaesthesia, surgical outcomes, perioperative nursing, quality improvement, innovation, evidence synthesis and population health.

Registration is required separately for each session you wish to attend.
Open to the TORG global community and international audience.

View the full programme and register for your preferred sessions here:
<https://torgceri.org/webinars/>

Strategic Measures To Overcome Barriers To Preventive Cervical Cancer Screening Among Women Attending Tertiary Health Facilities In Northwestern Zone, Nigeria

Authors: Mahmud Zubaina Yerima^{1,5*}, Mahammad A. Sabo², Babani M. Iliya¹, Abdullahi Adamu³, Ahmed Shuaibu Tsafi^{4,5}

¹ College of Nursing Sciences federal Medical Centre, Nguru Yobe State, Nigeria

² Franco-British International University (FBIU) Kaduna State Nigeria

³ Department of Environmental and Resources Management ,faculty of Engineering and Environmental Design
Usman Nanfodiyo University.

⁴ Federal medical Centre Nguru Nigeria

⁵ The Operating Room Global (TORG).

DOI: <https://doi.org/10.64573/torgj2608005>

ABSTRACT

Background/Objective: This study explored strategic measures for overcoming barriers to preventive cervical cancer screening among women attending tertiary health facilities in Northwestern Nigeria.

Study Design: Qualitative study.

Setting: The study was conducted across three health facilities in Jigawa, Kaduna, and Katsina States, Nigeria.

Methods: Data were collected using a semi-structured interview guide comprising demographic characteristics and six questions exploring potential strategies for overcoming barriers to cervical cancer screening. Sixty participants were interviewed, with 20 selected from each facility. Data was coded and analysed thematically.

Results: Most respondents were aged 40 years and above (42%). Participants generally did not support allowing women to self-collect samples and did not consider self-sampling an appropriate strategy for overcoming screening barriers, primarily because of concerns regarding possible sample contamination.

Conclusion/Recommendations: Most respondents did not support self-sampling for cervical cancer screening because of concerns about sample contamination. Strategies identified for addressing screening barriers included enhanced training for healthcare workers and intensified sensitisation and awareness activities within the study area.

Keywords: Strategic measures; cervical cancer prevention; cervical cancer screening; screening barriers; Nigeria.

***Corresponding Author:**
Mahmud Zubaina Yerima
zubainamahmud@gmail.com
Declaration:
Authors' Contributions:
See Contributions section.
Conflict of Interest: None
Funding: No funding received.

Article History:

Received: 25-08-2026
Accepted: 27-09-2026
Available Online: 30-09-2026

QR access this Article



INTRODUCTION

Improving the uptake of cervical cancer screening requires effective strategies to overcome barriers to its acceptance and utilisation. One important strategy is increased community sensitisation and awareness. The strategic measures to overcome barriers that will prevent cervical cancer screening were identified through various literature, some of the strategic measures commonly identified by respondents in different literature were: public campaigns, improve access to health facilities,

proper sensitization to the target population, employment of more skillful health personal, improve the screening services, ensure availability of screening equipment (1), (2) reported that, mass media campaigns on preventive cervical cancer screening, management, surgical and clinical features that affect cervical cancer screening are social norms, there is a need to improve in positive attitude change among the target population to prevent cervical cancer. Research reported that, reduction the charge of cervical cancer services, or government should make it free and preferably female healthcare providers should perform the procedure also health facilities should be located within the community (3).

MATERIAL/ METHOD

Design: Qualitative study

Study Setting: The study area of the study consists of three states in the northwestern geopolitical zone of Nigeria, namely: Jigawa, Kaduna and Katsina states

Study Population: 60 respondents, 20 selected from each of the three facilities

Inclusion: All health care providers working in Obstetric & Gynecological clinics

Exclusion Criteria: Those who refuse of give their consent to participate in the research

Sampling Strategy: The multi-stage sampling was applied, it follows three stages - In the first stage, three (3) out of seven (7) northwestern states were chosen at random using simple balloting method of simple random sampling. In the second stage, Teaching hospitals were purposely as the tertiary hospitals for the study. Finally, the health personnel serving at the departments were used for the purpose of interview.

Participant recruitment: The researcher and the research assistants were physically present in facilities and interacted with the respondents to clarify and further explain the questionnaire contents where necessary. The assistants were trained about the interview guide used and the process to be followed while conducting the interview. The team was thoroughly monitored by the researcher during the data collection period.

Interview procedures: Semi-structured interview guide was used for the study, which is of two sections: Section 'A' on Demographic data with four (4) items on Age, Sex, Highest qualification and years of working experience. 'B' section which contains six (6) items enquiries on the possible strategies to overcome barriers to preventive cervical cancer screening among the study population Three health facilities were under study in which the in-person interview.

Interview duration: 15-30 minutes

Thematic analysis procedure: Data were coded and analyzed thematically using (4) six-phase approach.

Measures undertaken to ensure credibility: Trustworthiness and Authenticity of the data collection instruments was ensured using the four alternative criteria paralleling for ensuring Validity and Reliability as in the case of quantitative study.

RESULTS

Table: 1 Demographic data of the respondents

S/N	AGE	Frequency	Percentages
1	40 and above	23	42
2	30-39	20	36
3	20-29	12	22
	Total	55	100%
	SEX	Frequency	percentages
1	Male	15	27
2	Female	40	73
	Total	55	100%
	Highest qualification	Frequency	Percentages
1	Diploma in midwifery	17	31
2	HND	10	19
3	BNSC	10	25

4	MBBS	9	16
5	MSC	5	9
	Total	55	100%

	Years of experience	Frequency	Percentages
1	Above 30	4	7
2	20-39	9	16
3	10-19	19	35
4	0-09	23	42
	Total	55	100%

The data on table 1 indicates that, majority of the respondents fall within 40 and above years, female were dominated (73%), diploma in midwifery (32%) and years of experience 0-9 (42%)

Theme 1: Respondents views on allowing women to be taking sample by themselves as a strategy to overcome the barrier Based on the interviews conducted, virtually all the respondents expressed that, they don't allow client to take sample by themselves and hold the view that, they don't see doing that as a measure to overcome barrier to the screening. To some, doing that may even leads to contamination of the samples instead. As can be reflected in this response quoted "No, we do not; Nurse takes the sample for safety and accuracy. No allowing them to take the sample to me cannot be among the strategies to overcome any barrier to cervical cancer screening". (KD Midwife, 41years).

Theme 2: Communication and empathy of the health care providers help in reducing women's fear and even overcome resistance to be treated by a male health care provider

According to the study findings, the good communication and showing empathy to the client while conducting cervical cancer screening can be a strategy or measure to overcome barrier to the screening among the study population. This has been what is containing in the respondents' views across the institutions under study. A justification to the said is a quote from the respondents view while responding on the role good communication and empathy of the health provider play role in reducing patients fear during screening and overcome their resistance to be treated or screened by a male health worker is a precise response of one respondent from Kaduna State Teaching Hospital "Yes, when we communicate well and show empathy women will feel safe and more respected, it help them to overcome fear and trust the male health provider more. Friendly approaches always make a different". (KD Midwife, 35 years).

Theme 3: Continuous training of doctors and other healthcare providers carrying out the screening serve as strategy to overcome barrier to the cervical cancer screening

All the respondents interviewed across the three institutions under study viewed that continuous training of the health workers will go a long way in overcoming the barrier to the screening among the population of the study.

Theme 4: Showing honesty to the patients, building their confidence and ensuring confidentiality of their health status serves as a strategy to overcome barrier to screening.

Responses from the respondents has been revolving around these areas when asked regarding ways to improve trust in health service in general and in the cervical cancer screening relevance in particular as a strategic measure to overcome barrier to the screening. A good example of these views is one expressed by a respondent from katsina State Teaching Hospital "Trust can help greatly because we if are honest to our patients, the patients will feel free with you and sometime even discuss something with you even not discuss with her husband, it give a successful outcome in every intervention, confidentiality will be maintained. You know when patient trust you, she is confident on you, so she can view out her problems, share her own ideas, feeling and whatsoever". (KD Public health, 55years).

Theme 5: Ways to improve level of uptake of cervical cancer screening among women attending obstetrics and gynecology in the institutions under study.

Respondents have expressed numerous views in response to this theme, but the views can be curtailed within three key areas as bellow:

1. Providing regular health education by the health workers on the stressing the relevance of the cervical cancer screening at hospital clinics and wards.
2. Taking enlightenment campaigns on cervical cancer screening to communities and various gatherings.

3. Ensuring availability of free and adequate cervical cancer screening service at various health facilities to cut across primary, secondary and tertiary.

However, above are the responses from the respondents across the three tertiary health facilities covered by the study. Some responses can be seen below for clarification:

“It can be improved through continuous health education. At every step of the contact out- patients (both attending ante-natal and other clinics) should be enlighten more on the benefits of the screening”. KT Medical doctor 45 years “Creating awareness, meeting them at community level, do not wait for them to come to the tertiary institutions, they should be met at the grass root level, creating awareness on the disease and where to get help”. (KT Midwife, 55 years).

DISCUSSION

Majority of the respondents fall within 40 and above years, The study is in contrast with the previous study conducted by (5), which showed that, majority of respondents were within the age range of ,50–59 years (40.7%), However, sex wise, majority of the respondents are female occupying while only fewer were male, this might be associated with the nature of the department. The study supported a previous study conducted by (5), which revealed that, majority (88.9%) were female and (11.1%) are Male. On the highest qualification obtained by the individual respondents, those with diploma in midwifery are the majority then, followed by BNSC holders , HND, MBBS and MSc .The finding in corroborates with the finding of (5). Medical Doctor, Nurse (40.7%) Midwife (11.1%)The years of experience of the as shown, majority (42%) are within the range of 00 - 09 years of experience, (35%) fall within 10 - 19, (16%) are within 20 - 29 and (7%) within the range of thirty (30) and above respectively.

Respondents' views on allowing women to be taking sample by themselves as a strategy to overcome the barrier Based on the interview conducted, virtually all the respondents expressed that, they don't allow client to take sample by themselves and hold the view that, they don't see doing that as a measure to overcome barrier to the screening. To some doing that may even lead to contamination of the samples instead. As can be reflected in this response quoted “No, we do not; Nurse takes the sample for safety and accuracy. No allowing them to take the sample to me cannot be among the strategies to overcome any barrier to cervical cancer screening”.(KD Midwife 41) The finding is consisted with the studies of (6) found out, respondents preferred to do they examinations by themselves than health care provider, the beliefs it might help to minimizer pain. it depends on the patient if the patient feels comfortable that way we can allow her to take it by herself KD, midwife ,35years

Communication and empathy of the health care providers help in reducing women's fear and even overcome resistance to be treated by a male health care provider.

According to the study finding, the good communication and showing empathy to the client while conducting cervical cancer screening can be a strategy or measure to overcome barrier to the screening among the study population. This has been what is containing in the respondents' views across the institutions under study. A justification to the said is a quote from the respondents view while responding on the role good communication and empathy of the health provider play role in reducing patients fear during screening and overcome their resistance to be treated or screened by a male health worker is a precise response of one respondent from Kaduna State Teaching Hospital “Yes, when we communicate well and show empathy women will feel safe and more respected, it help them to overcome fear and trust the male health provider more. Friendly approaches always make a different”. KD Midwife 35 years “The finding of this study supported the previous study of (5), who found out that, good communication skills of health personnel can contribute massively in encouraging the participants acceptability to a procedure of cervical cancer screening or Pap smears. In same study, the author lamented that respondents feel uncomfortable if it a male health care provider to carried out the procedure on gynecological investigation. “We feel more comfortable if it is female health personnel is performing the procedure” said by majority of the respondents.

Also, respondents indicate that, bad communication between clients and health personnel affect the acceptance of the screening, they lamented that some health personnel will not have time to exemplify the procedure or some do not do the ideal regarding the procedures (5), unlike the present study which indicate that, Good communication and sympathy among health care workers can help in reduces participants fear and allows male health personnel to attend to them (5), good communication skill and Friendly approaches can allow male health personnel to perform the procedure. (3), reported that, respondents preferred female health care personnel for the cervical cancer screening while some did not identify.

Continuous training of doctors and other healthcare providers carrying out the screening serve as strategy to overcome barrier to the cervical cancer screening.

All the respondents interviewed across the three institutions under study viewed that continuous training of the health workers will go a long way in overcoming the barrier to the screening among the population of the study. The finding is consisted with finding of (5), who reported that, lack of training of health personnel lead misinterpretation of result, so there is need for training of health personnel and also recommended that some investigation instruments on cervical cancer screening such as human papilloma virus detection or colposcopy in the Centre. Establishment of services there is need for small training like workshop and seminar on cervical cancer screening and longtime training such as take a course, this will help in the update of knowledge (7). The study showed that, health personnel should undergo training, and materials should be availability in order to maintaining the achievement of screening exercises (8).

Showing honesty to the patients, building their confidence and ensuring confidentiality of their health status serves as a strategy to overcome barrier to screening.

Responses from the respondents has been revolving around these areas when asked regarding ways to improve trust in health service in general and in the cervical cancer screening relevance in particular as a strategic measure to overcome barrier to the screening. A good example of these views is one expressed by a respondent from katsina State Teaching Hospital "Trust can help greatly because we if are honest to our patients, the patients will feel free with you and sometime even discuss something with you even not discuss with her husband, it give a successful outcome in every intervention, confidentiality will be maintained. You know when patient trust you, she is confident on you, so she can view out her problems, share her own ideas, feeling and whatsoever". KD Public health 55years" The finding of this study is in consisted by study conducted by (9), it was reported that, respondents were feeling shy during the procedure as result of some health care workers do not maintain confidentiality. There is needs for sensitization amongst health care provider, continues and maintain trust and confidentiality in the process of carried out they duties. The research was shown that, improving confidence of the respondents by health personnel should endure screening are recommended. (7).

Ways to improve level of uptake of cervical cancer screening among women attending obstetrics and gynecology in the institutions under study.

Respondents have expressed numerous views in response to this theme, but the views can be curtailed within three key areas as below:

1. Providing regular health education by the health workers on the stressing the relevance of the cervical cancer screening at hospital clinics and wards.
2. Taking enlightenment campaigns on cervical cancer screening to communities and various gatherings.
3. Ensuring availability of free and adequate cervical cancer screening service at various health facilities to cut across primary, secondary and tertiary.

However, above are the responses from the respondents across the three tertiary health facilities covered by the study. Some responses can be seen below for clarification:

"It can be improved through continuous health education. At every step of the contact out- patients (both attending ante-natal and other clinics) should be enlighten more on the benefits of the screening". KT Medical doctor 45 years. The finding of this study is contrast with finding of (5), continues health education help in improved participants acceptability of cervical cancer screening.

"Creating awareness, meeting them at community level, do not wait for them to come to the tertiary institutions, they should be met at the grass root level, creating awareness on the disease and where to get help". KT Midwife 55 years" The finding of this study is supported the study of which shows that health personnel need to improve through good communication this can encourage the uptake of cervical cancer screening (5). The finding of this study is consisted with the finding of (11) found out that, awareness on cervical cancer screening play vital role in acceptability of the procedure. The finding of this study is supported the finding of (1), the study identify a major strategic to improved cervical cancer screening are: sensitization of the target population, employment of more skilful health personal, improved of screening services, facilities should be near to people in the community, make available of screening equipment. Health care personnel should reinforcement of awareness regarding the cervical cancer screening (11). This study is aligned with (2) reported that, there is a need to improve in positive attitude change among the target population to prevent cervical cancer. (3) found out that, respondents belief reducing the cost of the screening on cervical cancer and make it free help improved acceptability of screening procedure.

CONCLUSION AND RECOMMENDATION

Most respondents reported that they did not allow clients to self-collect samples and did not consider self-sampling an appropriate strategy for overcoming barriers to cervical cancer screening. In contrast, previous studies have reported greater acceptance of self-sampling, suggesting that it may reduce discomfort and improve screening uptake. Effective communication and empathy towards clients may also facilitate acceptance of cervical cancer screening. The study recommends additional training for healthcare personnel and increased community sensitisation and awareness regarding cervical cancer screening.

Ethical Considerations: Introductory letter was obtained from Maryam Sani Abacha American University Niger, and Ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects of the three health facilities, prior to data collection. An informed and written consent was obtained from all participants. However, references and date of approval from each facility of study are as follows:

1. Rasheed Rshekoni federal University Teaching Hospital Duste, RST.UTH/GEN/226/V.11 date, 17th November, 2025
2. Ahamdu Bello University Teaching Hospital Shika Zaria, Nigeria, NNHREC/ABUTH-HREC/29/08/23, 16th September, 2025
3. Federal Teaching Hospital Katsinna Umaru Musa Yar, adua, FTHKTNNHREC.REG.24/06/22c/267, date 03rd September 2025.

Authors' Contributions: Mahmud Z.Y.: Conceptualization, data collection and manuscript drafting; Prof. Abdullahi Sabo: Supervision and critical review; Dr. Abdullahi Adamu: Study design; Ahmed Shuaibu Tsafi: Proofreading and publication support; Babani M. Iliya: Data presentation, analysis and referencing.

REFERENCES

1. Landis FC, Yolande-Blandine NF, Enow-Orock G, Omer N, Marcelin NN. Perception on cervical cancer and enhancing strategies to screening uptake among women in Bamenda, Cameroon: A qualitative method. *J Public Health Epidemiol.* 2022;14(4):149-159. doi: 10.5897/JPHPE2022.1410
2. World Health Organization. Global strategy to accelerate the elimination of cervical cancer as a public health problem. Geneva: World Health Organization; 2020. Licence: CC BY-NC-SA 3.0 IGO.
3. Olubodun T, Balogun MR, Odeyemi AK, Odukoya OO, Ogunyemi AO, Okafor OJ, et al. Knowledge and acceptability of cervical cancer screening among female undergraduates in Babcock University Ilishan-Remo, Ogun State, Nigeria. *BMC Public Health.* 2023; 23:123. <https://doi.org/10.3332/s12905-023-X>
4. Braun & Clerkr V. Thematic analysis: A Practical guide. Londow: Sage Publications: 2021. E-books.
5. Vega Crespo B, Alejandra NV, Segarra J, Andrade A, Ortiz GG, Flores A, et al. Barriers and facilitators to cervical cancer screening among under-screened women in Cuenca, Ecuador: the perspectives of women and health professionals. *BMC Public Health.* 2022;22:2144. <https://doi.org/10.1186/s12889-022-14601-y>
6. Jentschke M, Lehmann R, Drews N, Hansel A, Schmitz M, Hillemanns P. Psychological distress in cervical cancer screening: results from a German online survey. *Arch Gynecol Obstet.* 2020;302(3):699-705. <https://doi.org/10.1007/s00404-020-05661-9>
7. Assefa AA, Feleke T, Assefa SG, Degela F. Utilization and associated factors of cervical cancer screening service among eligible women attending maternal health services at Adare General Hospital, Hawassa city, Southern Ethiopia. *Sci Rep.* 2024;14:2774. <https://doi.org/10.1038/s41598-024-52924-5>
8. Dyken JA, Smith JS, Demment M, Marshall E, Schuh T, Peters K, et al. Evaluating the implementation of cervical cancer screening programs in low-resource settings globally: a systematized review. *Cancer Causes Control.* 2020;31(5):417-429. <https://doi.org/10.1007/s10552-020-01290-4>
9. Pearce B, Aziato L, Achempim-Ansong G. Exploring the perspectives of young adults on cervical cancer screening in the Western Region of Ghana: A qualitative enquiry. *Asian Pac J Cancer Care.* 2023;8(1):11-20. doi: 10.31557/APJCC.2023.8.1.11
10. Olatubi MI, Ewoma GE, Ademuyiwa GO, Bello CB, Dosumu TO, Famakinwa TT, et al. Awareness and uptake of cervical cancer screening, vaccination and associated factors among female undergraduates in Nigeria. *Nurs Health Care.* 2024;6(1):1284-1301. <https://dx.doi.org/10.4314>

11. Gizaw T, Khatib Z, Wolancho W, Amdissa M, Bamboro IM. Uptake of cervical cancer screening and its predictors among women of reproductive age in Gomma district, South West Ethiopia: a community-based cross-sectional study. *Infect Agent Cancer*. 2022;17:43. <https://doi.org/10.1186/s13027-022-00455-x>
12. Rosenbaum AJ, Gage JC, Alfaro KM, Ditzian LR, Maza M, Scarinci IC. Acceptability of self-collected versus provider-collected sampling for HPV DNA testing among women in rural El Salvador. *Int J Gynaecol Obstet*. 2014;126(2):156-160. <https://doi.org/10.1016/j.ijgo.2014.02.026>

CITE THIS ARTICLE:

- **APA (7th edition):** Yerima, M. Z., Sabo, M. A., Iliya, B. M., Adamu, A., & Tsafi, A. S. (2026, September 30). *Strategic measures to overcome barriers to preventive cervical cancer screening among women attending tertiary health facilities in Northwestern Zone, Nigeria. The Operating Room Global Journal (TORGJ)*, 2(3). <https://doi.org/10.64573/torgj2608005>
- **Harvard:**Yerima, M.Z., Sabo, M.A., Iliya, B.M., Adamu, A. and Tsafi, A.S., 2026. *Strategic measures to overcome barriers to preventive cervical cancer screening among women attending tertiary health facilities in Northwestern Zone, Nigeria. The Operating Room Global Journal (TORGJ)*, 2(3). Published 30 September. Available at: <https://doi.org/10.64573/torgj2608005>
- **Vancouver:** Yerima MZ, Sabo MA, Iliya BM, Adamu A, Tsafi AS. Strategic measures to overcome barriers to preventive cervical cancer screening among women attending tertiary health facilities in Northwestern Zone, Nigeria. *The Operating Room Global Journal (TORGJ)*. 2026 Sep 30;2(3). <https://doi.org/10.64573/torgj2608005>
- **MLA (9th edition):** Yerima, Mahmud Zubaina, et al. "Strategic Measures to Overcome Barriers to Preventive Cervical Cancer Screening among Women Attending Tertiary Health Facilities in Northwestern Zone, Nigeria." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 3, 30 Sept. 2026, <https://doi.org/10.64573/torgj2608005>
- **Chicago (Author-Date):** Yerima, Mahmud Zubaina, Mahammad A. Sabo, Babani M. Iliya, Abdullahi Adamu, and Ahmed Shuaibu Tsafi. 2026. "Strategic Measures to Overcome Barriers to Preventive Cervical Cancer Screening among Women Attending Tertiary Health Facilities in Northwestern Zone, Nigeria." *The Operating Room Global Journal (TORGJ)* 2 (3), September 30. <https://doi.org/10.64573/torgj2608005>



The flyer is a call for submissions for the TORG-IRB. It features a dark blue background with a white central box. At the top left, the TORG-IRB logo is displayed in yellow and white. To the right, registration information is provided: 'Registered with the U.S. Office for Human Research Protections (OHRP) (FWA Number: FWA00035510 | IORG Number: IORG0012466 | IRB Number: IRB00014742)'. The central white box contains the TORG-IRB logo, the full name 'The Operating Room Global Institutional Review Board', and a large 'Call for Submissions' heading. Below this, it states 'ROLLING SUBMISSIONS — SUBMIT ANYTIME'. A section titled 'WHAT IS IT FOR?' describes the board's role in ethical review. Another section titled 'WHY SUBMIT?' lists five bullet points: independent ethical review, participant protection, research integrity and accountability, ethical governance beyond approval and publication, and support for responsible research. A 'SUBMIT TODAY' button with a right arrow and a 'Scan QR Code' button are present, along with a QR code. A megaphone icon is at the bottom left, and a website URL is provided. The bottom right features a circular seal and a tagline about being the largest network of operating room professionals.

TORG-IRB

Registered with the U.S. Office for Human Research Protections (OHRP)
(FWA Number: FWA00035510 | IORG Number: IORG0012466 |
IRB Number: IRB00014742)

TORG-IRB

*The Operating Room Global
Institutional Review Board*

Call for Submissions

ROLLING SUBMISSIONS — SUBMIT ANYTIME

WHAT IS IT FOR?

Ethical review of health research
involving human participants to protect
participants, promote scientific integrity,
and ensure ethical conduct.

WHY SUBMIT?

- Independent ethical review
- Participant protection
- Research integrity and accountability
- Ethical governance beyond approval and publication
- Support for responsible research.

SUBMIT TODAY → Scan QR Code

Upholding Ethical Research Excellence!

Visit Our Website
<https://operatingroomissues.org>

The Largest Network of all Operating
Room Professionals in One Place!

Call for Submissions | TORG-IRB

The Operating Room Global Institutional Review Board (TORG-IRB) welcomes rolling submissions for ethical review of health research involving human participants. Our role goes beyond ethical approval. TORG-IRB supports responsible research through participant protection, research integrity, accountability, and ethical governance beyond approval and publication.

Submissions are open on a rolling basis, submit anytime.

- ◆ Independent ethical review
- ◆ Participant protection
- ◆ Research integrity and accountability
- ◆ Ethical governance beyond approval and publication
- ◆ Support for responsible research

Ready to submit? Scan the QR code on the flyer or visit the TORG-IRB page for information and access to the submission portal:

<https://torgceri.org/torg-irb/>

TORG-IRB, Upholding Ethical Research Excellence.

Incidence And Predictors Of Rebound Pain Following Peripheral Nerve Block Among Orthopedics Surgical Patients

Authors: Belete Muluadam Admassie^{1,2*}, Adebisola Adenike Owokole^{2,3,4,5}

¹ Department of Anesthesia, College of Medicine and Health science, Bahir Dar University, Bahir Dar, Amhara, Ethiopia

² The Operating Room Global (TORG)

³ The Robotic Global Surgical Society (TROGSS)

⁴ UL Hospitals, Ireland

⁵ University of Limerick (UL), Ireland

DOI: <https://doi.org/10.64573/torgj2609001>

ABSTRACT

Background: Rebound pain is an underestimated postoperative complication, characterized by severe pain after the resolution of the block. Although PNBs are increasingly utilized in orthopedic surgery, data regarding rebound pain incidence and predictors is scarce, especially in low-resource settings.

Aim: The study aimed to assess the incidence and predictors of rebound pain among adults who underwent orthopedic surgeries of the upper extremities under peripheral nerve block in Ethiopia, 2025/2026.

Methods: A prospective cohort study was conducted among 200 adult patients who underwent orthopedic surgery with peripheral nerve block. Patients were monitored for 48 hours after surgery, and data collection was done through structured questionnaires and chart reviews. Pain intensity was measured using the Numeric Rating Scale after the sensory block resolution. Rebound pain assessed at 12–24 hours post-block resolution. Multivariable logistic regression was performed to identify independent predictors, with statistical significance at $p < 0.05$.

Results: The incidence of rebound pain was found to be 88/200(44.5%). Dexamethasone pre-medication and Intraoperative analgesia were independently associated with lower odds of rebound pain (AOR = 0.18; 95% CI: 0.04-0.92) and (AOR = 0.39; 95% CI: 0.16-0.96), respectively, while NLR ≥ 3 was independently associated with higher odds of rebound pain (AOR = 8.20; 95% CI: 3.71-18.31).

Conclusion: Rebound pain was prevalent following PNB after orthopedic surgeries of the upper extremities. Intraoperative analgesia and dexamethasone premedication have a protective effect against rebound pain while higher NLR levels are risk factors for the development of rebound pain. These results advocate for further investigation into multimodal analgesic approaches and inflammatory risk indicators in perioperative pain management.

Keywords: Analgesia, Dexamethasone, incidence, Nerve block, Pain, Risk factors.

*Corresponding Author:

Belete Muluadam Admassie

uogbelete@gmail.com

Declaration:

Authors' Contributions:

BMA: Conceptualization, study design, data collection, analysis, interpretation and manuscript preparation; AAO: Supervision, study design, interpretation, and critical review. Both authors approved the final manuscript.

Conflict of Interest: None

Funding: No funding received.

Article History:

Received: 28-08-2026

Accepted: 28-09-2026

Available Online: 02-10-2026

QR access this Article



INTRODUCTION

Pain is a major global health problem involving disability, decreased quality of life, and significant socio-economic costs to society, making it a public health priority (1, 2). WHO considers proper pain management to be an essential part of healthcare and one of the basic rights of humans (3). Post-surgical pain management is challenging and, even when adequately treated,

can be a risk factor for morbidity (1-4). 41% of people suffer from post-surgical pain, among orthopedic surgeries, the incidence is highest (5,6,7). Post-surgical pain that is improperly treated can lead to delayed healing, increased length of hospitalization, morbidity, and the development of chronic post-surgical pain (8,9,10). Peripheral nerve blocks (PNBs) are effective procedures for post-operative analgesia, which are frequently applied as part of multimodal analgesia and play an integral role in procedures such as arthroscopic rotator cuff repair (11). PNBs can assist with reducing opioid use and accelerating post-operative recovery and patient satisfaction (12-15).

However, despite the analgesia that PNBs provide, pain can increase substantially following the resolution of the block (11). Specifically, single-shot PNBs can be followed by rebound pain, which is a severe pain occurring after the resolution of anesthesia which may be greater than the initial post-operative pain (15,16). Rebound pain occurs in about half the people on whom PNB is given and is especially prevalent in ambulatory orthopedic surgery (18,19). The mechanism by which it occurs is not entirely understood, although several theories have been postulated, including abrupt restoration of nociceptive inputs, peripheral and central sensitization, and inflammatory hyperalgesia (20,21). The severity of rebound pain may be influenced by a range of patient- and surgery-related factors (17,20,21). Moreover, lack of transitional analgesia and systemic inflammatory response can also worsen the severity of rebound pain (20,22). Therefore, the phenomenon of rebound pain can be seen as an important limitation of single-shot peripheral nerve blocks despite their effective analgesic properties (16,23,24).

Clinically, rebound pain can have a negative impact on post-operative outcomes by adversely affecting recovery and increasing the requirement for rescue opioids (17,18). As such, there has been a growing interest for strategies to counter rebound pain. Preventive strategies include multimodal analgesia, adjuvants, early oral analgesia before the resolution of the block, and continuous peripheral nerve block catheters (20,21,25). The Gate Control Theory of Pain provides an informative conceptual basis for understanding rebound pain after resolution of a nerve block, postulating that the transmission of nociceptive signals is modulated in the spinal cord, and alterations of this modulation can underlie enhanced pain after the resolution of a block (17,20,26). Despite the increasing appreciation of the phenomenon of rebound pain, the evidence for its incidence and predictors is limited. This is especially true for low-income settings such as Ethiopia, where data on rebound pain are scarce. Moreover, the role of the systemic inflammatory response in rebound pain is poorly characterized. Inflammatory biomarkers, specifically the neutrophil-to-lymphocyte ratio (NLR), may have promising prognostic implications in rebound pain (27,28).

Therefore, this study examines the incidence and predictors of rebound pain in Ethiopian tertiary hospitals. By providing the much-needed evidence on the incidence and outcomes of rebound pain in this low-income setting and evaluating potential predictors, including the inflammatory biomarker NLR, the study contributes to the generation of context-specific and optimal strategies for the prevention and management of rebound pain.

Aim

The study aims to assess the incidence and predictors of rebound pain following peripheral nerve block in adult patients undergoing upper extremity orthopedic surgery at Tibebe Ghion Specialized Hospital in Ethiopia during 2025/2026.

Objectives

To assess the incidence of rebound pain following peripheral nerve block among adult upper extremity orthopedic surgical patients at Tibebe Ghion Specialized Hospital, Ethiopia, 2025/2026

To identify patient-related, surgical, and anesthesia-related factors associated with rebound pain among adult upper extremity orthopedic surgical patients at Tibebe Ghion Specialized Hospital, Ethiopia, 2025/2026

METHODS

Study Design and Period

A prospective cohort study involving two hundred orthopedic patients was conducted from December 2025 to July 2026 to determine factors related to rebound pain following peripheral nerve block anesthesia (PNB).

Study Setting

The study was conducted at Tibebe Ghion Specialized Hospital, a tertiary teaching and referral hospital, associated with Bahir Dar University found in Bahir Dar, northwest Ethiopia. The hospital has a wide range of orthopedic surgical procedures and utilizes peripheral nerve block as one of its anesthetic procedures.

Study Population

Adult patients underwent orthopedic surgical procedures under the peripheral nerve block at Tibebe Ghion Specialized Hospital during data collection period.

Eligibility Criteria

Adult patients aged 18 years and older who underwent orthopedic surgery with PNB and provided informed consent to participate were included in the study. Patients who could not communicate or express their level of pain, those converted to general anesthesia during the procedure, and those with neurological conditions that might interfere with pain sensation were excluded from the study.

Sample Size Determination and sampling technique

The sample size for the study was calculated, using a single-population proportion formula with an expected proportion of 70.9% (28). Using a 95% confidence level and a 5% margin of error, the initial sample size was determined to be 316. Considering the accessible population of approximately 200 patients undergoing orthopedic surgery, a finite population correction (FPC) was applied, resulting in a final sample size of 123. To optimize precision, all 200 eligible patients were consecutively recruited, and included in the final analysis.

Operational Definitions

Rebound pain is severe post-operative pain (measured by NRS 7/10) that occurs peripherally in the 12–24 hours after resolution of the sensory block, revealed by the return of sensation to the patient's skin following peripheral nerve block (18).

The rebound pain score was calculated as the difference between the maximum pain score on the first 12 hours since resolution of the peripheral nerve block and the minimum pain score measured during the 12 hours preceding block resolution (23).

Data Collection Tools

A standardized questionnaire and clinical checklist were used to collect data on clinical and sociodemographic factors, intraoperative information, anaesthetic methods, analgesic use, and laboratory markers such the neutrophil-to-lymphocyte ratio. A standardized numerical rating scale (NRS) was used to assess pain severity.

Validity and Reliability Assurance

To guarantee clarity and consistency, the data collecting questionnaire which was modified from previous studies and validated by an expert in the anesthesia department through a four-day descriptive pilot trial with three patients. A four-day pilot study was conducted to assess the clarity, applicability, and consistency of the questionnaire. Prior to the primary data collection, adjustments were made.

Data Collection Procedure

Data were collected during the perioperative period, including preoperative data, intraoperative variables, and postoperative pain assessments at set intervals after nerve block resolution, with trained data collectors ensuring accuracy and consistency

Data Processing and Statistical Analysis

Data were analyzed using SPSS version 20 with both descriptive and inferential statistics. Continuous variable distributions were assessed through skewness and kurtosis, while categorical variables were summarized via frequencies and percentages. Means and standard deviations described continuous variables that were normally distributed. Categorical bivariable comparisons utilized Pearson's chi-square test. Binary logistic regression identified factors related to rebound pain, considering variables with $p < 0.25$ from bivariable analysis and clinically relevant factors for multivariable logistic regression. Crude and adjusted odds ratios (CORs and AORs) with 95% confidence intervals were presented, with statistical significance at $p < 0.05$. An available-case analysis was performed for missing data, and model fit was evaluated using the Hosmer–Lemeshow test ($\chi^2 = 6.91$, $p = 0.54$). Multicollinearity analysis included VIF and tolerance statistics, revealing a maximum VIF of 4.69 and a minimum tolerance of 0.21.

Ethics approval and consent to participate

Ethical approval was obtained from TORG-IRB (reference number TORG-IRB-20260227-02). Written informed consent was obtained from each participant. The confidentiality of the information provided was ensured, as all details were kept strictly confidential and were used only by the researchers. In addition, each participant could withdraw from the study without suffering any negative consequences. There were no financial temptations for those participating in the research. Finally, the study did not involve any significant risks to the participants' health, as it only included routine treatment observation and regular pain assessments. All data collected were secured and available only to the researchers.

RESULTS

Socio-Demographic and Preoperative Clinical Characteristics

Among 200 study patients, 71.5% were male, and 54.0% had a BMI of 18.5-24.9 kg/m². Most patients classified as ASA I-II, with 29.0% having at least one coexisting medical condition. Preoperative complete blood count testing was performed on 91.5% of participants. Detailed characteristics are shown in Table 1.

Table 1. Socio-Demographic and Preoperative Clinical Characteristics of Participants (N = 200)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	143	71.5
	Female	57	28.5
Body mass index (kg/m ²)	18.5–24.9	108	54.0
	>24.9	92	46.0
ASA physical status	ASA I	26	13.0
	ASA II	105	52.5
	ASA ≥III	69	34.5
Coexisting disease	Yes	58	29.0
	No	142	71.0
Type of coexisting disease(n=58)	Diabetes mellitus	11	18.9
	Hypertension	19	32.8
	Asthma	6	10.3
	Epilepsy	6	10.3
	Heart disease	5	8.6
	Anemia	11	18.9
Complete blood count performed	Yes	183	91.5
	No	17	8.5
Neutrophil-to-lymphocyte ratio	<3	113	56.5
	≥3	87	43.5
Preoperative pain	Yes	92	46.0
	No	108	54.0
Preoperative analgesia received	Yes	79	39.5
	No	121	60.5
Type of preoperative analgesia	Opioids	43	54.4
	NSAIDs	34	43.0
	Paracetamol	39	49.4

Footnote: PCM; paracetamol, NSAIDs; non-steroidal anti-inflammatory drugs, HD; Heart Disease, DM ;Diabetes mellitus, HTN; Hypertension, percentages for specific comorbidities were calculated among patients with coexisting disease(n=58), BMI; Body mass index, ASA; American Society of Anesthesiologists, in analgesic categories multiple responses were permitted and percentage calculated among the 79 patients who received preoperative analgesia.

Operative Characteristics

Bone surgery comprised 54.5% of the procedures. Tourniquet duration data was available for 76 out of 119 patients who underwent a tourniquet. Analyses that required tourniquet duration considered only cases with available data as shown in Table 2.

Table 2. Operative Characteristics (N = 200)

Variable	Category	Frequency (n)	Percentage (%)
Urgency of the procedure	Elective	106	53.0
	Emergency	94	47.0
Type of Surgery	Bone	109	54.5
	Soft Tissue	91	45.5
Tourniquet Use	Yes	119	59.5
	No	81	40.5
Duration of Tourniquet (n=76)	Below Mean(67.48min)	39	19.5
	Above Mean(67.48min)	37	18.5
Surgical Procedure	Fixation	47	23.5
	Plating	13	6.5
	D&I	58	29.0
	Removal	28	14.0
	Amputation	4	2.0
	Skin graft	13	6.5
	Pinning	16	8.0

Footnote: D&I; Irrigation and Debridement, tourniquet duration available, n=76/119

Peripheral Nerve Block and Anesthetic Characteristics

Supraclavicular block was the most frequently utilized peripheral nerve block, accounting for 46.5% of cases. Bupivacaine was administered to 165 patients (82.5%). Out of 111 patients receiving an adjuvant, the type was recorded for 85, with 26 lacking this information. Analyses involving adjuvant types were based on available cases, with detailed characteristics provided in Table 3.

Table 3. Peripheral Nerve Block and Anesthetic Characteristics (N = 200)

Variable	Category	Frequency (n)	Percentage (%)
Type of Peripheral Nerve Block	Interscalene	3	1.5
	Supraclavicular	93	46.5
	Axillary	92	46.0
	Wrist	12	6.0
Local Anesthetic Type	Bupivacaine	165	82.5
	Lidocaine	35	17.5
Adjuvant Used	Yes	111	55.5
	No	89	44.5
Type of Adjuvant(n=85)	Dexamethasone	64	32.0
	Opioid	21	10.5
Dexamethasone Premedication	Yes	109	54.5
	No	91	45.5
Intraoperative Analgesia Received	Yes	108	54.0
	No	92	46.0

Footnote: although 111 patients received adjuvants, 26 data's missed adjuvant type records

Postoperative Outcomes and Block Characteristics

Postoperative opioid analgesics were given to 50% of patients. After the sensory block resolved, 70.5% reported moderate-to-severe pain. The mean duration of sensory block was 10.05 hours, with a mean time to block resolution of 15.44 hours (Table 4).

Table 4. Postoperative Outcomes and Block-Related Characteristics (N = 200)

Variable	Category	Frequency (n)	Percentage (%)
----------	----------	---------------	----------------

Postoperative Opioid Use	Yes	100	50.0
	No	100	50.0
Postoperative NSAID Use	Yes	108	54.0
	No	92	46.0
Postoperative Paracetamol Use	Yes	106	53.0
	No	94	47.0
Severity of Pain After Block Resolution	No pain	3	1.5
	Mild Pain	56	28.0
	Moderate pain	52	26.0
	Severe Pain	89	44.5
Rebound Pain	Yes	89	44.5
	No	111	55.5
PNB Type (Dichotomized)	Distal Brachial Plexus Block	104	52.0
	Proximal Brachial Plexus Block	96	48.0
Duration of Motor Block	<8.84hr	126	63.0
	≥8.84 hr	74	37.0
Duration of Sensory Block	<10.05 hr	100	50.0
	≥10.05 hr	100	50.0
Time to Block Resolution	<15.44 hr	109	54.5
	≥15.44 hr	91	45.5

Footnote: NSAIDs; non-steroidal anti-inflammatory drugs, PNB; Peripheral nerve block, Proximal brachial plexus block (Interscalene and supraclavicular), Distal brachial plexus block(axillaries and wrist)

Descriptive Statistics of Continuous Variables

Normality assessment through skewness and kurtosis values indicated that all variables were approximately normally distributed, with skewness values between -0.304 and 0.709, reflecting a balanced and near-symmetrical distribution of the data (Table 5).

Table 5. Descriptive statistics for continuous variables

Variables	N	Min	Max	Mean±SD	Skewness	Kurtosis
Duration of tourniquet(min)	76	31	96	67.48±18.46	-.288	-.864
Volume of LA(mL)	200	14	40	30.04±6.77	-.304	-.627
Time to Block resolution(h)	200	8	23	15.44±4.62	.079	-1.218
Duration of surgery(h)	200	1	3	1.50±.63	-.018	-1.050
Duration of Motor Block(h)	200	5	16	8.84±2.81	.615	-.494
Duration of Sensory Block(h)	200	6	18	10.05±2.65	.709	-.047

Footnote: LA; Local anesthetic, SD; standard deviation, Max; Maximum, Min; Minimum

Incidence of Rebound Pain Following Peripheral Nerve Block

Among 200 patients 89 developed rebound pain, giving incidence of rebound pain (RP) following peripheral nerve block of 44.5% (95% CI: 38.0–51.5) (Figure 1).

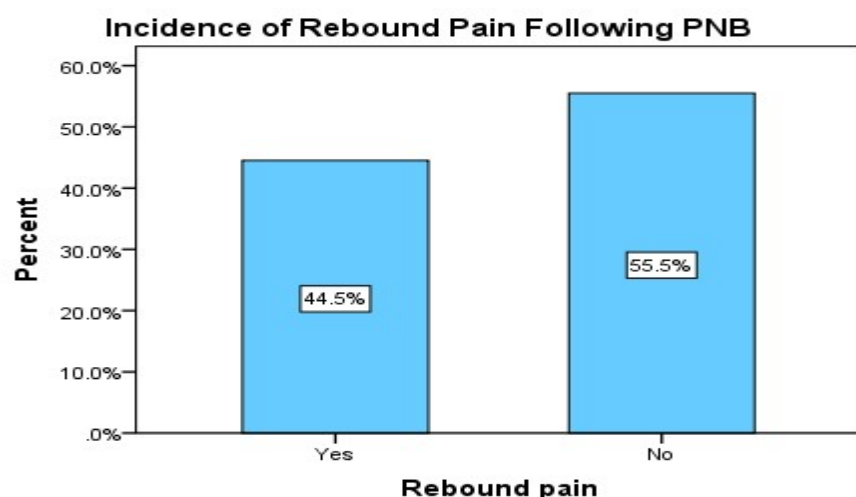


Figure 1. Incidence of rebound pain following peripheral nerve block

Chi-square Analysis of Factors Associated with Rebound Pain Following Peripheral Nerve Block

Pearson's chi-square analysis revealed an association between RP, preoperative pain preoperative pain ($\chi^2 = 16.10$, $p < 0.001$), neutrophil-to-lymphocyte ratio (NLR) ($\chi^2 = 37.30$, $p < 0.001$), dexamethasone premedication ($\chi^2 = 24.90$, $p < 0.001$), intraoperative analgesia ($\chi^2 = 54.80$, $p < 0.001$), and adjuvant use ($\chi^2 = 25.40$, $p < 0.001$). Additionally, perioperative factors such as tourniquet use ($\chi^2 = 6.87$, $p = 0.009$), postoperative opioid use ($\chi^2 = 27.70$, $p < 0.001$), and time to block resolution ($\chi^2 = 19.60$, $p < 0.001$) were also significantly associated with RP. However, no significant associations were found for gender, age, coexisting disease, ASA physical status, preoperative analgesia, urgency of surgery, type of surgery, and various other factors (all $p > 0.05$). Detailed results are provided in Table 6.

Table 6. Chi-square analysis of factors associated with rebound pain following peripheral nerve block

Variable	Category	Rebound pain, Yes n (Expected)	Rebound pain, No n (Expected)	χ^2	P-value
Gender	Male	65 (63.6)	78 (79.4)	0.18	0.660
	Female	24 (25.4)	33 (31.6)		
Age (years)	≥ 60	67 (65.4)	80 (81.6)	0.26	0.600
	< 60	22 (23.6)	31 (29.4)		
Coexisting disease	Yes	26 (25.8)	32 (32.2)	0.81	0.660
	No	63 (62.7)	78 (78.3)		
ASA status	ASA I	14 (11.6)	12 (14.4)	1.06	0.588
	ASA II	45 (46.7)	60 (58.3)		
	ASA $\geq$ III	30 (30.7)	39 (38.3)		
Dexamethasone premedication	Yes	66 (48.5)	43 (60.5)	24.90	<0.001
	No	23 (40.5)	68 (50.5)		
Preoperative pain	Yes	55 (40.9)	37 (51.1)	16.10	<0.001
	No	34 (48.1)	74 (59.9)		
Preoperative analgesia	Yes	41 (35.2)	38 (43.8)	2.80	0.089
	No	48 (53.8)	73 (67.2)		
Tourniquet use	Yes	62 (53.0)	57 (66.0)	6.87	0.009
	No	27 (36.0)	54 (45.0)		
Adjuvant used	Yes	67 (49.4)	44 (61.6)	25.40	<0.001
	No	22 (39.6)	67 (49.4)		
Intraoperative analgesia	No	74 (48.1)	34 (59.9)	54.80	<0.001
	Yes	15 (40.9)	77 (51.1)		
Postoperative opioid	Yes	63 (44.5)	33 (55.5)	27.70	<0.001
	No	26 (44.5)	74 (55.5)		
Time of block resolution	< Mean	64 (48.5)	45 (60.5)	19.60	<0.001
	$\geq$ Mean	25 (40.5)	66 (50.5)		

Tourniquet duration	<67.48 min	16(17.4)	23 (21.6)	1.7	0.42
	≥67.48min	20 (16.5)	17 (20.5)		
Neutrophil-to-lymphocyte ratio	<3	29 (50.3)	84 (62.7)	37.30	<0.001
	≥3	60 (38.7)	27 (48.3)		

ASA: American Society of Anesthesiologists

Bivariable and Multivariable Logistic Regression Analysis

In a bivariable logistic regression analysis, factors associated with rebound pain (RP) included intraoperative analgesia, postoperative opioid use, tourniquet use, dexamethasone premedication, preoperative pain, preoperative analgesia, adjuvant use, time to block resolution and neutrophil-to-lymphocyte ratio (NLR). Variables with a p-value <0.25 and clinically relevant factors were analyzed in a multivariable model. After adjustment for potential confounder's, NLR ≥ 3 (AOR = 8.2; p<0.001) was associated with higher odds of rebound pain, while intraoperative analgesia (AOR = 0.18; p=0.039) and dexamethasone premedication (AOR = 0.39; p=0.04) were associated with lower odds of rebound pain (Table 7).

Table 7. Bivariable and multivariable logistic regression analysis

Variable	Category	COR (95% CI)	P-value	AOR (95% CI)	P-value
Dexamethasone premedication	Yes vs No	0.22 (0.12–0.41)	<0.001	0.39 (0.16–0.96)	0.041
Preoperative pain	Yes vs No	0.31 (0.17–0.55)	<0.001	0.54 (0.22–1.33)	0.180
Preoperative analgesia	Yes vs No	0.61 (0.34–1.08)	0.090	0.65 (0.31–1.40)	0.271
Tourniquet use	Yes vs No	0.46(0.25–0.82)	0.009	0.81 (0.36–1.79)	0.61
Adjuvant use	Yes vs No	0.22 (0.12–0.39)	<0.001	0.87 (0.35–2.20)	0.77
Intraoperative analgesia	Yes vs No	0.09 (0.05–0.18)	<0.001	0.18 (0.04–0.92)	0.039
Postoperative opioid use	Yes vs No	0.21 (0.11–0.38)	<0.001	1.4 (0.34–5.90)	0.638
Neutrophil-to-lymphocyte ratio	≥3 vs <3	6.40 (2.46–11.96)	<0.001	8.2(3.71–18.31)	<0.001
Time to block resolution	Above vs Below mean	0.26 (0.15–0.48)	<0.001	1.29 (0.38–4.41)	0.684

Footnote: CI; Confidence interval, COR; crude odds ratio, AOR; Adjusted Odds ratio, variables with p<0.25 in bivariable analysis and clinically relevant variables were entered into the multivariable model and p<0.05 in multivariable model considered as statically significant.

DISCUSSION

This prospective cohort study examined the incidence and predictors of rebound pain after peripheral nerve block in adult patients undergoing upper extremity orthopedic surgery. It revealed a 44.5% incidence of rebound pain, indicating that nearly half of the patients experienced a significant increase in pain after resolution of the block. This result verifies that rebound pain is a frequent occurrence after surgery in orthopedics, especially within Ethiopian practice(25). The similar incidences have also been reported approximately 40–60% of patients have experienced rebound pain after ambulatory orthopedic and ankle fracture surgeries, as previously reported(21,11). Narrative reviews also show that rebound pain is a major problem for many people who receive single-shot peripheral nerve blocks (19, 30). The results confirm that rebound pain is a frequent phenomenon following surgery, not an isolated event. Variations in reported incidence arise from differences in patient characteristics, surgical techniques, nerve block methods, anesthetic agents, analgesic protocols, and definitions of rebound pain. In addition, differences in healthcare systems, access to acute pain services, and patient education can affect how often rebound pain is reported.

One of the notable findings of this study is that receipt of intraoperative analgesia was associated with lower odds of rebound pain. This observation is consistent with interventional evidence that timely intraoperative analgesia can mitigate severe rebound pain by enhancing transitional analgesia during the resolution of the block (28). Previous reviews also

emphasized the importance of administering systemic analgesics before resolution of the block for preventing rebound pain (13, 30). Analgesia administered during surgery may have a biological link to reduced nociceptive transmission as the patient moves from sensory blockade to the return of nerve function. Although the observational nature of the study cannot establish causality, this short-lived analgesia might lessen the abrupt exposure to unrelieved surgical nociception.

The other finding of this study dexamethasone premedication was associated with lower odds of rebound pain. Dexamethasone can prolong the duration of peripheral nerve blocks and reduce postoperative inflammation, contributing to a smoother recovery, even though the observational design of the study limits any causal conclusions (13,30). The strong association observed between $\text{NLR} \geq$ and Rebound pain suggests that preoperative inflammatory status may have potential value in identifying patients an increased risk However, this finding should be interpreted cautiously and requires external validation before NLR can be recommended as clinical predictive marker. Higher NLR levels, which serve as a biomarker of systemic inflammation, can amplify inflammatory responses and make postoperative pain more severe (13). Since NLR is a widely recognized biomarker of systemic inflammation, patients with elevated NLR may have greater inflammatory responses after tissue injury, predisposing them to more severe postoperative pain. Furthermore, prior prediction models and a retrospective cohort study identified inflammatory and patient-related characteristics as significant contributors to severe rebound pain. (26,27).

Even though NLR was not directly assessed, these studies suggest that inflammatory status influences the intensity of rebound pain. Thus, with these findings, the current study suggests that NLR could serve as a simple and cost-effective biomarker to identify patients at higher risk of rebound pain prior to surgery. The present study did not demonstrate statistically significant independent associations between rebound pain and tourniquet use, postoperative opioid use, adjuvant use, or preoperative pain after multivariable adjustment. Although prolonged tourniquet inflation has previously been associated with ischemia-reperfusion injury and increased postoperative pain, the absence of an independent association in the current study agrees with previous study, who found that procedural characteristics frequently lose significance after adjustment for analgesic and patient-related factors (21). Similarly, perioperative analgesic management has a greater influence on rebound pain than most surgical variables (27).

Likewise, preoperative pain and postoperative opioid administration were not independently associated with rebound pain. Comparable observations were reported by previous where baseline pain characteristics lost statistical significance after adjustment for multiple clinical variables (26). These results suggest that rebound pain is shaped considerably by postoperative inflammatory responses and analgesic approaches, to a greater degree than by baseline pain intensity or the use of opioids on its own. Overall, the findings support that rebound pain is multifactorial and associated with inflammatory status, perioperative analgesic management, and individual patient characteristics. The observed associations of intraoperative analgesia and dexamethasone premedication with lower odds of rebound pain along with the association of elevated NLR with higher odds, identify clinically relevant areas for further investigation and risk-informed perioperative care.

IMPLICATIONS

The results indicate better perioperative pain management for orthopedic surgery, with an emphasis on rebound pain after single-shot peripheral nerve blocks. Before the block wears off, clinicians ought to use evidence-based multimodal analgesia. Moreover, the link between a higher neutrophil-to-lymphocyte ratio and rebound pain suggests that low-cost laboratory markers could be used for risk assessment, provided they are validated in larger studies. Institutions should establish standardized protocols for rebound pain management within enhanced recovery frameworks and provide educational initiatives to anesthesia professionals to recognize and prevent rebound pain, thus supporting personalized pain management in low-resource environments.

LIMITATIONS

Some limitations of the study include its single center design; observational design and therefore inability to establish causality; possibility residual/ unmeasured cofounding; heterogeneity in surgical procedure and analgesic regimens; missing data for some variables; reliance on patient-reported pain scores; and the absence of some potentially relevant psychological variables.

CONCLUSION

Rebound pain was common among adult patients undergoing upper extremity orthopedics' surgery following peripheral nerve block. Neutrophil-to-lymphocyte ratio (NLR) ≥ 3 was independently associated with higher odds of rebound pain, whereas dexamethasone premedication and intraoperative analgesia were associated with lower odds. These results assist in identifying potentially higher-risk patients and informing future research and perioperative pain management strategies. Further multicenter studies and external validation are required before these findings can be incorporated into predictive clinical practice.

RECOMMENDATIONS

Based on the study's findings, the following recommendations are made: For clinical practice, hospitals should enhance multimodal transitional analgesia protocols and evaluate the role of dexamethasone in relevant studies. The preoperative neutrophil-to-lymphocyte ratio should be further assessed as a risk marker. For hospitals and policymakers, there is a need to create guidelines for preventing and managing rebound pain after peripheral nerve blocks and to incorporate standardized patient education into perioperative care. In education, training for anesthesia providers should focus on identifying and managing rebound pain with evidence-based analgesic strategies. Subsequent investigations ought to center on multicenter trials involving bigger sample sizes to confirm the results, investigate ideal analgesic regimens, evaluate how well inflammatory biomarkers predict outcomes, and contrast continuous peripheral nerve blocks with single-shot approaches for handling rebound pain.

Acknowledgment

First, I am obliged to The Operating Room Global (TORG) and the TORG Fellowship Directorate for their role in making the TORG Global Research Fellowship (Mentorship Track) program possible, which is crucial for the improvement of research capacities. My special thanks go to my amazing mentor Prof. Adebisola A. Owokole for mentoring me throughout the research process, thus helping me improve the quality of this thesis. Moreover, I would like to thank all the study participants for giving their time to be a part of this research and the data collectors for their efforts in gathering the data. OpenAI's ChatGPT was acknowledged as a valuable tool in refining concepts and language during the thesis development.

Authors contribution statement

BMA participated in the conception and design of the study, data collection, data analysis, interpretation of the results, and preparation of the manuscript. Prof. Adebisola, who supervised, provided guidance throughout the research process, participated in the design of the study and the interpretation of the results, and critically revised and reviewed the manuscript. Both authors approved the final version of the manuscript.

Conflicts of interests: The authors declare no conflicts of interests

Source of funding: This work did not receive any grant from funding agencies in the public, commercial or not-for-profit sectors.

Availability of data and materials

The data sets used and analyzed during the study are available from the corresponding author on reasonable request.

Abbreviations

AOR; Adjusted odds Ratio, ASA; American Society of Anesthesiologists, BMI; Body mass index, COR; Crude Odds Ratio, DM; Diabetes mellitus, HD; Heart Disease, HTN; Hypertension, LA; Local Anesthetics, NLR; Neutrophil-lymphocyte Ratio, NSAIDs; non-steroidal anti-inflammatory drugs, PCM; paracetamol, PNB; Peripheral Nerve Block, RP; Rebound pain, TORG; The Operating Room Global

Declaration on the Use of Generative AI: Generative AI tools were applied to the manuscript during preparation for the purposes of language refinement, grammatical correction, clarification of sentence construction, and assistance with the organisation of the written content. The design of the research, data collection, statistical analysis, interpretation of data, scientific conclusions, and final intellectual content are undertaken and verified by the author of this manuscript. The author is solely responsible for the accuracy of this work.

Tables and Figures

Table 1. Socio-Demographic and Preoperative Clinical Characteristics of Participants (N = 200)

Table 2. Operative Characteristics (N = 200)

Table 3. Peripheral Nerve Block and Anesthetic Characteristics (N = 200)

Table 4. Postoperative Outcomes and Block-Related Characteristics (N = 200)

Table 5. Descriptive statistics for continuous variables

Table 6. Chi-square analysis of factors associated with rebound pain following peripheral nerve

Table 7. Bivariable and multivariable logistic regression analysis

Figure 1. Incidence of rebound pain following peripheral nerve block.

REFERENCES

- Goldberg DS, McGee SJ. Pain as a global public health priority. *BMC public health*. 2011 Oct 6;11(1):770.
- King NB, Fraser V. Untreated pain, narcotics regulation, and global health ideologies. *PLoS medicine*. 2013 Apr 2;10(4):e1001411.
- Kumar N. WHO normative guidelines on pain management. Geneva: World Health Organization. 2007 Jun:3-4.
- Gaskin DJ, Richard P. The economic costs of pain in the United States. *The journal of pain*. 2012 Aug 1;13(8):715-24.
- Sommer M, De Rijke JM, Van Kleef M, Kessels AG, Peters ML, Geurts JW, Gramke HF, Marcus MA. The prevalence of postoperative pain in a sample of 1490 surgical inpatients. *European journal of anaesthesiology*. 2008 Apr;25(4):267-74.
- Buvanendran A, Fiala J, Patel KA, Golden AD, Moric M, Kroin JS. The incidence and severity of postoperative pain following inpatient surgery. *Pain medicine*. 2015 Dec 1;16(12):2277-83.
- Fuzier R, Rousset J, Bataille B, Salces-y-Nédéo A, Maguès JP. One half of patients reports persistent pain three months after orthopaedic surgery. *Anaesthesia Critical Care & Pain Medicine*. 2015 Jun 1;34(3):159-64.
- Raja SN, Carr DB, Cohen M, Finnerup NB, Flor H, Gibson S, Keefe FJ, Mogil JS, Ringkamp M, Sluka KA, Song XJ. The revised International Association for the Study of Pain definition of pain: concepts, challenges, and compromises. *Pain*. 2020 Sep 1;161(9):1976-82.
- Kehlet H, Dahl JB. Anaesthesia, surgery, and challenges in postoperative recovery. *The Lancet*. 2003 Dec 6;362(9399):1921-8.
- Yang X, Yang Y, Qin S, Chen Y. Research progress of rebound pain after nerve block in arthroscopic rotator cuff repair. *Frontiers in Medicine*. 2025 Oct 15;12:1659133.
- Uquillas CA, Capogna BM, Rossy WH, Mahure SA, Rokito AS. Postoperative pain control after arthroscopic rotator cuff repair. *Journal of shoulder and elbow surgery*. 2016 Jul 1;25(7):1204-13.
- Joshi G, Gandhi K, Shah N, Gadsden J, Corman SL. Peripheral nerve blocks in the management of postoperative pain: challenges and opportunities. *Journal of clinical anesthesia*. 2016 Dec 1;35:524-9.
- Gabriel RA, Ilfeld BM. Use of regional anesthesia for outpatient surgery within the United States: a prevalence study using a nationwide database. *Anesthesia & Analgesia*. 2018 Jun 1;126(6):2078-84.
- Abdallah FW, Halpern SH, Aoyama K, Brull R. Will the real benefits of single-shot interscalene block please stand up? A systematic review and meta-analysis. *Anesthesia & Analgesia*. 2015 May 1;120(5):1114-29.
- Hutton M, Brull R, Macfarlane AJ. Regional anaesthesia and outcomes. *BJA education*. 2018 Feb 1;18(2):52-6.
- Sort R, Brorson S, Gögenur I, Nielsen JK, Møller AM. Rebound pain following peripheral nerve block anaesthesia in acute ankle fracture surgery: an exploratory pilot study. *Acta Anaesthesiologica Scandinavica*. 2019 Mar;63(3):396-402.
- Dada O, Gonzalez Zacarias A, Ongaigui C, Echeverria-Villalobos M, Kushelev M, Bergese SD, Moran K. Does rebound pain after peripheral nerve block for orthopedic surgery impact postoperative analgesia and opioid consumption? A narrative review. *International journal of environmental research and public health*. 2019 Sep;16(18):3257.

- Barry GS, Bailey JG, Sardinha J, Brousseau P, Uppal V. Factors associated with rebound pain after peripheral nerve block for ambulatory surgery. *British journal of anaesthesia*. 2021 Apr 1;126(4):862-71.
- Admassie BM, Tegegne BA, Alemu WM, Getahun AB. Magnitude and severity of rebound pain after resolution of peripheral nerve block and associated factors among patients undergoes surgery at university of gondar comprehensive specialized hospital northwest, Ethiopia, 2022. Longitudinal cross-sectional study. *Annals of Medicine and Surgery*. 2022 Dec 1;84:104915.
- Muñoz-Leyva F, Cubillos J, Chin KJ. Managing rebound pain after regional anesthesia. *Korean journal of anesthesiology*. 2020 Aug 10;73(5):372-83.
- Nobre LV, Cunha GP, Sousa PC, Takeda A, Ferraro LH. Peripheral nerve block and rebound pain: literature review. *Revista Brasileira de Anestesiologia*. 2019;69(6):587-93.
- Murphy KJ, O'Donnell B. Rebound Pain—Management Strategies for Transitional Analgesia: A Narrative Review. *Journal of Clinical Medicine*. 2025 Jan 31;14(3):936.
- Williams BA, Bottegall MT, Kentor ML, Irrgang JJ, Williams JP. Rebound pain scores as a function of femoral nerve block duration after anterior cruciate ligament reconstruction: retrospective analysis of a prospective, randomized clinical trial. *Regional Anesthesia & Pain Medicine*. 2007 May 1;32(3):186-92.
- Henningsen MJ, Sort R, Møller AM, Herling SF. Peripheral nerve block in ankle fracture surgery: a qualitative study of patients' experiences. *Anaesthesia*. 2018 Jan;73(1):49-58.
- Touil N, Pavlopoulou A, Barbier O, Libouton X, Lavand'homme P. Evaluation of intraoperative ketamine on the prevention of severe rebound pain upon cessation of peripheral nerve block: a prospective randomised, double-blind, placebo-controlled study. *British journal of anaesthesia*. 2022 Apr 1;128(4):734-41.
- Hamilton DL. Rebound pain: distinct pain phenomenon or nonentity?. *British Journal of Anaesthesia*. 2021 Apr 1;126(4):761-3.
- Wang YM, Liang JN, Liu DC, Zhao BC, Zhang H, Zhang HF. Factors associated with postoperative rebound pain after peripheral nerve block anaesthesia for orthopedic trauma surgery: a retrospective cohort analysis. *Journal of Orthopaedic Surgery and Research*. 2025 Oct 28;20(1):931.
- Gobeze NZ, Yehualaw MZ, Asmare TB, Deress GM, Belete KG, Teshome D, Demilew BC, Yitbarek MM, Mossie KD, Mekuriaw BY, Wubet HB. Prevalence and Predictors of Severity of Rebound Pain After Regional Anesthesia in Patients Undergoing Orthopedic Surgery: A Cross-Sectional Study. *Pain Research and Management*. 2025;2025(1):2130050.
- Jen TT, Ke JX, Wing KJ, Denomme J, McIsaac DI, Huang SC, Ree RM, Prabhakar C, Schwarz SK, Yarnold CH. Development and internal validation of a multivariable risk prediction model for severe rebound pain after foot and ankle surgery involving single-shot popliteal sciatic nerve block. *British Journal of Anaesthesia*. 2022 Jul 1;129(1):127-35.

CITE THIS ARTICLE:

- **APA (7th edition):** Admassie, B. M., & Owokole, A. A. (2026, October 2). *Incidence and predictors of rebound pain following peripheral nerve block among orthopedics surgical patients*. *The Operating Room Global Journal (TORGJ)*, 2(4). <https://doi.org/10.64573/torgj2609001>
- **Harvard:** Admassie, B.M. and Owokole, A.A., 2026. *Incidence and predictors of rebound pain following peripheral nerve block among orthopedics surgical patients*. *The Operating Room Global Journal (TORGJ)*, 2(4). Published 2 October. Available at: <https://doi.org/10.64573/torgj2609001>
- **Vancouver:** Admassie BM, Owokole AA. Incidence and predictors of rebound pain following peripheral nerve block among orthopedics surgical patients. *The Operating Room Global Journal (TORGJ)*. 2026 Oct 2;2(4). <https://doi.org/10.64573/torgj2609001>
- **MLA (9th edition):** Admassie, Belete Muluadam, and Adebisola Adenike Owokole. "Incidence and Predictors of Rebound Pain Following Peripheral Nerve Block Among Orthopedics Surgical Patients." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 4, 2 Oct. 2026, <https://doi.org/10.64573/torgj2609001>
- **Chicago (Author-Date):** Admassie, Belete Muluadam, and Adebisola Adenike Owokole. 2026. "Incidence and Predictors of Rebound Pain Following Peripheral Nerve Block Among Orthopedics Surgical Patients." *The Operating Room Global Journal (TORGJ)* 2 (4), October 2. <https://doi.org/10.64573/torgj2609001>

The Operating Room Global (TORG) ANNOUNCING A NEW STRATEGIC PARTNERSHIP WITH

**Jimma University Medical
Center (JUMC)**
Jimma University, Ethiopia.



TORG × JUMC

**JUMC is now a TORG
Affiliated Institution**

The Operating Room Global (TORG)
operatingroomissues.org

Jimma University Medical Center (JUMC)
ju.edu.et/jimma-medical-center

**THE OPERATING ROOM
GLOBAL (TORG)**



Partner With Us

"Join us in transforming
healthcare through
strategic partnerships in
education, research, and
innovation"

LEARN MORE

Our Global Community
<https://linktr.ee/operatingroomissues>

SCAN QR CODE



Introducing the TORG Specialty Networks Community (TORG-TSN)



Introducing TORG Specialty Networks (TORG-TSN)

The Operating Room Global (TORG) is proud to launch the TORG Specialty Networks (TORG-TSN), a dedicated professional networking community designed to connect members based on their specialties, subspecialties, professions, and areas of interest.

[Join Now](#)

➔

Featured Specialty Networks

- General Surgery
- Obstetrics & Gynecology
- Orthopedic Surgery
- Ophthalmology
- Plastic & Reconstructive Surgery
- Oral & Maxillofacial Surgery
- ENT & Head-Neck Surgery
- Neurosurgery
- Urology
- Minimally Invasive & Robotic Surgery
- Cardiothoracic Surgery
- Pediatric Surgery
- Anesthesia & Critical Care
- Perioperative Nursing
- Surgical Technology & First Assistants
- CSSD & Sterile Processing
- Infection Prevention & Control
- Physiotherapy & Rehabilitation
- Perfusion & ECMO
- Medical Students
- Research & Academic Network
- ...and many more



The Operating Room Global (TORG)
!The Largest Network of all Operating Room Professionals in One Place!
 117+ Countries | 270,000+ Members | 42 Disciplines
<https://linktr.ee/operatingroomissues>

As our global membership continues to grow, The Operating Room Global (TORG) is pleased to launch the *TORG Specialty Networks Community (TORG-TSN). This new initiative provides dedicated spaces for professionals to connect, collaborate, learn, share experiences, participate in research, discuss cases, and engage in specialty-focused educational activities with colleagues from around the world.

Members are encouraged to join one or more specialty groups relevant to their profession, specialty, subspecialty, or area of interest. Whether you are a surgeon, anesthesia provider, perioperative nurse, surgical technologist, infection prevention specialist, perfusionist, physiotherapist, researcher, student, or another member of the surgical and perioperative workforce, there is a network for you.

Join the community and become part of a more focused, collaborative, and connected global professional network. Together, we continue to strengthen collaboration, education, innovation, research, and patient care across the global surgical community.



The poster is for a webinar titled "TORG-GET Accredited Surgical Video Discussion Series (SVDS) 2.0". The theme is "FREE FLAP RECONSTRUCTION: FROM DEFECT ASSESSMENT TO SUCCESSFUL TISSUE TRANSFER". The speaker is Dr. Metasebia Worku Abebe, MD, MPH, FCS-ECSA, Associate Professor of Plastic Surgery, Hand and Reconstructive Microsurgeon, Saint Paul Hospital Millennium Medical College, Addis Ababa, Ethiopia; Fellow, College of Surgeons of East, Central, and Southern Africa (COSECSA); Former Secretary General, Ethiopian Society of Plastic and Reconstructive Surgeons, Ethiopia. The event is on Sunday, 15th November 2026 at 18:00 BST. The poster includes a QR code and a link to register: <https://linktr.ee/operatingroomissues>. The poster also features a circular logo for The Operating Room Global (TORG) Centre for Education, Research & Innovation.

THE OPERATING ROOM GLOBAL (TORG)
Centre for Education, Research & Innovation.

**TORG-GET
SURGICAL VIDEO
DISCUSSION SERIES
SVDS 2.0**

**THEME: "FREE FLAP
RECONSTRUCTION: FROM
DEFECT ASSESSMENT TO
SUCCESSFUL TISSUE
TRANSFER"**

MEET THE SPEAKER
Dr. Metasebia Worku Abebe
MD, MPH, FCS-ECSA; Associate Professor of Plastic Surgery,
Hand and Reconstructive Microsurgeon, Saint Paul
Hospital Millennium Medical College, Addis Ababa,
Ethiopia; Fellow, College of Surgeons of East, Central, and
Southern Africa (COSECSA); Former Secretary General,
Ethiopian Society of Plastic and Reconstructive Surgeons,
Ethiopia.

SUNDAY, 15TH NOVEMBER 2026 AT 18:00 BST

ACCREDITED
Our Community!
The Largest Network of all Operating
Room Professionals in One Place!
<https://linktr.ee/operatingroomissues>
REGISTER NOW



Join us for TORG-GET Accredited Surgical Video Discussion Series (SVDS) 2.0.

Theme: "Free Flap Reconstruction: From Defect Assessment to Successful Tissue Transfer"

For other upcoming webinars, visit;

<https://torgceri.org/webinars/>

Thank you, and we look forward to your participation!



THE OPERATING ROOM GLOBAL JOURNAL (TORGJ)

PEER-REVIEWED, OPEN-ACCESS & INTERNATIONAL.
CC-BY 4.0 LICENSED



ISSN 3105-3262