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Awareness, Perception, and Readiness for Telesurgery among Medical Students and Doctors in a University and Tertiary Teaching Hospital in Nigeria

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ABSTRACT

Background: Despite the growing interest in telesurgery, empirical data from low- and middle-income countries, including Nigeria, remains minimal. This study assessed the awareness, perception of barriers and benefits, and readiness for telesurgery among medical students at Ambrose Alli University, Nigeria and medical doctors at Irrua Specialist Teaching Hospital, Nigeria.

Methods: This study adopted a cross-sectional mixed-methods design. 390 respondents were included (280 clinical-year medical students and 110 medical doctors) in the survey. Four focus group discussions were analysed.

Results: Among 390 respondents (280 medical students and 110 doctors), 80.5% were aware of telesurgery, but only 10.5% had received formal robotic or telesurgery training. Doctors demonstrated significantly greater awareness than students (93.6% vs 75.4%; $p < 0.001$). Most respondents believed telesurgery could improve access to specialist care (68.7%) and be safe with adequate infrastructure (73.3%). However, only 22.1% rated their institutions as moderately ready or better, while 55.6% considered them not at all ready. Although 52.3% were willing to undergo training, major barriers included unreliable electricity (70.0%), poor internet connectivity (62.1%), and equipment costs (50.5%). Focus group discussions reinforced concerns about infrastructure, training, and regulatory preparedness.

Conclusion: Telesurgery awareness was high, but formal training, practical exposure, and institutional readiness remained limited. Doctors demonstrated greater awareness and knowledge than medical students, with similar attitudes and readiness. Phased implementation through education, telementoring, infrastructure development, and appropriate regulation is recommended.

Keywords: telesurgery; telemedicine; awareness; readiness; medical students; Nigeria

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Authors' Contributions:

MAA: Conceptualization, methodology, investigation, project administration, original draft; PIA: Formal analysis, investigation, drafting, review and editing; FOA: Data curation, review and editing; CCO: Investigation, participant recruitment, review and editing; Prof. AAO: Supervision, methodology, validation, review and editing. All authors reviewed and approved the final manuscript.

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INTRODUCTION

Telesurgery can also be called remote or cyber surgery; it is a type of surgery where the surgeon is able to carry out a surgical procedure on a patient with the use of a robotic system with one or more arms that is controlled with a console located in a place different from where the patient is.¹⁻⁴ The Lindbergh Operation of 2001 proved that telesurgery is technically feasible, however, challenges like network latency, unstable bandwidth, absence of haptic feedback have limited its advancement and also significantly constrained widespread clinical adoption.^{1,5} Recent advancements in 5G networks, artificial intelligence, and augmented/virtual reality have boosted interest in telesurgery by enabling ultra-low latency communication and enhanced remote visuals, thereby improving the safety and scalability of telesurgery.^{6,7}

The Lindbergh Operation of 7 September 2001 marked a crucial milestone, as the first successful telerobotic-assisted laparoscopic cholecystectomy. It was performed in Strasbourg, France, by Professor Jacques Marescaux who was operating from New York, USA, the surgery lasted for 54 minutes without complication. It proved the technical feasibility of remote surgery through the ZEUS surgical robot and high-speed telecom links.^{1-4,8} Robotic surgery became more developed and widely used in the early 2000s, laying the technological foundation for telesurgery, with the da Vinci system by Intuitive accounting for the majority of cases performed worldwide, over 10 million in the last two decades across 5 specialties.^{8,9}

Prior to the global COVID-19 pandemic, the advancement and adoption of telemedicine (the broad field encompassing remote clinical care, including telesurgery) were relatively slow. The pandemic marked an important turning point that accelerated the implementation of telehealth services globally. This has since become an important component of routine healthcare.¹⁰⁻¹² Recent studies suggest that telemedicine, and by extension telesurgery, offers benefits that include enhanced access to healthcare and training opportunities, but also carries risks like high cost, inadequate infrastructure, and regulatory, medicolegal, and safety concerns; these factors collectively predict preparedness and willingness to adopt telesurgery.¹³⁻¹⁵

About 5 billion people worldwide lack access to surgical care, with Africa representing a major part of the statistics, requiring an additional 143 million life-saving surgeries each year, holding the fewest surgeons per capita of any region.¹⁶ Telesurgery, however, becomes attractive amidst this deficit, although adoption is inhibited by inadequate infrastructure, high cost and limited trained personnel.^{17,18} In Nigeria, the situation is further limited by uneven workforce distribution, frequent power outages, and unstable internet connectivity, even though telemedicine has demonstrated partial success in improving access and continuity of care.^{19,20}

A recent study among Ambrose Alli University medical students reveals that 70% of students are aware of telehealth and 82% are interested in getting trained, with challenges including lack of institutional support and poor internet.²¹ Another study among University of Jos medical students reported that only 37% had good knowledge of telemedicine.²² These studies reflect growing interest in telemedicine generally, however, telesurgery remains an under-explored subset requiring further findings.

A related but different concept is telementoring, it refers to the process whereby an expert surgeon provides remote guidance/mentoring to a trainee or less experienced surgeon during a procedure remotely.²³ The difference between telesurgery and telementoring is that telementoring does not require the mentor to physically carry out the surgery but serves as a bridge between conventional surgery training and full remote surgical operation. Readiness, in application to this study, is defined as health professionals' preparedness to adopt and implement a new health technology. This is assessed across core readiness (recognition of need and dissatisfaction with current practice), engagement readiness (willingness to participate and undergo training), and structured readiness (infrastructure and technical skills availability).²⁴

This study adopted the Technology Acceptance Model (TAM) as its guiding theoretical framework. TAM states that a person's acceptance and use of a new technology are primarily determined by two factors: perceived usefulness, the

extent to which the individual believes the technology would enhance their performance, and perceived ease of use, the extent to which the individual believes using the technology would be free of effort; these two shape attitude toward use, and, ultimately, the intention to adopt.^{25,26} TAM has in the past been used to explain telemedicine adoption among clinicians, including within the Nigerian context, where it has captured the factors facilitating its use such as infrastructure, institutional support and individual perception.²⁷

Empirical evidence on the awareness, perception, and readiness of medical students and doctors regarding telesurgery in Nigeria remains limited despite current development, as existing local studies have been more focused on general telemedicine rather than advanced surgical applications. This deficit affects informed planning, training, and policy formation for future telesurgery initiatives. Despite the growing interest in telesurgery, empirical data from low- and middle-income countries, including Nigeria, remains minimal. Existing studies in Nigeria have focused on general telemedicine awareness among medical students and/or healthcare workers. Telesurgery, however, as a specialized and highly technological subset of telemedicine, requires distinct infrastructure, skills, and acceptance patterns; therefore, awareness and adoption insights from general telemedicine cannot replace telesurgery-specific data. Furthermore, no published study has specifically focused on awareness, perceptions, and readiness for telesurgery among both medical students and doctors in the Nigerian context. Hence, the need for this study. This gap is very significant, as readiness for telesurgery does not only depend on technology but also on the user's knowledge, attitude, training exposure, and policy guiding its use.

Aim and Objectives

This study made an assessment of the awareness, readiness, and perceived barriers and benefits of telesurgery among medical students and doctors at Ambrose Alli University and Irrua Specialist Teaching Hospital (ISTH), Nigeria, concurrently.

This study:

1. Determined the level of awareness and knowledge of medical students in their clinical training years and doctors about telesurgery.
2. Assessed the perception and attitude of medical students and doctors towards telesurgery, including perceived usefulness, benefits, and risks, in the Nigerian healthcare context.
3. Determined the readiness to accept telesurgery as well as barriers to wide implementation of telesurgery in Nigeria, including sociocultural, infrastructural, ethical and legal barriers.
4. Assessed their perceived patients' acceptance and willingness to adopt telesurgery.
5. Compared the awareness, perception, and readiness to adopt telesurgery between medical students and doctors in Nigeria.

Null Hypothesis (H_0): There is no statistically significant difference in the awareness, perception, and readiness to accept telesurgery between medical students and doctors in the Nigerian healthcare context.

Alternative Hypothesis (H_1): There is a statistically significant difference in the awareness, perception, and readiness to accept telesurgery between medical students and doctors in the Nigerian healthcare context.

METHODOLOGY

Study Design and Setting

This study used a cross-sectional and mixed-method design. The quantitative component involved a self-administered questionnaire that assessed for the awareness, perception and readiness for telesurgery. The qualitative component involved the use of Focus Group Discussions, done separately for doctors and medical students, which assessed the in-depth/underlying reasons for the quantitative findings. A mixed-method study was justified because it allows for data triangulation and strengthens the validity of the results.

This study was conducted at Ambrose Alli University (AAU), Ekpoma, Edo State, Nigeria, and Irrua Specialist Teaching Hospital (ISTH), Irrua, Edo State, Nigeria. Ambrose Alli University (AAU) is a state-owned tertiary

institution located in Ekpoma, Edo State, Nigeria, with an accredited College of Medicine where medical students undergo preclinical and clinical training. The institution uses Irrua Specialist Teaching Hospital for clinical training for its medical school. Irrua Specialist Teaching Hospital (ISTH) is a federal tertiary hospital that serves as a major referral centre in Edo State and neighbouring regions. It provides a wide range of specialized medical and surgical services and serves as a training centre for undergraduate medical students and postgraduate resident doctors. Both institutions represent an appropriate setting for assessing awareness, perception, and readiness for telesurgery in the Nigerian healthcare context.

The study was conducted from January to September 2026.

Study Population / Data Source

The study population comprised medical students at Ambrose Alli University, all of whom were in their clinical years, 4th to 6th years, due to several years of admission break, and medical doctors practicing at Irrua Specialist Teaching Hospital, including house officers, residents, and consultants across various surgical and non-surgical specialties.

Eligibility Criteria

Inclusion Criteria

- Registered medical students of Ambrose Alli University who provide informed consent.
- Medical doctors (including house officers, medical officers, residents, and consultants) practicing at Irrua Specialist Teaching Hospital who provide informed consent.

Exclusion Criteria

- Medical students who were unavailable during the period of data collection.
- Medical doctors who were unavailable during the period of data collection.

Sampling and Sample Size

A stratified convenience sampling technique was used to get the quantitative data component. The study population was stratified into 2 strata: clinical-year medical students of Ambrose Alli University, and medical doctors of Irrua Specialist Teaching Hospital. Proportionate allocation was also employed to ensure proper representation of each stratum. Eligible candidates were recruited until the desired study population was reached. Purposive sampling technique was used for the qualitative data component, and representation across the medical student groups (4th, 5th and 6th year) and the medical doctors' groups (house officer/medical officer, resident, and fellow/consultant) was ensured.

An initial target of 400 respondents was proposed for the quantitative data component with proportional allocation for the 2 groups (doctors and students). With 10% non-response added, a respondents' target of 440 sets of quantitative data was proposed, with 280 medical students and 160 medical doctors, since the medical students' population in Ambrose Alli University at the time of this study was 700, and the estimated population of doctors in Irrua Specialist Teaching Hospital was 400 (though lower). The final cleaned data used for analysis was 390 respondents (280 students and 110 doctors). The proposed sample size was determined based on the principal researcher's perceived feasibility and proper representation of the study population strata (since it was above the minimum calculated by Cochran Formula). Four Focus Group Discussions (FGDs) were proposed, with 2 doctors' FGDs and 2 students' FGDs, 6-8 participants targeted for each FGD, giving a total of 24-32 participants. However, during the four FGDs, 11 students and 12 doctors participated in the FGDs, giving a total of 23 FGD participants.

Data Collection / Study Procedures

A self-administered questionnaire was used for the quantitative component of the study; this questionnaire was developed by the researcher, since there was no standard or validated instrument for assessing awareness, perception and readiness for telesurgery. The questionnaire was developed following a review of relevant literature on telesurgery, telemedicine, and healthcare technology adoption frameworks. It consisted of the following sections: socio-demographic and professional background; awareness and knowledge of telesurgery; perception and attitude towards telesurgery; readiness for telesurgery adoption; and perceived barriers and facilitators to telesurgery.

adoption. Likert-scale responses were used to measure most items, while other questions were close-ended. The questionnaire was administered in electronic Google format and sent to medical doctors' and medical students' WhatsApp group chats; other questionnaires were administered in printed format and distributed at participants' convenience. For the qualitative component, a semi-structured FGD guide was used to explore participants' perceptions, concerns, expectations, and perceived readiness for telesurgery.

A pilot study involving 19 participants was conducted before the data collection proper outside the study population, to determine clarity and relevance of the questionnaire. Feedback was used to fine-tune the questionnaire. The questionnaire was also reviewed by the research mentor before and after the pilot study. Focus Group Discussions (FGDs) were conducted online (Google Meet), and the 2 groups' (doctors and students) FGDs were done separately to minimize power dynamics and encourage open discussion by participants. FGDs were moderated by the principal researcher, recordings were made after consent was provided by each participant and were AI auto transcribed. Additional notes were taken by one of the co-researchers for non-verbal cues.

Statistical / Qualitative Analysis

We summarised the categorical variables as frequencies and percentages. The main question was how medical students and doctors differed, so that is where most of the testing went. For 2×2 tables we used Pearson's chi-square test with continuity correction, and we switched to Fisher's exact test whenever any expected cell count fell below 5. Odds ratios (doctors relative to medical students) are given for these comparisons, with Wald 95% confidence intervals. For ordinal variables with more than two categories we used Pearson's chi-square test as long as no more than 20% of the expected counts were below 5 and none was below 1. When that condition was not met, we ran a Monte Carlo permutation test of the chi-square statistic (10,000 permutations) instead. The effect size for these comparisons is Cramér's V , with percentile bootstrap 95% confidence intervals from 2,000 resamples. In all, 19 comparisons were made. As planned, we report unadjusted p values, and we added Holm step-down adjusted p values as a sensitivity analysis to allow for the number of tests. Significance was set at $p < .05$, two-sided. Barriers, supports, benefits, risks and information sources were not tested; each option is simply reported on its own, overall and by group. We did not fit regression models, build composite scores or run factor analyses. Every analysis was run from a single reproducible script (Python 3.12.3, pandas 3.0.2, NumPy 2.4.4, SciPy 1.17.1) with fixed random seeds. For the focus group transcripts, we used framework (codebook) thematic analysis. The research supervisor had set out eight domains beforehand: awareness and its sources; perceived benefits; safety and technical concerns; infrastructure and institutional readiness; medicolegal and regulatory issues; training and workforce readiness; implementation barriers (cost, trust and culture, governance, sustainability); and recommendations. Within each domain, subthemes were built up inductively by reading the full cleaned transcripts closely and repeatedly. One analyst, the principal investigator, did all the coding. The survey and focus group findings were then brought together at the interpretation stage, which is how we triangulated them.

Ethical Considerations

Ethical approval for this study was gotten from Irrua Specialist Teaching Hospital Health Research Ethics Committee (ISTH-HREC), with ethical approval reference number as ISTH/HREC/20262402/857. The process of this study complied with the Declaration of Helsinki principles and other relevant national and local ethical guidelines of research on human subjects.

Participation in the study was entirely voluntary; from each participant was obtained informed consent, which included detailed information about the process, potential risks, and benefits of participation in this study. Written consent was also gotten from participants before each Focus Group Discussion (FGD). Participants' ability to withdraw from the study at any point without any consequence was retained.

Questionnaire participation was anonymous, confidentiality was upheld, and data were adequately protected. Personal data was not collected in the questionnaire. Electronic data was stored with password protection; filled hard copy questionnaire was converted to electronic data, while the hard copy was incinerated. FGD Audio/video recordings were transcribed, after which they were deleted. Transcripts were rendered anonymous. The study posed minimal risk to participants. So, medical students, with the lowest under cadre, were however considered a potentially vulnerable group. Notwithstanding, their participation was voluntary, and participation did not have any influence

on academic standing or assessment. Medical students and doctors were on different FGDs. There was no physical intervention.

RESULTS

Participant Characteristics

A total of 390 respondents' data were analysed, out of which 280 were medical students and 110 were medical doctors. 287 (73.6%) were aged between 20-29 years, 209 (53.6%) were males and 175 (44.9%) were females. Out of the doctors sub-set, 48 were house officers, 36 were residents/registrars, and 26 were fellows/specialists/consultants. 64 doctors were in the medical specialty, 44 in surgical specialty, and 2 in diagnostic/laboratory specialty. The most prevalent duration of practice was less than 1 year (29 of 110; 26.4%) (Table 1).

Table 1. Characteristics of the respondents

Characteristic	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)	All (n = 390) n (%)
Age group			
20–24 years	57 (20.4)	6 (5.5)	63 (16.2)
25–29 years	197 (70.4)	27 (24.5)	224 (57.4)
30–34 years	20 (7.1)	23 (20.9)	43 (11.0)
35–39 years	3 (1.1)	15 (13.6)	18 (4.6)
40–44 years	1 (0.4)	15 (13.6)	16 (4.1)
45–49 years	1 (0.4)	13 (11.8)	14 (3.6)
50–54 years	0 (0.0)	8 (7.3)	8 (2.1)
55–59 years	1 (0.4)	3 (2.7)	4 (1.0)
Gender			
Male	144 (51.4)	65 (59.1)	209 (53.6)
Female	132 (47.1)	43 (39.1)	175 (44.9)
Prefer not to say	4 (1.4)	2 (1.8)	6 (1.5)
Role and level of training			
Medical student, 400 level	66 (23.6)	–	66 (16.9)
Medical student, 500 level	212 (75.7)	–	212 (54.4)
Medical student, 600 level	2 (0.7)	–	2 (0.5)
House officer or medical officer	–	48 (43.6)	48 (12.3)
Resident or registrar	–	36 (32.7)	36 (9.2)
Fellow, specialist or consultant	–	26 (23.6)	26 (6.7)
Specialty area (doctors only)			
Medical specialty	–	64 (58.2)	–
Surgical specialty	–	44 (40.0)	–
Diagnostic or Laboratory specialty	–	2 (1.8)	–
Years of clinical practice since graduation (doctors only)			
<1 year	–	29 (26.4)	–
1–3 years	–	20 (18.2)	–
4–6 years	–	8 (7.3)	–
7–9 years	–	12 (10.9)	–
10–15 years	–	15 (13.6)	–
16–20 years	–	12 (10.9)	–
>20 years	–	14 (12.7)	–

Note. Percentages are column percentages within each group, except for specialty and years of practice, which use the number of doctors as denominator.

Formal training in telemedicine was reported by 65 of 390 respondents (16.7%), and formal training in robotic surgery or telesurgery by 41 (10.5%). Personally, observing or assisting in a robotic or remote-assisted procedure was reported by 11 respondents (2.8%), and this was not significantly different between doctors and medical students (2.7% of doctors' vs 2.9% of medical students; Fisher's exact test, $p = 1.000$).

Four focus group discussions were analysed: two with medical students (11 contributing participants across the two sessions) and two with doctors (12 contributing participants across the two sessions). Quotations below are attributed only to group and session (S1/S2 for the two student sessions, D1/D2 for the two doctor sessions); no participant name or identifying detail is reported, consistent with the anonymity assured to participants.

Previous training, exposure, awareness and knowledge

Overall, 314 respondents (80.5%) had heard the term 'telesurgery' before the survey; this was more common among doctors than among medical students (93.6% of doctors' vs 75.4% of medical students; $\chi^2(1) = 15.67$, $p < .001$, OR = 4.81, 95% CI 2.13–10.84). On self-rated knowledge, 63 (16.2%) had never heard of telesurgery, 193 (49.5%) knew very little, and 134 (34.4%) reported moderate or better knowledge. Self-rated knowledge differed between the groups (permutation test, $\chi^2 = 22.15$, $p < .001$, Cramér's $V = 0.24$); 49.1% of doctors' vs 28.6% of medical students rated their knowledge as moderate or better (Table 2; Figure 1).

Table 2. Previous training and exposure, awareness and self-rated knowledge, by role

Item	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)	Test	p	Effect size (95% CI)
Formal training in telemedicine (any)	19 (6.8)	46 (41.8)	$\chi^2(1) = 67.29$	< .001	OR 9.87 (5.42–18.00)
Formal training in robotic surgery or telesurgery (any)	19 (6.8)	22 (20.0)	$\chi^2(1) = 13.29$	< .001	OR 3.43 (1.78–6.64)
Has observed or assisted in a robotic or remote-assisted procedure	8 (2.9)	3 (2.7)	Fisher's exact test	1.000	OR 0.95 (0.25–3.66)
Had heard the term 'telesurgery' before the survey	211 (75.4)	103 (93.6)	$\chi^2(1) = 15.67$	< .001	OR 4.81 (2.13–10.84)
Self-rated knowledge of telesurgery: moderate/basic or higher	80 (28.6)	54 (49.1)	permutation test, $\chi^2 = 22.15$	< .001	V 0.24 (0.17–0.34)

Note. Effect size: odds ratio (doctors vs medical students) for yes/no items, Cramér's V for self-rated knowledge (tested on all five response levels; the pooled row is descriptive). p values are unadjusted.

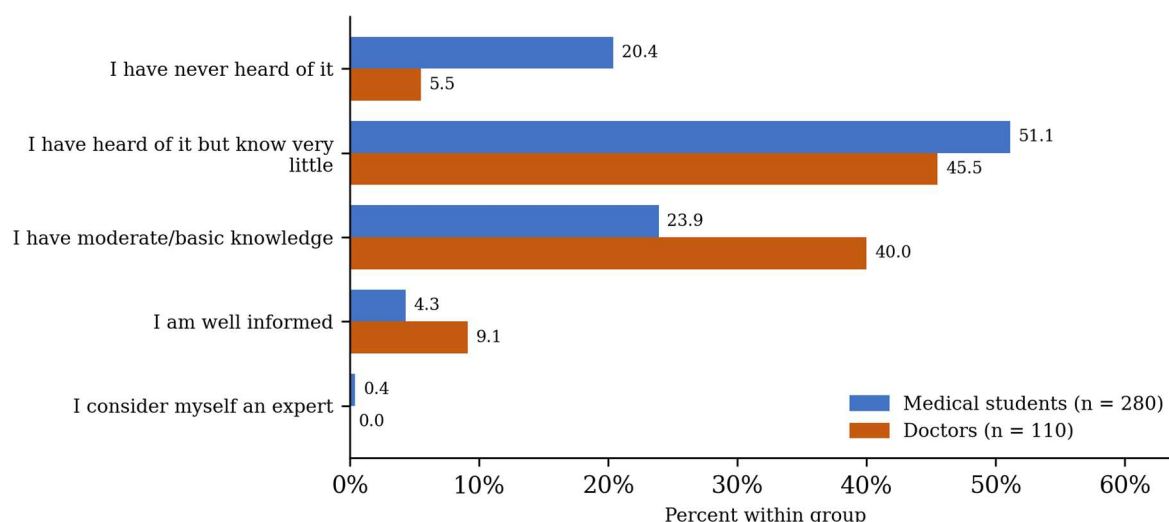


Figure 1. Self-rated knowledge of telesurgery, by role. Percentages are within each group.

Perceived benefits and risks

The benefits selected most often were improved access to specialist surgeons in remote areas (242, 62.1%), reduced patient travel and associated costs (205, 52.6%) and faster expert mentoring / training for surgeons (195, 50.0%). The risks or limitations selected most often were network latency / loss of connection (251, 64.4%), high cost of equipment and maintenance (243, 62.3%) and equipment failure or maintenance issues (236, 60.5%) (Table 3).

Table 3. Perceived benefits, risks and sources of information (multiple response)

Option	All (n = 390) n (%)	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)
Potential benefits of telesurgery			
Improved access to specialist surgeons in remote areas	242 (62.1)	157 (56.1)	85 (77.3)
Reduced patient travel and associated costs	205 (52.6)	126 (45.0)	79 (71.8)
Faster expert mentoring / training for surgeons	195 (50.0)	130 (46.4)	65 (59.1)
Potential for reduced time to definitive surgery (quicker specialist input)	191 (49.0)	121 (43.2)	70 (63.6)
Potential for improved surgical outcomes due to specialist input	147 (37.7)	87 (31.1)	60 (54.5)
No benefits / unsure	35 (9.0)	33 (11.8)	2 (1.8)
Potential risks or limitations of telesurgery			
Network latency / loss of connection	251 (64.4)	158 (56.4)	93 (84.5)
High cost of equipment and maintenance	243 (62.3)	153 (54.6)	90 (81.8)
Equipment failure or maintenance issues	236 (60.5)	154 (55.0)	82 (74.5)
Lack of haptic/tactile feedback for surgeon	180 (46.2)	124 (44.3)	56 (50.9)
Legal / medicolegal uncertainty (liability)	160 (41.0)	100 (35.7)	60 (54.5)
Patient privacy / cybersecurity concerns	152 (39.0)	97 (34.6)	55 (50.0)
No risks / unsure	31 (7.9)	28 (10.0)	3 (2.7)
Where respondents had learned about telesurgery			
Social media / internet	250 (64.1)	168 (60.0)	82 (74.5)
Journals / news articles	76 (19.5)	48 (17.1)	28 (25.5)

Option	All (n = 390) n (%)	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)
Colleagues / mentors	68 (17.4)	40 (14.3)	28 (25.5)
Never heard of it before	51 (13.1)	46 (16.4)	5 (4.5)
Formal lectures / coursework	42 (10.8)	18 (6.4)	24 (21.8)
Workshops / conferences	27 (6.9)	15 (5.4)	12 (10.9)
Other	1 (0.3)	1 (0.4)	0 (0.0)
Posters and billboards	0 (0.0)	0 (0.0)	0 (0.0)

Note. Multiple-response items: each option is a percentage of all respondents in the column, and respondents could select more than one option. Descriptive only; no significance tests were applied.

Perceptions of telesurgery

Responses to the nine perception statements are shown in Figure 2 and Table 4. Overall, 68.7% agreed that telesurgery could improve access to specialist care, 65.1% that it is likely to improve surgical training opportunities and 73.3% that it would be safe if adequate infrastructure and protocols were in place. Regarding patients, 53.8% would be comfortable referring a patient to a proven telesurgery service and 39.5% believed their patients would accept telesurgery if they recommended it. Where differences were found, the associations were small (Cramér's V 0.16 to 0.19), and none remained significant after Holm adjustment for multiple comparisons.

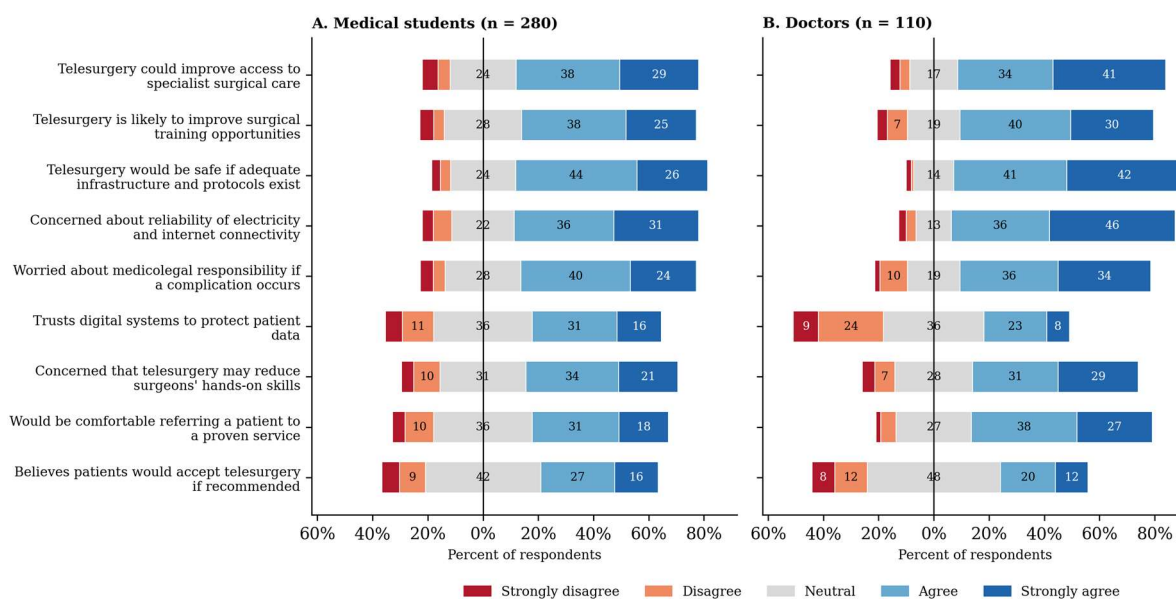


Figure 2. Responses to the nine perception statements among (A) medical students and (B) doctors, showing the percentage distribution of responses in each group. For concern-related statements, agreement represents respondents' level of concern.

Table 4. Agreement with the perception statements, by role

Statement (agree or strongly agree)	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)	Difference, percentage points (95% CI)	Test	p	Holm p
Telesurgery could improve access to specialist surgical care	185 (66.1)	83 (75.5)	+9.4 (-0.9 to +18.5)	$\chi^2(4)$ 6.27	= .180	.899
Telesurgery is likely to improve surgical training opportunities	177 (63.2)	77 (70.0)	+6.8 (-3.8 to +16.5)	$\chi^2(4)$ 5.25	= .262	1.000
Telesurgery would be safe if adequate infrastructure and protocols exist	195 (69.6)	91 (82.7)	+13.1 (+3.5 to +21.3)	$\chi^2(4)$ 12.53	= .014	.166
Concerned about reliability of electricity and internet connectivity (concern-worded)	187 (66.8)	89 (80.9)	+14.1 (+4.3 to +22.6)	$\chi^2(4)$ 10.39	= .034	.343
Worried about medicolegal responsibility if a complication occurs (concern-worded)	178 (63.6)	76 (69.1)	+5.5 (-5.1 to +15.3)	$\chi^2(4)$ 11.38	= .023	.248
Trusts digital systems to protect patient data	131 (46.8)	34 (30.9)	-15.9 (-25.7 to -5.1)	$\chi^2(4)$ 14.28	= .006	.090
Concerned that telesurgery may reduce surgeons' hands-on skills (concern-worded)	154 (55.0)	66 (60.0)	+5.0 (-6.0 to +15.5)	$\chi^2(4)$ 2.86	= .581	1.000
Would be comfortable referring a patient to a proven service	138 (49.3)	72 (65.5)	+16.2 (+5.2 to +26.2)	$\chi^2(4)$ 9.94	= .042	.374
Believes patients would accept telesurgery if recommended	119 (42.5)	35 (31.8)	-10.7 (-20.6 to +0.1)	$\chi^2(4)$ 3.88	= .422	1.000

Note. Percentages are those agreeing or strongly agreeing; difference = doctors minus medical students. Statements marked concern-worded are phrased as concerns, so agreement indicates concern.

Readiness, feasibility, willingness to train and views on policy

Personal readiness to take part in telesurgery within five years was rated moderate or higher by 206 respondents (52.8%), with 50.0% of medical students and 60.0% of doctors doing so (no significant difference detected: $\chi^2(4) = 7.70$, $p = .103$). Perceived institutional readiness at present was low: only 86 respondents (22.1%) rated it moderate or higher, and 217 (55.6%) rated their institution as not at all ready; the two groups did not differ significantly (permutation test, $\chi^2 = 7.65$, $p = .099$). 204 respondents (52.3%) were definitely willing to undergo training in telesurgery or robotics and a further 158 (40.5%) were willing depending on time and cost; a higher proportion of doctors than medical students were definitely willing (60.9% of doctors' vs 48.9% of medical students; $\chi^2(2) = 8.80$, $p = .012$, Cramér's $V = 0.15$) (Table 5).

Table 5. Readiness, feasibility, willingness to train and importance of policy, by role

Item	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)	Difference, percentage points (95% CI)	Test	p	Holm p	V
Personal readiness (within five years) rated moderate or higher	140 (50.0)	66 (60.0)	+10.0 (-1.0 to +20.4)	$\chi^2(4) = 7.70$	.103	.694	0.14
Institutional readiness (at present) rated moderate or higher	67 (23.9)	19 (17.3)	-6.7 (-14.6 to +2.7)	permutation test, $\chi^2 = 7.65$	.099	.694	0.14
Telesurgery judged feasible within five years (with or without major investment)	119 (42.5)	62 (56.4)	+13.9 (+2.9 to +24.4)	$\chi^2(3) = 14.75$	.002	.031	0.19
Definitely willing to undergo training	137 (48.9)	67 (60.9)	+12.0 (+1.0 to +22.4)	$\chi^2(2) = 8.80$	.012	.160	0.15
Policy or regulation rated very important or essential	223 (79.6)	98 (89.1)	+9.4 (+1.1 to +16.3)	$\chi^2(4) = 8.55$	.073	.586	0.15

Note. Percentages are those giving the response described; difference = doctors minus medical students. V = Cramér's V. p values unadjusted; Holm = Holm-adjusted across the 19 comparisons.

Barriers to implementation

Respondents were asked to select up to three barriers; 80 of 390 respondents (20.5%) selected more than three. The options selected by the largest numbers of respondents were unreliable power supply (273, 70.0%), poor internet bandwidth / latency problems (242, 62.1%) and high equipment cost and maintenance (197, 50.5%); the most frequently selected, unreliable power supply, was chosen by 66.1% of medical students and 80.0% of doctors. Selection proportions for every option are given in Table 6.

Table 6. Barriers to implementing telesurgery (multiple response)

Option	All (n = 390) (%)	Medical students (n = 280) n (%)	Doctors (n = 110) n (%)
Unreliable power supply	273 (70.0)	185 (66.1)	88 (80.0)
Poor internet bandwidth / latency problems	242 (62.1)	167 (59.6)	75 (68.2)
High equipment cost and maintenance	197 (50.5)	132 (47.1)	65 (59.1)
Lack of trained personnel / theatre staff expertise	165 (42.3)	110 (39.3)	55 (50.0)
Patient acceptance / cultural concerns	109 (27.9)	75 (26.8)	34 (30.9)
Medicolegal / regulatory framework absence	92 (23.6)	74 (26.4)	18 (16.4)
Cybersecurity / data privacy risks	77 (19.7)	55 (19.6)	22 (20.0)
Lack of institutional or governmental funding support	63 (16.2)	40 (14.3)	23 (20.9)

Note. Respondents could select more than one option (requested maximum: 3); percentages are of all respondents in the column, so they sum to more than 100%. Descriptive only; no significance tests were applied.

Qualitative Findings from the Focus Group Discussions

All eight of the supervisor's specified domains were identified in both groups' discussions, though with differing emphasis (Table 7).

Infrastructure and institutional readiness. This was the most consistently and strongly raised domain in both groups, with several doctors' rating institutional readiness as close to zero. "we're not ready because even the basic things, we can't even do... Institutional readiness in Nigeria... I'll just tell you, almost, it's almost zero" (Doctor, D2)

No qualitative theme was identified in doctors that was entirely absent from students, or vice versa; the eight domains were shared, and the difference between groups was one of emphasis and depth (for example, medicolegal reasoning and blunt readiness judgements were more developed among doctors) rather than the presence or absence of a theme.

Table 7. Focus-group themes identified, by group

Domain	Medical students	Doctors
Awareness and its sources	5 contributors, 2/2 sessions	4 contributors, 2/2 sessions
Perceived benefits	4 contributors, 2/2 sessions	5 contributors, 2/2 sessions
Safety and technical concerns	4 contributors, 2/2 sessions	2 contributors, 2/2 sessions
Infrastructure and institutional readiness	3 contributors, 2/2 sessions	4 contributors, 2/2 sessions
Medicolegal and regulatory issues	2 contributors, 1/2 sessions	3 contributors, 2/2 sessions
Training and workforce readiness	3 contributors, 2/2 sessions	3 contributors, 2/2 sessions
Implementation barriers (cost, trust, governance, sustainability)	3 contributors, 2/2 sessions	3 contributors, 2/2 sessions
Recommendations and way forward	3 contributors, 2/2 sessions	2 contributors, 2/2 sessions

DISCUSSION

The results of this research show a gap between awareness and preparedness for telesurgery. Four in five respondents (80.5%) had heard about telesurgery; however, only 10.5% had had formal training in robotic surgery or telesurgery, and only 22.1% rated their institution as moderately ready or better. Participants showed support for the technology, but infrastructure, regulatory policy, and training were identified as conditions.

Awareness and Knowledge

The level of awareness of telesurgery found in this study is comparable with 70% telehealth awareness findings at Ambrose Alli University,²¹ however, it is higher than the telemedicine knowledge at the University of Jos,²² although these studies focused on the wider concept of telemedicine. Bilawal et al.²⁸ reported that 93.9% of students and health professionals in Karachi had heard of telesurgery, but only 33.6% had demonstrated a clear understanding of the concept. This is consistent with our findings of 80.5% awareness, although self-rated knowledge was considerably lower at 34.4%. A systematic review by Ghaddaripouri et al.²⁹ associated inadequate telemedicine knowledge among medical students with the lack of specific courses on the subject, and our training gap, with 6.8% of students versus 41.8% of doctors reporting telemedicine training, supports this claim. In this study, social media was the commonest source of information (64.1%), while formal lectures accounted for 10.8%, therefore, informal, rather than formal exposure seems to be a greater driver of awareness, which poses a risk for uneven understanding. Unsurprisingly, doctors' hands-on exposure was rare given that robotic surgery in Africa remains minimal.^{17,18}

Perception of Telesurgery

A large proportion of respondents viewed telesurgery as a possible way of improving access to specialist care and surgical education. 68.7% believed that it could improve access to specialist care, while 65.1% felt it could improve surgical training. Also, 73.3% considered telesurgery potentially safe provided that appropriate infrastructure and protocol were available. This finding supports the arguments that telesurgery could ease the deficit in surgical access in Africa,¹⁶ which is also consistent with Technology Acceptance Model, which proposes that a person's willingness to use a technology is influenced by how useful they believe it will be.²⁵ Meanwhile, concerns about infrastructure reliability (70.8%), medicolegal responsibility (65.1%) and loss of hands-on skills (56.4%) were captured, and only 42.3% trusted digital systems to protect patients' data. A similar ethical concern in telesurgery has been reported by Covas Moschovas et al.³⁰ Such enthusiasm and caution are typical of the telesurgery and telehealth findings of Kemp

et al.¹⁴ and Patel et al.³¹. Because few respondents had real-life experience in the use of robotics, perceived ease of use, the second model construct, was an interpretation and not a tested finding.

Readiness and Barriers

Five-year personal readiness was rated moderate or higher by 52.8% of respondents, but only 22.1% rated institutional readiness as moderate or higher, and 55.6% considered their institution "not at all ready". This similarly occurred in the study by Olufunlayo et al.³², where federally funded tertiary institutions in Nigeria were placed at a beginner level of telemedicine maturity. The major barriers identified by respondents were unreliable power supply (70.0%), poor internet bandwidth or latency (62.1%) and equipment cost and maintenance at 50.5%. These findings are similar to those reported by Cole et al.³³ and Dodoo et al.²⁰ concerning telemedicine in Nigeria and by Falola et al.¹⁷ and Gemechu et al.¹⁸ regarding robotic surgery in Africa. The FGDs explained this convergence: doctors described intermittent failure of electronic records systems due to power and network interruptions, and several rated institutional readiness as close to zero. Telesurgery, however, relies more on lower latency than teleconsultation, therefore, the presence of AI and 5G cannot be assumed to guarantee local readiness while basic utilities remain unreliable and unstable.

Regulatory structures are important because they provide guidance for how telesurgery should be conducted. Although only 23.6% identified the absence of medicolegal framework as a main barrier, 65.1% expressed concerns about liability and 82.3% considered policy to be very important or essential. This likely reflects infrastructural barriers crowding out other options, reflecting the limited-choice barriers item rather than indifference. During the FGDs, doctors revealed important legal questions, particularly regarding who would be responsible if a remote surgical procedure failed (the hosting facility, the remote surgeon, or the network provider) and also questioned the absence of telesurgery-specific policy in Nigeria. These questions reflect issues of liability, licensure, consent, and jurisdiction in the literature^{31,34} as well as the weakness of Nigeria's digital health legal framework.³⁵

Patient Acceptance and Willingness to Train

This study revealed that 39.5% believed their patients would accept telesurgery if they recommended it, while 53.8% would be comfortable referring their patients to a proven service. 44.9% in Karachi²⁸ study shows acceptance. The FGDs highlighted that there may be cultural and religious concerns about being operated on by a remotely controlled machine; however, patients were not participants in this study, so actual patients' acceptance cannot be inferred, and these concerns require investigation directly among patients. Willingness to train was high (52.3% willing and 40.5% willing depending on time and cost), reflecting the interest in training reported at Ambrose Alli University.²¹

Medical Students Compared with Doctors

Before adjustments, 11 out of 19 comparisons showed differences between medical students and doctors. However, after applying the Holm adjustments, only five of these differences remained statistically significant. The null hypothesis was rejected only for prior telemedicine training, robotic surgery or telesurgery training, awareness of telesurgery, self-rated knowledge and perceived feasibility within five years. Attitudinal differences were small and did not survive adjustments. Because role is confounded with age and experience, these differences describe association only. Both doctor and student groups identified similar issues across the eight thematic domains. Nevertheless, doctors placed greater emphasis on questions of liability and were blunter when judging the level of readiness.

A Phased Pathway

Both doctors and students supported a gradual approach to telesurgery implementation. They favored telementoring while simultaneously improving laparoscopic surgical capacity, whereas 173 of the 181 respondents who judged functional telesurgery feasible within 5 years noted a need for major investment. This is in keeping with the evidence that telementoring is a more attainable outcome toward remote surgery in low resource settings.^{23,36} Some doctors also questioned whether limited resources should be directed towards telesurgery before surgical services and capacity had been adequately established. This concern is like the findings of Mehta et al.¹⁶ which highlighted the continuing surgical deficit in Africa.

IMPLICATIONS

Education: The low level of formal training and strong willingness to learn support introducing telemedicine, robotic surgery, and telesurgery content into undergraduate curricula and postgraduate or continuing professional development programs. Of the respondents, 46.4% chose local simulation and hands-on training as a confidence-promoting support; this offers a practical solution, and learning should also promote legal and ethical remote surgical practices.

Clinical practice and leadership: The most chosen support was reliable power backup and network redundancy (64.1%). Hospital leadership considering telesurgery should therefore assess and strengthen power supply and internet connectivity before any pilot, and telementoring should be considered first where failure poses less risk.

Policy: The high demand for clear policy (82.3%) and the preferences for a joint committee of management, clinicians, information technology and legal experts (32.6%), suggest that liability, licensure, consent, and data protection are mostly important in the national framework; therefore, governance should be settled before clinical use.

Research: Findings in this study are a baseline for tracking change. Regarding the Technology Acceptance Model, facilitating infrastructural and regulatory conditions may matter as much as perceived usefulness in this setting; therefore, future studies should test this proposition. This points to a sequence whereby training, infrastructure, and governance precede any investment in hardware, which may require that investment in telesurgery be weighed against basic surgical needs.

RECOMMENDATIONS

Education: Medical schools and postgraduate training institutions should include telemedicine, robotic surgery and telesurgery content in curricula and continuing professional development, in addition to simulation-based training and expert surgeon mentorship. Short, accredited courses would enable willing, practicing doctors to build competence at a manageable cost.

Infrastructure: Teaching hospitals considering telesurgery implementation should assess and strengthen dependable power backup and network redundancy, and institutional readiness should be assessed using a validated tool before piloting any remote surgical service. Uninterrupted electricity and low-latency connectivity for theaters, as well as maintenance, are priorities that institutions should assess. Shared funding could be explored by government and development partners to address costly equipment.

Policy: The Federal Ministry of Health, legislative arm of government and clinical professional bodies should develop telesurgery policy covering liability, licensure, consent, international use, and data protection.

Practice: The introduction of telesurgery should take place gradually rather than all at once. Initial efforts should focus on telementoring, improving laparoscopic surgical skills and capacity, and understanding cultural concerns that may affect acceptance. Patients' education should also form part of the implementation process so that patients can make informed decisions about the technology.

Research: Future studies should involve probability sampling across different states and geopolitical zones, patients' acceptance, policymaker perspectives, and cost-effectiveness evaluation. Follow-up of trained cohorts will show whether training changes readiness and adoption over time.

LIMITATIONS

The cross-sectional design makes causality impossible to establish. Stratified convenience sampling was used at 2 institutions in one state, therefore, findings may not be generalizable. The final doctors' sample size of 110 was below planned. All data were self-reported, and knowledge was self-rated rather than tested. Many respondents exceeded the requested number of barrier and support selections, so results show breadth rather than priority of importance. Perceived patient acceptance reflects clinicians' beliefs, not patients' views. Qualitatively, two of the four sessions had fewer participants than planned, coding was done by a single analyst, and the moderator was the principal investigator, which may have influenced responses. The two strands were integrated at sample level rather than through linked individual data.

CONCLUSION

Medical students and doctors know about telesurgery, have good perception of its benefits in elevating surgical and emergency care; however, practical exposure to the technology is very low, signifying a gap of training and retraining, especially among students. Both groups hold strong belief that institutional readiness is poor, with barriers majorly poor power supply and internet connection. In addition, FGDs revealed that aside from poor infrastructure, legal responsibility, high cost of technology, and cultural acceptance are major barriers to be addressed. While willingness, according to the study, was not the major driver of readiness in Nigeria, rather, poor infrastructural, training and guiding policy supports were noted as the major culprits (drivers).

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AUTHOR CONTRIBUTIONS (CRediT)

MAA: Conceptualization, Methodology, Investigation, Project Administration, Writing - Original Draft. Matthew Abiodun took part in every stage of the study except the statistical analysis. He shaped the study design, carried out most of the data collection, and wrote the first three chapters of the dissertation (introduction, literature review and methodology) along with the reporting and discussion of the results.

PIA: Formal Analysis, Investigation, Writing - Original Draft, Writing - Review & Editing. Precious Aitanun carried out the statistical analysis, helped to report the results, took a small part in the data collection, and proofread the manuscript.

FOA: Data Curation, Writing - Review & Editing. Favour Akhere entered more than 230 questionnaire responses into the dataset and proofread the manuscript.

CCO: Investigation, Writing - Review & Editing. Chinemezu Ogbonna collected about 40 questionnaire responses, helped to recruit participants, took an active part in the focus group discussions, and proofread the manuscript.

Prof. AAO: Supervision, Methodology, Validation, Writing - Review & Editing. Prof. Adebisola Owokole supervised the study and mentored the lead author throughout. She guided the methodology, made suggestions along the way, helped validate the approach, and critically reviewed every stage and proofread the manuscript.

All authors reviewed and approved the final manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest in relation to this study.

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DATA AVAILABILITY

The de-identified data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable ethical and data-protection requirements.

ETHICAL APPROVAL

Ethical approval for this study was gotten from the Irrua Specialist Teaching Hospital Health Research Ethics Committee (ISTH-HREC), with ethical approval reference number as ISTH/HREC/20262402/857, with the study approved to be carried out from 13th March 2026 to 12th March 2027. Data collection was carried out following acquisition of ethical approval. All the processes of this study complied with the Declaration of Helsinki principles and other relevant national and local ethical guidelines of research on human subjects.

ARTIFICIAL INTELLIGENCE USE DECLARATION

Artificial intelligence (AI) tools were used to assist with the study and manuscript preparation in the following ways: Fireflies AI was used for FGD recording and raw transcription; ChatGPT and Claude (Anthropic) were used for limited literature searches, grammatical and punctuation correction, as well as proofreading and fact-checking of the manuscript. AI tools were used as supportive aids and did not generate or independently prepare any section of the study. AI-generated outputs were verified by the authors, who took full responsibility for the accuracy, integrity, and originality of the final work.

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