

Can Telesurgery Bridge Bangladesh's Urban-Rural Healthcare Divide? A Narrative Review of Feasibility, Cybersecurity, and Cost Barriers



Sumit Kumar Pramanik¹, Khondaker A. Mamun^{1*}

Abstract

Background: Telesurgery — robotic surgery performed across a physical distance — has moved from experimental demonstration to occasional clinical reality over the past two decades, yet its uptake in low- and middle-income countries remains negligible. Whether Bangladesh, a country with a pronounced urban-rural disparity in specialist surgical access, could realistically adopt the technology is not yet well understood, and this review sets out to ask that question directly rather than assume an answer. **Methods:** Rather than a formal systematic review, we conducted a structured narrative synthesis of twelve studies published mostly between 2018 and 2023, deliberately retaining one earlier 2015 study for its foundational relevance to telesurgical cybersecurity. Literature was identified through Google Scholar, IEEE Xplore, PubMed, and ScienceDirect, supplemented by reference-list snowballing, and extracted thematically across feasibility, network architecture, cybersecurity, and clinical adoption. **Results:** The core robotics and 5G-enabled low-latency communication now appear technically sound — even validated in cross-border cardiac surgery — but cybersecurity vulnerabilities, unresolved cross-jurisdictional regulation, and acquisition costs reaching several million dollars remain serious, largely unresolved obstacles. Urology, gynaecology, and

oncosurgery currently dominate global robotic caseloads, suggesting plausible starting points for a Bangladeshi pilot. **Conclusion:** Closing the gap appears to depend less on robotic capability itself, which is arguably ready, and more on telecommunications investment, shared or subsidized infrastructure models, and a regulatory framework purpose-built for cross-border operative liability. Whether Bangladesh seizes this window will likely hinge on deliberate policy choices rather than technological readiness alone.

Keywords

Telesurgery; Robotic Surgery; Tactile Internet; Bangladesh; Healthcare Access

1. Introduction

For most of surgical history, the surgeon's hands had to be in the room. That assumption — quietly, almost without anyone declaring it dead — has started to give way. Telesurgery, sometimes called robotic or remote surgery, allows a clinician to operate on a patient who may be a city, a country, or an ocean away, and it does this by routing the surgeon's movements through a robotic console rather than through the surgeon's own arms

Significance | First feasibility synthesis situating telesurgery's technical readiness, cybersecurity risks, and cost barriers specifically within Bangladesh's healthcare context.

*Correspondence.

Khondaker A. Mamun, Department of Computer Science and Engineering, United International University, Dhaka, Bangladesh. E-mail: mamun@cse.uiu.ac.bd.

Editor Mohammad Shafiqul Alam, Ph.D. And accepted by the Editorial Board Aug 16, 2023 (received for review Jun 20, 2023)

Author Affiliation: ¹ Department of Computer Science and Engineering, United International University, Dhaka, Bangladesh.

Please cite this article as: Pramanik, S. K., Mamun, K. A. (2023). "Can Telesurgery Bridge Bangladesh's Urban-Rural Healthcare Divide? A Narrative Review of Feasibility, Cybersecurity, and Cost Barriers", *Data Modeling*, 4(1), 1-11, 10809

© 2023 (Data Modeling), a publication of Eman Research, USA.
This is an open access article under the CC BY-NC-ND license.
(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)
(<https://publishing.emanresearch.org>)

(Gupta et al., 2019). It sounds, admittedly, like something out of speculative fiction, and for a while it more or less was. But the technology has aged out of that category. What remains uncertain is not whether telesurgery works — it does, at least under favorable conditions — but where, and for whom, it can be made to work reliably.

Bangladesh is a useful, if underexamined, place to ask that question. The country's urban centers host a reasonable concentration of surgical specialists, while large stretches of the rural population remain functionally cut off from anything beyond general surgical care (Tamalvanan, 2021). This is not a uniquely Bangladeshi problem — it is close to the defining structural challenge of surgical access across most low- and middle-income countries — but it is one that telesurgery is, at least in principle, well suited to address, provided the surrounding conditions can be made to cooperate.

It is worth pausing, briefly, on how the field got here. The first widely cited demonstration of transoceanic telesurgery, Operation Lindbergh, saw a French surgical team operate on a patient using the ZEUS robotic system in 2001, an event that is often treated, somewhat informally, as telesurgery's proof-of-concept moment (Gupta et al., 2019). What has followed since is less a single trajectory than a slow accumulation of platforms, protocols, and cautionary case studies — see Table 1 for a comparative overview of the major systems developed since the early 1990s.

Understood mechanically, a telesurgical system has two principal components: a surgeon console, through which the operating physician views the surgical field and manipulates the robotic arms, and a patient console, situated at the bedside, which relays haptic feedback, vital signs, and imaging back to the surgeon while providing local safeguards such as an emergency-stop mechanism (Figure 1). These two consoles are, functionally, in near-constant conversation across three operational phases — pre-operative connection and security checks, intra-operative execution, and post-operative data retention — and it is worth noting that of the three, the intra-operative phase carries essentially zero tolerance for network failure (Gupta et al., 2019).

The COVID-19 pandemic did something unexpected for this field: it made the case for telesurgery on grounds that had nothing to do with rural access. When operating-room personnel could not always maintain the physical distance

recommended by public health authorities, remote operation became, briefly, a matter of clinician safety rather than patient equity (Tamalvanan, 2021). That the same technology serves both purposes is, arguably, part of why interest in it has not receded now that the acute phase of the pandemic has passed.

Yet enthusiasm has consistently run ahead of infrastructure. Telesurgical platforms remain expensive — acquisition costs alone can run from several hundred thousand to several million dollars, before accounting for the recurring cost of the high-bandwidth networking these systems require (Wikipedia, n.d.) — and the security architecture underpinning them has not kept pace with the pace of adoption. Existing frameworks such as SecureSurgeNET address authentication and encryption reasonably well, but stop short of resolving what happens, legally and procedurally, when the surgeon and the patient sit on opposite sides of a national border (Iqbal et al., 2019).

This paper asks, without pretending the answer is obvious either way, whether Bangladesh could realistically adopt telesurgery given where the technology currently stands, and if not yet, what specifically stands in the way. We do not attempt a formal systematic review; instead, we work through a curated body of recent literature to build a picture that is, we hope, more useful for being modest about its own limits than a more confident-sounding account might be.

2. Methods

2.1 Design

This is a narrative review, not a systematic review or meta-analysis, and we state that plainly here rather than let readers infer it from the absence of a PRISMA flow diagram. We chose this design because the underlying literature on telesurgical feasibility is overwhelmingly descriptive, simulation-based, or framework-proposing rather than comparative-trial based; forcing a quantitative synthesis onto that evidence base would have implied a precision the literature does not actually support. That said, we have tried, wherever practical, to document our process with enough specificity that another team could substantially retrace it — a standard closer to what would be expected of a scoping review, even if we stop short of claiming that label formally.

2.2 Information Sources and Search Strategy

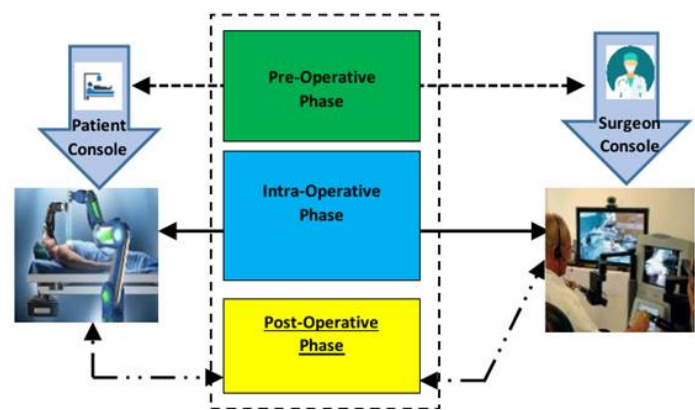


Figure 1: Schematic overview of a telesurgical system architecture, illustrating the surgeon console and patient console and their constituent functions (display, haptic feedback, camera and communication control on the surgeon side; vital-sign monitoring, surgical-site imaging, and emergency-stop functionality on the patient side) across the pre-operative, intra-operative, and post-operative phases of a remote surgical procedure.

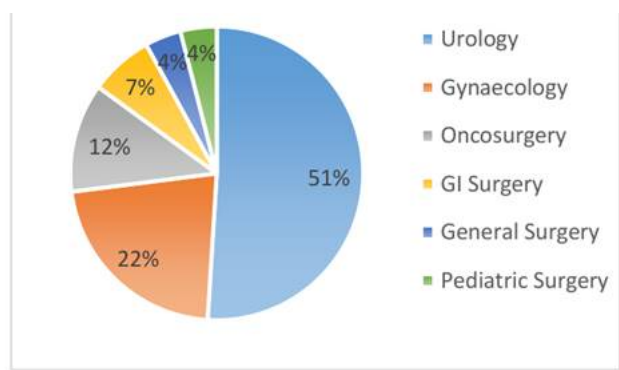


Figure 2: Distribution of robotic surgery cases across medical specialties, showing the proportional share attributable to urology, gynaecology, oncosurgery, and other specialties. Data adapted from Sinha et al. (2021).

Table 1: Comparative overview of major telesurgical and surgical robotic platforms developed worldwide, 1991–2022, detailing year of introduction, manufacturer, country of last documented use, technical description, advantages, and disadvantages. Adapted from Gupta et al. (2019) and cross-checked against manufacturer and regulatory documentation.

Name of the Robot	Year	Company	Country (Last Used)	Description	Advantages	Disadvantages
Medrobotics	1991	Flex Robotic Systems	USA (1991)	Used for stereotactic brain surgery with improved accuracy	Surgeons' choice of implants	Not suitable for colorectal applications
ROBODOC	1992	Integrated Surgical Systems, Inc., Sacramento, CA	Canada (1995)	Used for hip replacement	Safe surgery	High cost
MKM system	1993	Zeiss, Germany	Germany (2001)	During neurosurgical procedures, this robotic microscope was utilized.	A complete robotic solution for stem and cup	No external safety
ZEUS robotic Surgical System	1994	Computer Motion Ltd., USA	USA (2001)	Tubal re-anastomosis	Get rid of templates that are less accurate and adopt jig-based technology.	Accuracy
RAMS Robot	1995	NASA, USA	USA (2001)	Compatible with MRI	Open-platform surgical system	No real-time services for information updates
The Steady Hand system	1995	John Hopkins University, Maryland	USA (2000)	Detects pressure put by the surgeon in neurosurgery	Precise pre-surgical planning is executed every time	No sufficient range of motion is required for general-purpose surgery
ZEUS Robot	1998	Computer Motion Ltd., USA	USA (2001)	Surgery without cardiac bypass	Precise computer-assisted preparation of the bone cavity and joint surfaces	No Tactile feedback
Da Vinci Robotic Surgery System	1998	Intuitive Surgical	USA (2000)	Used to harvest the internal thoracic artery	Rich in technically. Available experienced surgeons at all locations	Most physicians performing prostate surgery have not been trained in this procedure.
Da Vinci Surgical System	2000	Intuitive Surgical	USA (2014)	Performing surgeries with a minimally invasive approach, even for complex cases.	Patients who undergo this medical procedure experience lower risk of complications, reduced blood loss, fewer transfusions, and less pain.	Adverse effects, such as incontinence and erectile dysfunction, may occur and there is a risk of blood clots and infection.
Da Vinci Robot	2000	Intuitive Surgical	USA (2014)	Complicated gynecological surgeries	Non-optical technology	Only used for gynecological surgeries
Vascular Robotic System	2002	Corindus Corpath	USA (2014)	Perform percutaneous coronary interventions	Achieves full potential with forward-thinking physicians	Not progressed as rapidly as endovascular technology
Pathfinder Robot	2004	Armstrong Healthcare Ltd	UK (2016)	Proper guidance for the surgeons	Sub-millimeter dimensional accuracy	Used old technology

Senhance surgical robotics system	2006	Asensus Surgical, Inc.	USA (2023)	Laparoscopic Surgery	Advanced eye sensing camera, Haptic feedback, Direct visual contact, and reasonable cost	Limited procedural time for surgical field
The NeuroArmSYMBI S Robot	2007	IMRIS, USA	USA (2023)	MRI-based robot to remove brain tumor	Precise milling services to ensure optimal alignment.	Used only for brain tumor
ROSA	2007	Medtech, France	France (2022)	Brain surgery procedures	High-precision smart-tool technology, freedom of movement, and advanced assisted navigation.	Tearing or puncturing of vessels or internal organs
Renaissance Guidance System	2007	Mazor Robotics	Israel (2023)	Offers a direct blueprint for the surgical process and is tailored to each patient	Better precision during surgeries, ultimately leads to a decrease in complication rates and quicker recovery periods for patients.	Only used for spine surgery
Smart Tissue Autonomous Robot (STAR)	2009	Johns Hopkins University	USA (2020)	A corrected 3D model with multiple camera views was created using plenoptic imaging.	Stitching, sewing, looping, and threading	The camera was not fast enough to track tissue deformation accurately in real-time.
Mako Rio robot	2009	Stryker	USA (2023)	Used for partial knee replacements and hip surgeries	Immediate pain relief, less blood loss, and shorter hospital stays following hip or knee surgery.	May cause hip-joint misalignment
TSolution One	2014	Think Surgical, Inc.	USA (2017)	For orthopedic surgical procedures for the hip	Personalized pre-surgical plans	No differentiation between tissue types
DaVinci Xi robotic surgery	2014	Intuitive Surgical	USA (2023)	Involves minimal invasion during the procedure.	Perform multiple surgeries	Vision and motor functions were not included
Miniature Robot	2016	Virtual Incision Corp	USA (2023)	This is used to treat patients with Crohn's disease, colon cancer, diverticulitis, and ulcerative colitis.	Achieving a quicker and more efficient recovery.	Climate uncertainty
Epoch robotic surgery system	2018	Stereotaxis	USA (2020)	Magnets are used to control catheters that are inserted into the heart for manipulation.	Minimize x-ray exposure by up to 90% during procedures and enhance the capacity to treat intricate rhythms.	Not suitable for preoperative data
Navio surgical system	2018	Smith & Nephews	UK (2023)	Partial knee replacement	Faster recovery time, less pain, smaller incisions, and natural knee motion during rehabilitation.	Uni-compartmental Knee Replacement
SSI Mantra	2022	SS Innovation Pvt. Ltd.	India (2023)	For general surgery, used in a cancer institute	The design of the console is open-faced, modular, flexible, versatile, and has UPS backup.	Limited development time

We searched four databases — Google Scholar, IEEE Xplore, PubMed, and ScienceDirect — between [search dates to be specified by authors], supplemented by manual screening of the reference lists of key articles (snowball sampling). Search terms combined free-text keywords joined with Boolean operators, including combinations of "robotic surgery," "telesurgery," "opportunity," "challenges," and "Bangladesh" (e.g., ("telesurgery" OR "robotic surgery") AND ("challenges" OR "opportunity" OR "feasibility") AND ("Bangladesh" OR "low- and middle-income countries")). We did not restrict by document type at the outset; conference proceedings, peer-reviewed journal articles, and preprints (notably arXiv) were all eligible for screening, since a meaningful share of the more technically rigorous cybersecurity work in this space circulates first as a preprint (Takanashi et al., 2023).

2.3 Eligibility Criteria

The publication window was bounded to 2018–2023, with one deliberate exception: Bonaci et al. (2015), which we retained outside the window because it appears to be among the earliest empirical demonstrations of an adversarial attack — specifically, a distributed denial-of-service attack — against a telesurgical platform in a controlled setting. Excluding a foundational study on recency grounds alone struck us as a decision that would weaken, rather than strengthen, the review.

Studies were eligible if they addressed telesurgical feasibility, technical architecture (including 4G/5G and tactile-internet implementations), cybersecurity vulnerabilities or countermeasures, or clinical specialty-level adoption patterns. We excluded studies focused primarily on blockchain-based security mechanisms, on the judgment — a qualitative one, not a statistical one, and we say so plainly — that such approaches introduce a level of computational and procedural complexity disproportionate to their real-world deployability in low-resource settings.

2.4 Study Selection

Title and abstract screening was performed independently by both authors, with a preference for open-access articles or those to which institutional access permitted full-text retrieval. This is a pragmatic constraint rather than a methodological ideal, and we disclose it rather than gloss over it, since access barriers of this kind shape what gets cited in resource-limited settings just as concretely as they

shape what gets practiced clinically. From an initial pool in the low thousands of titles — we did not track an exact figure, which we acknowledge here as a limitation rather than defend as adequate — twelve articles were retained for full-text synthesis based on relevance to telesurgical feasibility, technical architecture, or cybersecurity (Table 2).

2.5 Data Extraction

For each of the twelve included sources, we extracted, where reported: study focus, telesurgical platform or protocol under discussion, network technology (4G/5G/tactile internet), reported latency figures, identified security vulnerabilities, and proposed mitigations. Extraction was performed independently by both authors and reconciled by discussion; disagreements were resolved by consensus rather than a third-reviewer arbitration process, which we note as a further methodological limitation appropriate to a two-author team.

To characterize the historical landscape of surgical robotics platforms more broadly, we additionally compiled a comparative table (Table 1) adapted from the architecture survey by Gupta et al. (2019), cross-checked against manufacturer and regulatory documentation where publicly available.

2.6 Cost and Contextual Data

Cost estimates for telesurgical infrastructure — acquisition costs and the recurring cost of high-bandwidth network access — were drawn from publicly available technical and encyclopedic sources (Wikipedia, n.d.), given the absence of standardized, peer-reviewed pricing data in this space. We flag this explicitly as a methodological soft spot: these figures should be read as directional estimates rather than validated data points, and we would encourage future work to seek out procurement records or manufacturer disclosures as a more authoritative alternative.

2.7 Synthesis Approach

Findings were organized thematically rather than chronologically, around three axes that emerged inductively from the included literature: (a) opportunities for telesurgical deployment in low- and middle-income country settings, (b) technical, regulatory, and ethical barriers, and (c) candidate interventions, contextualized specifically for Bangladesh's infrastructural and policy

Table 2: Summary of the twelve studies included in this narrative synthesis, listing publication year and primary focus area (e.g., telesurgical feasibility, network architecture, cybersecurity vulnerabilities and countermeasures, clinical implementation), alongside the focus area of the present study for comparison.

Paper	Title	Year	Focus Area
[1]	Foreseeable challenges in developing telesurgery for low-income and middle-income countries	2021	Telesurgery, Challenges, LMIC, Opportunities
[2]	Tactile-internet-based telesurgery system for healthcare 4.0: An architecture, research challenges, and future directions	2019	Telesurgery, 5G, tactile internet, latency, reliability
[3]	The feasibility of utilizing Telesurgery Service in the Autonomous Region of the Azores, with the support of 5G network.	2023	Telesurgery, 5G, remote surgery, feasibility, benefits
[4]	Protecting procedural care—cybersecurity considerations for robotic surgery	2022	Robotic surgery, cybersecurity, vulnerabilities, security measures
[5]	Telesurgery and robotics: an improved and efficient era	2021	Telesurgery, 5G networks, haptic feedback, tactile robotics, Internet of Things (IoT)
[6]	Cyber-Secure Teleoperation With Encrypted Four-Channel Bilateral Control	2023	Telesurgery, Challenges, Cybersecurity, Encryption
[7]	Experimental analysis of denial-of-service attacks on teleoperated robotic systems	2015	Telesurgery, DOS, Cybersecurity, Experimental Analysis
[8]	On cyber-physical attacks in bilateral teleoperation systems: An experimental analysis	2018	Telesurgery, Challenges, Cybersecurity, Experimental Analysis
[9]	RT-TelSurg: Real-time telesurgery using SDN, fog, and cloud as infrastructures	2021	Robotic surgery, cybersecurity, vulnerabilities, security measures, SDN, FOG, Cloud
[10]	SecureSurgiNET: A framework for ensuring security in telesurgery	2019	Telesurgery, Challenges, Cybersecurity, tactile robotics, Security Framework
[11]	Telesurgery robot based on 5G tactile internet. Mobile Networks and Applications	2018	Telesurgery, 5G networks, haptic feedback, tactile robotics, Internet of Things (IoT)
[13]	Robotic surgery in paediatric patients: Our initial experience and roadmap for successful implementation of robotic surgery programme	2021	Robotic Surgery, Medical Specialties, Implementation challenges.
Our Paper	Feasibility of Robotic Surgery: Opportunities and Challenges in Bangladesh	2023	Robotic Surgery, Bangladesh, Challenges, Opportunities, Recommendations

environment. No formal quality-appraisal instrument (e.g., GRADE, Newcastle-Ottawa) was applied, consistent with the narrative nature of this review; we consider this an area future iterations of this work should address directly, particularly if the intent is eventual publication in a venue that expects formal risk-of-bias assessment.

3. Results

3.1 Overview of Included Literature

Of the twelve sources retained for full synthesis, the majority ($n = 8$) addressed cybersecurity vulnerabilities or countermeasures in teleoperated surgical systems; the remainder focused on feasibility, network architecture, or clinical specialty distribution (Table 2).

3.2 Technical Feasibility

Across the included studies, a fairly consistent diagnosis emerges: the binding technical constraint on telesurgery is not robotic precision but network latency and reliability. Conventional networks remain limited by communication delay and overhead, whereas 5G Ultra-Reliable Low-Latency Communication, offering latency near one millisecond and reliability approaching 99.999%, would in principle support the kind of responsive, haptic-dependent communication telesurgery demands (de Medeiros Sousa & Pinto Santos, 2023). This distinction matters more than it might first appear — haptic feedback loops are notoriously latency-intolerant, and a delay of even a few hundred milliseconds can be the difference between a confident incision and a hesitant one.

A real-world demonstration of this principle comes from a case report of the world's first long-distance cardiac telesurgery performed using tactile internet as the network backbone, which showed improved response time and reliability relative to legacy infrastructure (Gordon et al., 2022). A separate feasibility analysis conducted in the geographically remote Azores region similarly found that distance from tertiary care need not be destiny, provided the underlying network layer is sufficiently robust (de Medeiros Sousa & Pinto Santos, 2023; Mohan et al., 2021).

3.3 Cybersecurity and Privacy

This theme dominated the literature pool more than we had expected going in. The vulnerability of robotic surgical systems to cyber threats is well documented across independent analyses, alongside the corresponding need

for proactive — rather than reactive — cybersecurity measures (Gordon et al., 2022; Takanashi et al., 2023; Munteanu et al., 2018). The earliest empirical demonstration in our pool, an experimental analysis of denial-of-service attacks on teleoperated robotic systems, established as far back as 2015 that this threat was not theoretical (Bonaci et al., 2015); the point was reinforced, rather than superseded, by a later experimental study of cyber-physical attacks in bilateral teleoperation systems (Munteanu et al., 2018).

Defensive work has not stood still in response. Purpose-built frameworks have since emerged, including SecureSurgiNET (Iqbal et al., 2019) and RT-TelSurg, a real-time architecture built around software-defined networking, fog, and cloud infrastructure (Sedaghat & Jahangir, 2021), alongside encryption-centric approaches such as encrypted four-channel bilateral control, which protects the integrity of the haptic feedback loop itself rather than merely the surrounding data channel (Takanashi et al., 2023). Notably, none of the frameworks identified in this review — SecureSurgiNET included — comprehensively addresses the cross-jurisdictional regulatory dimension of security: these frameworks specify how to encrypt and authenticate, but stop short of reconciling international, domestic, and institutional rules when the surgeon and patient are separated by a national border.

3.4 Clinical Adoption Patterns

Data on the global distribution of robotic surgery cases across specialties indicate that urology accounts for the largest share, followed by gynaecology and oncosurgery (Sinha et al., 2021) (Figure 2). This skew is not incidental; it tracks fairly closely with which procedures benefit most from the dexterity and visualization advantages robotic platforms offer over conventional laparoscopic approaches — a pattern worth bearing in mind if Bangladesh eventually chooses where to pilot its first telesurgical service line.

3.5 Cost and Infrastructure

The financial barrier is steep by almost any measure. Telesurgical platforms range from roughly \$900,000 to several million dollars in acquisition cost, with patients additionally responsible for surgeon fees and a share of the recurring cost of the high-bandwidth networking required to support the procedure, itself estimated at \$100,000–\$200,000 annually (Wikipedia, n.d.). Set against

Bangladesh's per-capita health expenditure, this is not merely a large figure; it is close to prohibitive without some combination of subsidy, shared infrastructure, or public investment.

4. Discussion

4.1 Principal Findings in Context

Taken together, the literature reviewed here resists both the breathless optimism sometimes attached to "future of surgery" narratives and the flat dismissal that cost concerns alone might invite. It suggests something more in-between, and arguably more useful for that: telesurgery is maturing technically faster than the regulatory and economic scaffolding around it, and Bangladesh's position is less about whether the technology works — it largely does, under increasingly realistic conditions — and more about whether the surrounding conditions can be built quickly enough to make its use safe, affordable, and equitable, rather than confined to a handful of urban tertiary centers.

The latency findings deserve particular emphasis. The shift from conventional, delay-prone networks toward near-millisecond, near-total-reliability 5G URLLC service is not a marginal engineering improvement; it is closer to the technology becoming clinically trustworthy rather than merely clinically possible (de Medeiros Sousa & Pinto Santos, 2023). Bangladesh's ongoing 5G rollout arrives, in that sense, at a genuinely opportune moment — though it would be premature to treat infrastructure alone as sufficient. The cardiac telesurgery case (Gordon et al., 2022) was a proof-of-concept deployment under favorable, well-resourced conditions, and it is not obvious that it transfers cleanly to a district hospital contending with intermittent power and variable connectivity.

4.2 The Centrality of Cybersecurity

If there is one theme this review cannot responsibly relegate to a secondary concern, it is cybersecurity — and we say this having gone into the synthesis expecting cost and infrastructure to dominate, only to find security threading through nearly every included source instead. A successful attack during an active telesurgical procedure is not a data breach in the ordinary sense; it is a direct, real-time threat to a patient mid-operation, which raises the stakes of cybersecurity failure well above what most other digital health applications carry (Bonaci et al., 2015; Munteanu et al., 2018).

The field has, encouragingly, not stood still: layered defenses including encrypted bilateral control (Takanashi et al., 2023) and SDN/fog/cloud-based architectures (Sedaghat & Jahangir, 2021) represent real progress. But for Bangladesh specifically, adopting any of these frameworks still means importing a security model that was not designed with cross-border regulatory asymmetries in mind (Iqbal et al., 2019).

4.3 Economic and Structural Barriers Revisited

The cost figures bear restating plainly, because plain restatement is sometimes the most honest form of analysis available: acquisition costs in the hundreds of thousands to millions of dollars, plus six-figure annual networking costs (Wikipedia, n.d.), sit in stark tension with the equity rationale that makes telesurgery appealing in the first place. A technology proposed as a remedy for healthcare access gaps cannot, paradoxically, be priced such that only the already well-resourced can afford it — that would simply relocate the inequity rather than resolve it (Tamalvanan, 2021). This is precisely why the recommendations advanced here lean on shared and subsidized models — public-private partnerships, manufacturer-negotiated pricing, mobile robotic units serving multiple facilities — rather than an assumption that individual hospitals will each acquire their own platform, a path that would likely entrench rather than reduce the urban-rural divide.

4.4 Strengths and Limitations

This review's strength lies in synthesizing a deliberately curated, security-attentive cross-section of the telesurgery literature into a context-specific feasibility assessment for a country that has, to our knowledge, received comparatively little direct attention in this literature to date. Its limitations are equally real: the search, while structured, was not conducted to PRISMA standards, and the twelve included sources cannot be assumed to represent the full universe of relevant work, particularly in fast-moving subfields such as post-2023 5G-enabled robotics or newer encryption schemes. Cost figures were drawn from non-peer-reviewed sources for lack of a better alternative and should be read as directional rather than precise. None of the conclusions rest on Bangladesh-specific pilot data; they are extrapolated from global evidence onto a local context that has not yet been directly studied.

4.5 Implications and Future Directions

None of these limitations, we would argue, undermine the review's central and fairly modest claim: telesurgery in Bangladesh is not currently feasible at scale, but it is not far from feasible either, and the gap appears to be closing faster on the technical side than on the regulatory and economic side. Future work would do well to move from narrative synthesis toward primary data — pilot deployments with measured latency and outcome data on Bangladeshi networks specifically, formal cost-effectiveness modeling against the alternative of patient transport to tertiary centers, and direct engagement with Bangladeshi regulatory bodies to identify exactly where existing law is silent on cross-border surgical liability.

5. Conclusion

Telesurgery in Bangladesh is not yet feasible at scale, but it is not far off, either — the technology itself appears to be maturing faster than the regulatory and economic structures meant to support it. Affordability, connectivity, training capacity, and unresolved cross-border liability remain the binding constraints, not robotic capability itself, which is arguably closer to ready than commonly assumed. Closing this gap will likely require coordinated effort across government, private industry, and international partners: stronger telecommunications infrastructure, clearer cross-jurisdictional regulation, and sustained investment in surgical training. Done well, and done deliberately rather than opportunistically, telesurgery could meaningfully narrow the urban-rural healthcare divide, allowing remote patients to draw on specialist expertise currently well beyond their reach. Whether Bangladesh actually seizes this opportunity, though, will depend less on the technology's arrival than on how intentionally the surrounding conditions are built.

Author Contributions

S.K.P.: conceptualization, literature search, data extraction, writing – original draft. K.A.M.: supervision, conceptualization, writing – review and editing.

Acknowledgements

The authors S.K.P. thank the Department of Computer Science and Engineering, United International University, for institutional support during the preparation of this manuscript. No external funding was received for this work.

Competing Financial Interests

The authors S.K.P. declare no competing financial interests.

References

- Bonaci, T., Yan, J., Herron, J., Kohno, T., & Chizeck, H. J. (2015). Experimental analysis of denial-of-service attacks on teleoperated robotic systems. In *Proceedings of the ACM/IEEE Sixth International Conference on Cyber-Physical Systems* (pp. 11–20). ACM/IEEE. <https://doi.org/10.1145/2735960.2735980>
- de Medeiros Sousa, G., & Pinto Santos, A. M. (2023). The viability of telesurgery service in the Autonomous Region of the Azores, supported by the 5G network. *Procedia Computer Science*, 219, 422–430. <https://doi.org/10.1016/j.procs.2023.01.309>
- Gordon, W. J., Ikoma, N., Lyu, H., Jackson, G. P., & Landman, A. (2022). Protecting procedural care—cybersecurity considerations for robotic surgery. *NPJ Digital Medicine*, 5(1), Article 148. <https://doi.org/10.1038/s41746-022-00693-4>
- Gupta, R., Tanwar, S., Tyagi, S., & Kumar, N. (2019). Tactile-internet-based telesurgery system for healthcare 4.0: An architecture, research challenges, and future directions. *IEEE Network*, 33(6), 22–29. <https://doi.org/10.1109/MNET.001.1900063>
- Iqbal, S., Farooq, S., Shahzad, K., Malik, A. W., Hamayun, M. M., & Hasan, O. (2019). SecureSurgeNET: A framework for ensuring security in telesurgery. *International Journal of Distributed Sensor Networks*, 15(9). <https://doi.org/10.1177/1550147719873811>
- Miao, Y., Jiang, Y., Peng, L., Hossain, M. S., & Muhammad, G. (2018). Telesurgery robot based on 5G tactile internet. *Mobile Networks and Applications*, 23, 1645–1654. <https://doi.org/10.1007/s11036-018-1110-3>
- Mohan, A., Wara, U. U., Shaikh, M. T. A., Rahman, R. M., Zaidi, Z. A., & Shaikh, M. T. A. (2021). Telesurgery and robotics: An improved and efficient era. *Cureus*, 13(3), Article e13775. <https://doi.org/10.7759/cureus.13775>
- Munteanu, A., Muradore, R., Merro, M., & Fiorini, P. (2018, May). On cyber-physical attacks in bilateral teleoperation systems: An experimental analysis. In *2018 IEEE Industrial Cyber-Physical Systems (ICPS)* (pp. 159–166). IEEE. <https://doi.org/10.1109/ICPHYS.2018.8387650>
- Sedaghat, S., & Jahangir, A. H. (2021). RT-TelSurg: Real-time telesurgery using SDN, fog, and cloud as infrastructures. *IEEE Access*, 9, 52238–52251. <https://doi.org/10.1109/ACCESS.2021.3069655>
- Sinha, A., Pathak, M., Vig, A., & Saxena, R. (2021). Robotic surgery in paediatric patients: Our initial experience and roadmap for successful implementation of robotic surgery programme. *Journal of Minimal Access Surgery*, 17(1), 32–37. https://doi.org/10.4103/jmas.JMAS_137_19
- Takanashi, H., Kosugi, A., Teranishi, K., Mizuya, T., Abe, K., & Kogiso, K. (2023). Cyber-secure teleoperation with encrypted four-channel bilateral control (arXiv:2302.13709). *arXiv*. <https://doi.org/10.48550/arXiv.2302.13709>
- Tamalanvan, V. (2021). Foreseeable challenges in developing telesurgery for low income and middle income countries. *International Surgery Journal*, 8(10), 3228–3230.

<https://doi.org/10.18203/2349-2902.isj20213821>

Wikipedia. (n.d.). Remote surgery. Retrieved July 22, 2026, from
https://en.wikipedia.org/wiki/Remote_surgery