



Building responsible surgical artificial intelligence: the AiCCESS Consortium and the next phase of translational innovation

Divya Kewalramani^{1,2} , Philip S. Barie^{2,3} , Mayur Narayan^{1,2}

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Artificial intelligence (AI) is rapidly permeating surgical care. Predictive analytics, computer vision, workflow optimization, large language models, and multimodal systems are now positioned to influence nearly every phase of surgical care - from diagnosis and perioperative planning, to prediction of surgical site infection (SSI) and other complications, intraoperative decision support, technical performance assessment, postoperative surveillance, and surgical education^[1,2]. Yet an important question remains insufficiently addressed: What kind of surgical AI ecosystem is actually being built?

The history of surgical innovation teaches that technical capability alone is never sufficient. Innovations that endure are those that become integrated into the realities of patient care, clinical judgment, systems infrastructure, education, implementation, and public trust. AI is unlikely to prove different. The future of AI in surgery will depend not only on algorithmic performance, but also on whether the field can develop frameworks that are rigorous scientifically, grounded in biology, educationally responsible^[3-5], relevant globally^[6], reproducible, and accountable to the patients and communities it serves^[7].

It is within this context that the AiCCESS Consortium - Artificial Intelligence for Comprehensive Care, Education, and Sustainability in Surgery - was established at Rutgers Robert Wood Johnson Medical School. The consortium was created around a simple but demanding premise: Surgical AI should improve outcomes not merely within highly resourced systems, but across the broad spectrum of surgical care delivery and education, including in environments constrained by workforce limitations, infrastructure variability, geography, or access^[6,8].

Acute Care Surgery (ACS) evolved from the convergence of trauma surgery, surgical critical care, and emergency general surgery into a discipline organized around the continuous care of patients with time- and context-sensitive surgical disease. Its



¹Division of Acute Care Surgery, Department of Surgery, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ 08901, USA.

²Artificial Intelligence for Comprehensive Care, Education, and Sustainability (AiCCESS) in Surgery, Rutgers Acute Care Surgery Research (RASR) Laboratory, Rutgers University, New Brunswick, NJ 08901, USA.

³Division of Trauma, Burns, Acute and Critical Care, Department of Surgery, Weill Cornell Medicine, New York, NY 10065, USA.

Correspondence to: Dr. Divya Kewalramani, Division of Acute Care Surgery, Department of Surgery, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ 08901, USA. E-mail: dk1362@rwjms.rutgers.edu

development reflected recognition that these patients often traverse traditional boundaries of diagnosis, resuscitation, operative intervention, intensive care, and rescue, requiring coordinated expertise across the entire episode of acute illness. ACS therefore represents more than the aggregation of several surgical practices; it is an integrated model of care designed to respond to physiologic instability, incomplete information, and rapidly changing clinical priorities^[9-11].

The AiCCESS Consortium emerged within this environment, accustomed to managing complex adaptive systems under conditions of physiologic instability, incomplete information, time pressure, and resource variability. ACS workflows require continuous integration of heterogeneous clinical signals across multidisciplinary teams and evolving operational environments. These characteristics make ACS not merely a setting for AI deployment, but an important translational laboratory for understanding how intelligent systems integrate into high-risk clinical ecosystems^[12,13].

The consortium likewise emerged from the intersection of two historically distinct domains: global surgery and AI in surgery. Traditionally, these fields have evolved along different trajectories. Global surgery has focused on access, workforce shortages, trauma infrastructure, systems development, and disparities in outcomes. AI in surgery, by contrast, has evolved so far in technologically advanced centers emphasizing robotics, computational sophistication, and predictive analytics. Increasingly, these domains are converging, although development, validation, and clinical deployment remain markedly uneven^[14].

The extant evidence base illustrates the uneven development and translation of surgical AI. A 2026 scoping review of 475 studies of AI in surgical care in low- and middle-income countries found that 79% originated in upper-middle-income countries, with China alone accounting for 64% of all studies, whereas only 1% originated in low-income countries. Moreover, 68% of studies were retrospective, only 30% included external validation, and just 3% reported clinical deployment^[14].

AI possesses the potential to narrow longstanding disparities in surgical care through scalable decision support, workflow augmentation, predictive systems, remote education, and intelligent triage. At the same time, poorly designed AI systems risk amplifying precisely the inequities they seek to solve. Algorithms trained exclusively in high-resource environments may fail when deployed elsewhere^[14]. Black-box systems that cannot be interrogated clinically may undermine trust. Models optimized for statistical performance but disconnected from biological plausibility, workflow integration, or implementation realities may produce elegant publications without meaningful clinical impact^[7].

These tensions have shaped the intellectual foundation of the AiCCESS Consortium from its inception. Several recurring risks accompany surgical AI deployment and inform the consortium's organizational philosophy^[15] [Table 1]. The consortium's design philosophy emphasizes biologic grounding over purely black-box inference, patient-centered outcomes over technical novelty alone, and implementation-aware deployment rather than algorithmic performance in isolation [Figure 1]. These principles inform project selection, mentorship structure, data governance, methodological standards, collaborative partnerships, and publication practices.

Current consortium work spans three major domains: AI-enabled surgical education and competency assessment, AI for surgical infection prediction and management, and the economics and implementation science of surgical AI systems. Concurrently, the consortium maintains active global surgery collaborations in India, Pakistan, Nigeria, and Somaliland focused on trauma systems development and outcomes research.

Table 1. Major risks and challenges in surgical AI

Domain	Risk	Potential consequence	Mitigation strategy
Data Bias	Non-representative training datasets	Reduced performance in underrepresented populations or resource-limited settings ^[14]	Diverse datasets; external validation; equity-focused evaluation
Black-Box Inference	Limited explainability of model outputs	Loss of clinician trust; unsafe recommendations ^[7]	Biological grounding; interpretable models; clinician oversight
Automation Bias	Overreliance on AI recommendations	Erosion of independent clinical judgment ^[15]	Human-in-the-loop systems; education in AI literacy
Reproducibility	Nontransparent methods or inaccessible code	Irreproducible findings; diminished scientific credibility	Open science standards; version-controlled code; reporting guidelines
Implementation Failure	Poor workflow integration	Low adoption despite strong technical performance ^[14]	Human factors engineering; implementation science
Privacy and Security	Use of sensitive clinical data	Confidentiality breaches; regulatory exposure	Robust governance; de-identification; secure infrastructure
Commercialization Pressures	Premature deployment or performance inflation	Patient harm; erosion of public trust	Independent validation; transparent conflict disclosure

AI: Artificial intelligence.

Importantly, these are not parallel efforts occurring in isolation. Rather, they are intentionally integrated programs designed to ensure that AI development remains connected to real-world surgical systems and diverse patient populations.

Surgical infection prevention illustrates this translational approach. The fragmented signals accompanying evolving infection and postoperative deterioration span laboratory data, imaging, operative details, nursing assessments, and longitudinal clinical documentation; AI may facilitate their integration for earlier recognition, risk stratification, and intervention^[16-18]. Because postoperative infection remains relevant across diverse care environments, it also provides a useful model for implementation-focused collaborative research.

The Consortium's early scholarly output reflects this orientation, emphasizing that AI may help bridge global surgical gaps when coupled with thoughtful systems integration, educational investment, accessibility, and attention to scalability^[8]. The rapidly expanding role of AI in surgical education is another focus of the Consortium. This area may prove to be among the more important applications of surgical AI. Beyond technical automation, AI is poised to reshape how surgeons acquire knowledge, assess competence, receive feedback, and maintain lifelong learning throughout practice^[3]. Video-based assessment systems, intelligent tutoring platforms, simulation environments, adaptive curricula, and multimodal educational systems may reshape the apprenticeship model that has defined surgical education for generations^[3,5,19-21].

Yet these technologies also raise crucial questions regarding validity, bias, surveillance, autonomy, and the preservation of human judgment. For this reason, the Consortium's educational mission extends beyond teaching surgeons how to use AI tools. It also seeks to train future investigators capable of evaluating, governing, validating, and integrating intelligent systems within complex clinical environments^[22,23]. Reproducibility, open science, transparent reporting, responsible AI disclosure, and methodologic rigor are therefore embedded in the Consortium's operational structure from the earliest stages of trainee development^[24]. In an era increasingly vulnerable to automation bias, this educational mission may prove as important as any individual algorithmic innovation^[15].

Equally important is the Consortium's explicit emphasis on mentorship culture. AiCCES frames scientific development as both an intellectual and moral enterprise grounded in accountability, collaboration, humility, and service. The Consortium draws upon the principle of *seva* - selfless service - as an animating

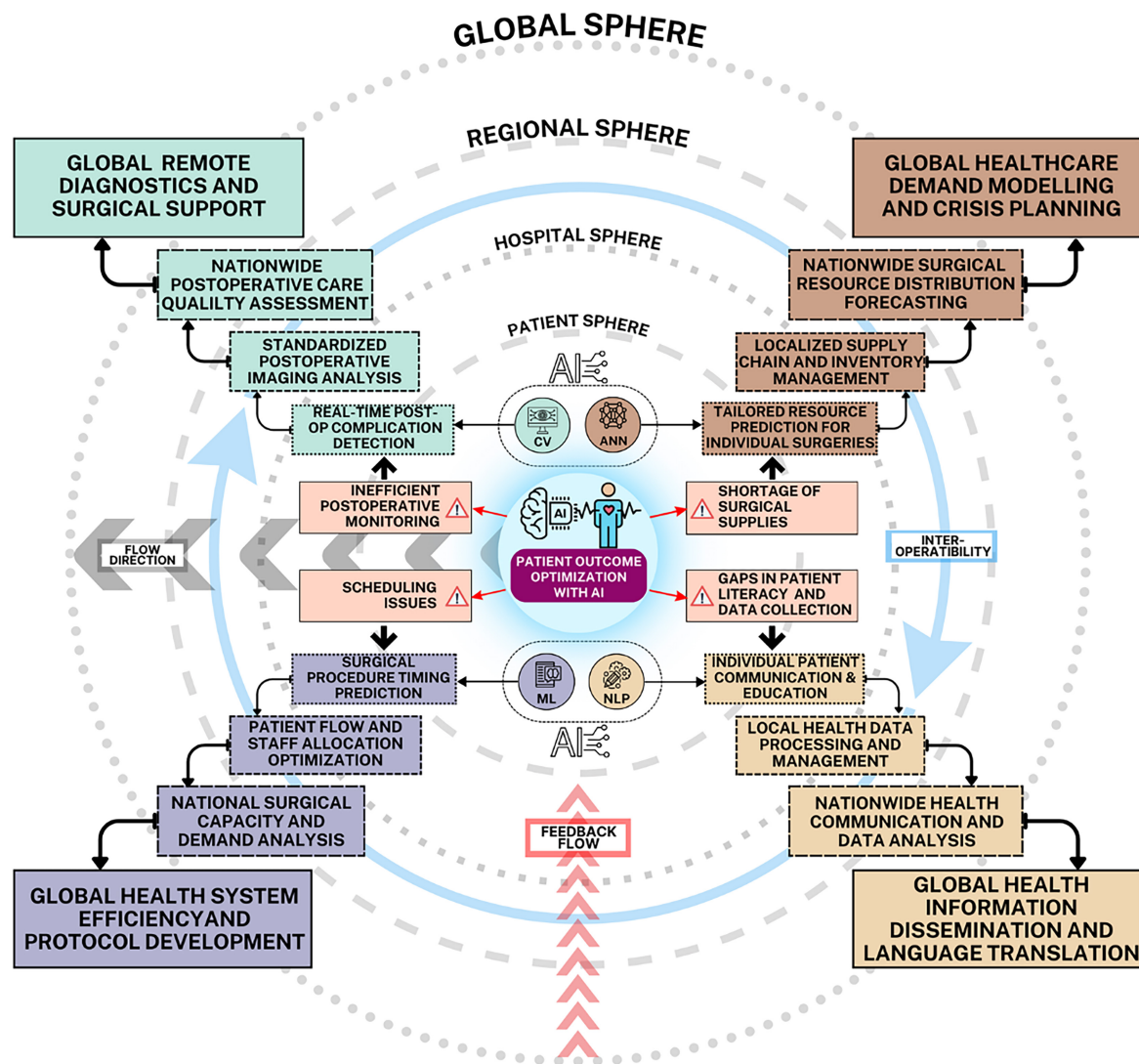


Figure 1. PCASE model. The PCASE model provides a multilevel framework for the expansion of AI across surgical care, illustrating how patient-centered applications can scale from the patient sphere to the hospital, regional, and global spheres. Beginning with individual patient needs and outcomes, AI modalities - including CV, ANN, ML, and NLP - address challenges in postoperative monitoring, surgical resource availability, scheduling, and patient communication and data collection. These applications progressively support broader functions, including postoperative complication detection, procedural timing and workforce optimization, individualized resource prediction, supply-chain management, health-data processing, and quality assessment. Through interoperability, bidirectional information flow, and iterative feedback, these capabilities can extend to national and global applications in surgical capacity planning, healthcare demand modeling, remote diagnostic and surgical support, health-system efficiency, protocol development, and information dissemination and language translation. The model emphasizes patient outcome optimization as the central objective, with data and insights generated across levels feeding back toward patient-level care and enabling context-responsive, scalable AI implementation in surgery. PCASE: Patient-Centered Artificial Intelligence Surgery Expansion; AI: artificial intelligence; CV: computer vision; ANN: artificial neural networks; ML: machine learning; NLP: natural language processing.

value. Such language is uncommon in discussions of AI, which are frequently dominated by technical benchmarks and commercial narratives. Yet surgical AI will ultimately be defined not solely by computational advances, but by the cultures, institutions, and ethical commitments that shape how those advances are developed, evaluated, and deployed.

The next phase of AI in surgery will require more than increasingly sophisticated models. Responsible surgical AI development depends on multidisciplinary expertise extending well beyond algorithm

Table 2. Multidisciplinary expertise required for responsible surgical AI development

Expertise domain	Contribution to consortium-based AI research
Acute Care Surgery and Surgical Critical Care	Clinical problem identification; outcome prioritization; implementation feasibility
Global Surgery	Contextualization for diverse and resource-variable care environments
Epidemiology	Study design; bias assessment; population-level inference
Biostatistics	Statistical modeling; validation; calibration; uncertainty assessment
Trial Design	Prospective evaluation; comparative effectiveness methodology
Computer Science/Machine Learning	Algorithm development; multimodal modeling; systems engineering
Health Economics	Cost-effectiveness; implementation sustainability; value assessment
Surgical Education	AI curriculum development; competency assessment; AI literacy
Implementation Science	Workflow integration; adoption science; scalability
Ethics and Governance	Transparency; accountability; fairness; regulatory alignment
Engineering and Applied Design	Systems integration; device interoperability; workflow optimization; sensor, hardware, and translational technology development

AI: Artificial intelligence.

Table 3. Historical and operational features of ACS and their relevance to the integration of AI

ACS historical anchor	Operational characteristic	AI-relevant correlate
Trauma systems development ^[9,11]	Regional coordination under time pressure	Real-time triage and predictive decision support
Surgical critical care ^[9,10]	Continuous physiologic monitoring	Multimodal signal integration and surveillance
Emergency general surgery ^[9,11]	Decision-making with incomplete information	Probabilistic modeling under uncertainty
Perioperative rescue ^[9,11]	Dynamic escalation pathways	Early deterioration detection
Multidisciplinary ICU workflows ^[9,11]	Team-based coordination across data streams	Human-AI collaborative systems
Damage control philosophy ^[9]	Staged intervention in unstable systems	Adaptive and iterative decision support
ACS workforce model ^[10,11]	Continuous operational coverage	Workflow-aware implementation
Outcomes registries and verification ^[9,11]	Continuous performance assessment	Data-driven model validation and feedback loops

ACS: Acute Care Surgery; AI: artificial intelligence; ICU: intensive care unit.

development alone [Table 2]. It will require collaboration among surgeons, engineers, implementation scientists, educators, economists, ethicists, and global health investigators. It will require datasets that are representative rather than convenient, validation that prioritizes generalizability over performance inflation, and systems designed for transparency rather than opacity^[7,14]. Most importantly, it will require sustained attention to the question of whom these technologies are ultimately intended to serve.

The promise of surgical AI is real. But the measure of success will not be whether machines become more capable. It will be whether patients receive safer, more accessible, more equitable, and more humane surgical care because of them. The future of surgical AI will likely be determined less by standalone algorithmic sophistication than by the quality of its integration into complex clinical systems, educational structures, and cultures of accountable scientific practice [Table 3].

ACS may be one of the most receptive and informative environments in which to study responsible AI integration. That is the opportunity the AiCCESS Consortium was created to address.

DECLARATIONS

Authors' contributions

Conceptualization, Writing and Editing Manuscript: Kewalramani D, Barie PS, Narayan M

Availability of data and materials

Not applicable.

AI and AI-assisted tools statement

During the preparation of this manuscript, the AI tool ChatGPT (version 4.5, released 2025-02-27) was used solely for language editing. The tool did not influence the study design, data collection, analysis, interpretation, or the scientific content of the work. All authors take full responsibility for the accuracy, integrity, and final content of the manuscript.

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Conflicts of interest

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Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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