




Surgathon: a new model for creating a surgical innovation ecosystem in low-resource settings

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ABSTRACT

Innovation ecosystems and emerging technologies can potentially accelerate the access to safe, affordable surgical care in low-resource settings. There is a need to develop localised innovation ecosystems that can establish an initial culture and catalyse the creation, adoption and diffusion of innovation. The surgathon model outlines one approach to seeding surgical innovation ecosystems. International academic institutions collaborated on six global surgery, innovation and ethics-themed hackathons ('surgathons') across India and Rwanda between 2016 and 2019. Over 1598 local multidisciplinary students participated, learning about challenges in the delivery of surgical care and ideating solutions that could leverage appropriate technology and resources for impact. Pursuing student ideas and evaluating their implementation past the surgathons continues to be an active effort. Surgathons have unfolded in different permutations based on local faculty, institution and health system context. The surgathon model is a novel method of priority setting challenges in global surgery and utilises locally driven expertise and innovation capacity to derive ethical solutions. The model offers a path for low-resource setting students and faculty to learn, advocate and innovate for improved surgical care.

INTRODUCTION

Surgery is at a crossroads of two major inflection points. The first is the public recognition of surgery as one of the defining inequities of global health: the poorest 33% of the world has access to 6% of surgical procedures performed every year, resulting in up to 17 million preventable deaths every year.¹ The second is the ripe opportunity to leverage innovation ecosystems and emerging technologies in computer science and material science to tackle the challenges in surgical care delivery in low-resource settings.^{2 3} In addition to impacting patient-level care, powerful opportunities now exist to rapidly improve the operational challenges

Summary box

- ▶ Approaches to develop sustainable and ethical solutions that leverage technology for improved surgical care in low-resource settings are limited.
- ▶ Surgery innovation hackathons—or, 'surgathons'—offer a path for international academic institutions and its students and faculty to meaningfully learn, collaborate and contribute to improved surgical care.
- ▶ Surgathons use innovation challenges to seed localised innovation ecosystems that promote interest, exposure, experience and tangible solution-making for surgery.
- ▶ Early-stage surgathons have taken place in low-resource communities in India and Rwanda, encouraged and accompanied by high-resource academic institutions, to realise the creation of community-based surgical innovation ecosystems.

in surgical care at a population level, even in low-resource settings, because of the accessibility of low-cost technologies like smartphones and sensors. However, what is often missing in low-resource communities is the initial support and culture needed to establish an effective local innovation ecosystem that can catalyse the creation, adoption, and diffusion of innovation.

THE NEED

For innovation to be effective in improving surgical care delivery within low-resource settings, there is a need to develop a local innovation ecosystem. A local innovation ecosystem is defined as having local access, funding, policies and a culture towards collaboration, consultation and experimentation.⁴ Such ecosystems—often situated within academic centres and in proximity to the private sector—can unite and incentivise individuals, institutions and a community to



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solve problems sustainably. In countries like the USA, for example, local innovation ecosystems have successfully facilitated newer, faster, cheaper and better solutions across sectors.⁵ We believe that those academic institutions in high-resource settings that focus on innovation, or in particular on healthcare innovation, have an opportunity to extend their reach by sharing their knowledge in underserved regions. High-resource academic institutions can accompany and collaborate with institutions in low-resource settings towards developing local innovation ecosystems. The ecosystem must be led by a local coalition, not a single stakeholder, to prevent silos, as clinicians, engineers, business leaders and policymakers in low-resource settings will all have a key role to play.

In addition, we know that innovation efforts need to be focused on a specific area to build and sustain momentum.⁶ Focusing on a set of pressing problems is critical as it can enable stakeholders to engage with one another fluidly, embedding a meaningful purpose and legitimacy to the solution-making efforts. In our experience, surgery provides a unique and diverse range of challenges across multiple domains of a health system. We define surgical innovation as the design, invention, development and/or implementation of a new or altered product, service, process, system, business model or organisational structure that focuses on the delivery of surgical care. Importantly, the barriers that prevent access to safe, affordable and timely surgical care for 5 billion people are multiple. These barriers are not only bound to supply chain and workforce shortages seen by the health system but also instead extend out and impact all aspects of surgical care delivery from care coordination, communication, finances and even patient transport, to name a few. Solutions can be targeted within a health system and have multiple entry points for local stakeholders to engage with. Global surgical innovation to date has targeted challenges concerning the affordability, accessibility and/or quality of surgical care.

Conventional innovation efforts within global surgery have largely involved workshops and conferences where the majority of participants tend to be guests from resource-rich communities who have had projects and previous experiences in low-resource settings.⁷ While conferences and workshops foster collaboration and excitement, a method for structured and systematic local innovation that focuses on engaging professionals and students from low-resource settings lacks. As a result, there is a large gap in which the local individuals who experience the challenges in surgical care and who are potentially best positioned to solve these problems are often not invested in or fully engaged by resource-rich institutions and actors.⁸ It is the local change agents that global surgery needs the most, and innovation cannot tangibly or sustainability change surgical care and health systems for the better if it is passively 'transferred' from high to low-resource settings.

A NEW MODEL IN SURGICAL INNOVATION

We propose a new conceptual model for global surgical innovation that aims to be comprehensive in its approach to community engagement, resource allocation and human investment. We have applied this conceptual model to health hackathons in low-resource settings that, over the past decade, have become a common tool for sparking excitement and inspiring solutions for challenges in healthcare.^{9–13} A 'surgathon' shares problem statements that are focused on local challenges in the delivery of surgery and anaesthesia to multidisciplinary participants. The participants then build teams that focus on proposing potential solutions in a constrained time frame. Teams with promising ideas, or, at times, prototypes, win awards and may be offered financial support and mentorship. The surgathon model builds on the 'health hackathon' in two ways: (1) ideas that optimise existing resources (people, materials and knowledge) in the local community are prioritised in the judging and (2) successive surgathons (over an extended period of time) can seed a local innovation ecosystem.

The surgathon model uniquely places critical importance on investing time to build relationships and accompanying the faculty of local academic institutions with a programme of activities that is tailored to the social, cultural and health objectives of the community.¹⁴ Faculty and students gather support from their departments to deliver surgathons, and, with time, institutional excitement can result in the launch of a surgical innovation centre. The centre cements cross-discipline collaborations and extends the opportunity to problem-solve for improved surgical care to the wider community. The surgathons and designated innovation centre symbolise the nascent beginnings of a local surgical innovation ecosystem.

CORE PILLARS OF THE MODEL

There are three key core pillars that make up the foundation of the surgathon model: global surgery, innovation and ethics (figure 1). Within each pillar, there are concepts that drive the content and structure of the surgathons and encourage relationships and potential tangible outputs that may unfold in different permutations based on the local context.

The global surgery pillar focuses on sharing three buckets of knowledge with individuals: (1) the current pain points that exist in surgical care delivery globally and nationally for wider context, (2) the economic, political and human impacts of lacking surgical care and (3) the systems-thinking approach that can be applied to improve surgical care within a health system.¹⁵ During the surgathon, speakers and problem statements provide the buckets of knowledge (table 1). In the longer term, interested faculty members can broaden global surgery education for the institution through pursuits in surgical research and advocacy.

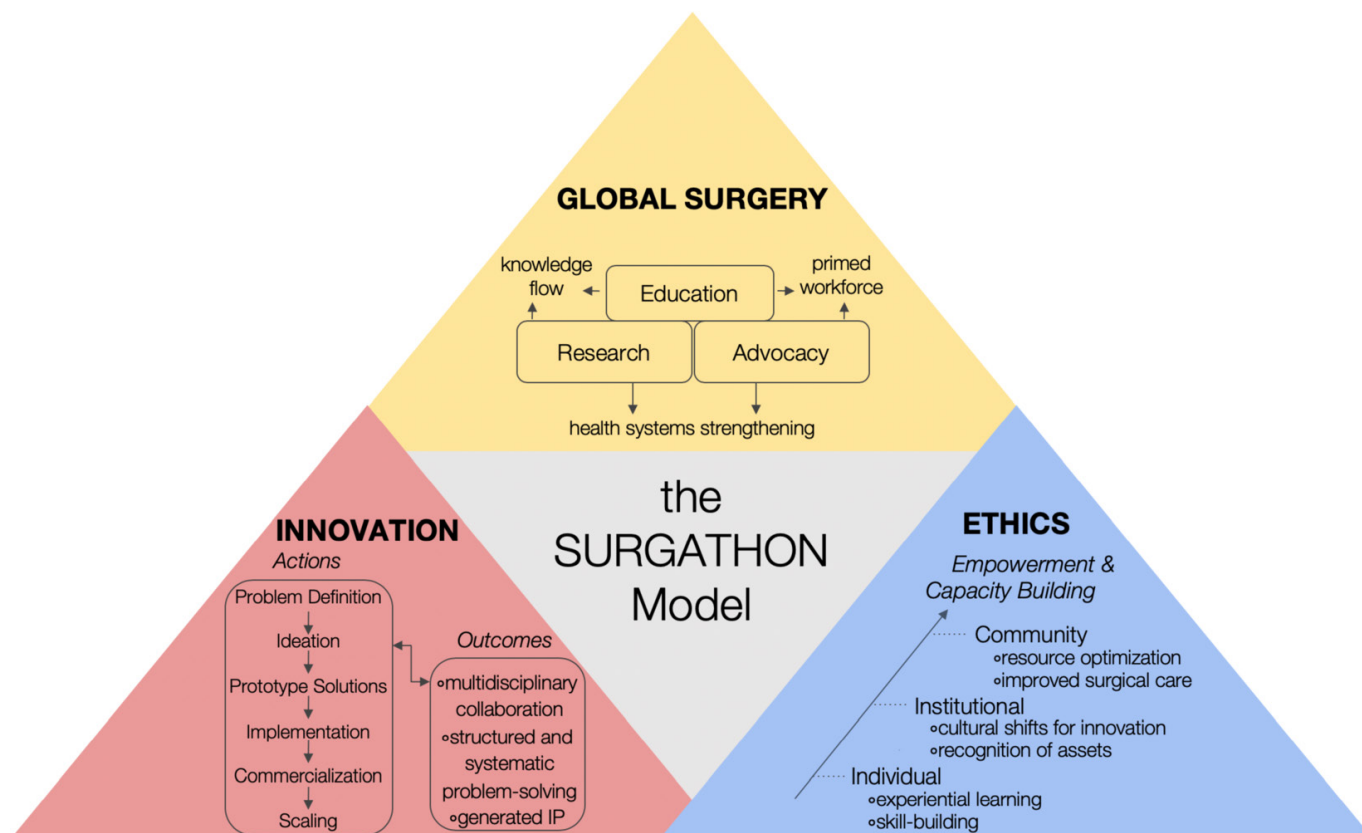


Figure 1 The Surgathon model consists of three pillars: global surgery, innovation, and ethics. Within each pillar there are key goals and concepts outlined.

The innovation pillar highlights activities that can begin in a surgathon—problem definition, ideation, pitching, prototyping—and continue after implementation,

commercialisation and scaling. Each activity in the life-cycle of an innovation disseminates skills and knowledge the participants while creating cultural shifts in

Table 1 Suggested key lectures for a surgathon

Surgathon lectures		
Global surgery	Ethics	Innovation
<p>‘Surgery Systems: Global & National Level’ Lecturer: SAO* Faculty</p> <ul style="list-style-type: none"> ▶ Define a health system ▶ Describe the need for global surgery† ▶ Overview of the key concepts around surgical capacity, domains of a health system and prevalent challenges <p>‘The Need for Surgery in (country)’ Lecturer: SAO* Faculty</p> <ul style="list-style-type: none"> ▶ Contextualise the national and local challenges ▶ Discuss rural versus urban setting challenges in surgical care 	<p>‘Why Innovate for Impact?’ Lecturer: any suitable</p> <ul style="list-style-type: none"> ▶ Define meaningful impact ▶ Provide examples of solutions that have uplifted communities ▶ Frame resource constraints as opportunities <p>‘How We Built _____’ (Case Study) Lecturer: invited business/start-up leader</p> <ul style="list-style-type: none"> ▶ Presentation on how this leader moved from prototyping to implementation ▶ Emphasis on how the individual navigated the local contexts 	<p>‘What is Innovation?’ Lecturer: entrepreneur in healthcare</p> <ul style="list-style-type: none"> ▶ Define the innovation process ▶ Introduce emerging trends and challenges in healthcare innovation in the country ▶ Discuss digital health and material science <p>‘Applying the Innovation Process to a Challenge’ (Case Study) Lecturer: faculty and/or entrepreneur</p> <ul style="list-style-type: none"> ▶ Discuss how a team moved from problem to solution ▶ Interactive question and answer session that focuses on resource optimisation

*Surgeon, anaesthesiologist or obstetrician.

†Source: Meara, *et al.*¹

the academic environment—including interdisciplinary collaboration and the generation of intellectual property.¹⁶ The surgathon model encourages those solutions that add meaningful value within a low-resource context in the long term.

The ethics pillar pushes for the empowerment of local individuals, the institution and the greater community to the forefront of all engagement. Ethics are uniquely incorporated in the surgathon model as its principles guide decision-making to ensure that power remains within and for low-resource academic centres and their communities.^{17 18} Values such as universal participation and the equitable flow of knowledge dampen a tendency in health hackathons to solve a problem without consideration to local needs and impact.¹⁹

IN PRACTICE

The surgathon model described in this manuscript has been demonstrated with over 1598 medical, engineering and business student participants and 153 faculty members across three institutions in India and Rwanda over the last 4 years. The model was initially led by a core group from the Programme in Global Surgery and Social Change at Harvard Medical School and Boston Children's Hospital, in collaboration with students, residents and faculty from Karunya Institute of Technology and Sciences, Saveetha Institute of Technical and Medical Sciences, University of Rwanda and InciSioN, the International Student Surgical Network. Six surgathons occurred between 2016 and 2019, each run by local faculty or students who facilitated lectures and sourced problem statements for a 2-day surgical innovation challenge. The surgathon follows a 10-step schedule: registration and event kick-off, introduction talks, keynote speaker presentations, pitching workshop, problem statements released, team formation, hacking, practice pitches, final presentation and prizes awarding. In our experience, the average surgathon involved 150 students, 10 problem statements and 14 total teams of 5–7 multidisciplinary students. Awards were given to the best ideas and the judging was constructive and transparent with the goal of maximising the teams' collective learning. The judging panels at surgathons included professionals in surgery, engineering, computer science and business who were locally based. The fivefold judging criteria to determine the winner hinged on the value of the solution for impact, sustainability, equity, applicability, and feasibility (table 2).

Pursuing student ideas and evaluating their implementation past the surgathons continues to be an active effort in India and Rwanda. Our team's experiences in India are with universities located in both rural and semiurban Tamil Nadu. Initially, a collaboration was formed with a faculty member who was interested, and with institutional support, they went on to establish an innovation centre at the university. To provide sustainable growth of the innovation centre, four medical and engineering students and five academic-surgeons were identified as a local leadership team, managing the vision and execution of

two surgathons between 2017 and 2019. Team members from high-resource institutions assisted with activities and workshops for each surgathon (table 3). Three 1-day surgical innovation workshops for an average of 300 students additionally occurred in between surgathons in India. These follow-up events encouraged ongoing engagement from the local community and helped establish the centre as a permanent resource in the eyes of local stakeholders and partners. Didactic lectures, invited speakers and previous surgathon winners were included, giving students an opportunity to show their progress to mentors and funding partners at the workshops.

In Rwanda, a partnership stemmed from the organisation InciSioN. InciSioN involves more than 5000 medical students and public health students, residents and young doctors in the fields of surgery, anaesthesia and obstetrics around the world. The two national coordinators for InciSioN Rwanda were cognizant of the technological advances that could be applied to strengthen a country's existing gaps in surgical education and surgical care. So, they chose to champion three surgathons between 2018 and 2019. Local and international faculty members were invited to join Rwanda's surgathons to deliver sessions, give talks and assist in mentorship for the purpose of growing a local surgical innovation ecosystem. Several public and private stakeholders took part in supporting, financing and contributing to the surgathons.

Surgathons in India focused on highlighting unsolved challenges for underserved rural communities²⁰ while in Rwanda, problem statements were broader, and sourced from local medical trainees. The initial objectives of both the Indian and Rwandan surgathons were facilitating multidisciplinary partnerships, as well as connecting students, faculty and local businesses to tackle surgical challenges. The surgical innovation centres in India thus far have been instrumental in providing a home for solution-making efforts and uniting partners, mentorship and funding bodies under one banner. Across Rwanda and India, a total of nine winning solutions have been developed by teams beyond the surgathons, three of which are currently undergoing a local patent review process and one of which has successfully secured a patent (table 4). The patented solution is a mouth blowing gesture-based communication and actuator system for paralytic patients. In the patent publication, the innovator describes how they first pitched their idea at a surgathon and then worked with faculty over the following year to create a prototype. The communication system is low-cost, built using locally available materials and intended to address a pressing patient challenge in the local health system—qualities that demonstrate how the surgathon model can materialise ethical and sustainable innovation.

THE IMPACT

The surgathon model can be a catalyst in developing a vibrant local innovation ecosystem in low-resource settings

Table 2 Judging criteria of a surgathon

Presentation						
Team members demonstrate cohesion and effort						
<i>Not polished</i>	1	2	3	4	5	<i>Clearly polished</i>
Creativity and ingenuity of the idea						
<i>Not a unique solution</i>	1	2	3	4	5	<i>A unique solution</i>
Story of the team moving from problem to solution						
<i>Unclear progression</i>	1	2	3	4	5	<i>Clear progression</i>
Applicability						
What is the problem, and why is it important?						
<i>Not well described</i>	1	2	3	4	5	<i>Clearly described</i>
Ability to articulate pain point(s) around the problem.						
<i>Unable to articulate</i>	1	2	3	4	5	<i>Well-articulated</i>
Clearly defined use-case that matches articulated pain points.						
<i>No use-case</i>	1	2	3	4	5	<i>Clearly defined</i>
Sustainability						
Plans for a beta version are clearly laid out						
<i>No plans</i>	1	2	3	4	5	<i>Clearly laid out</i>
Path to market						
<i>No path</i>	1	2	3	4	5	<i>Clear path</i>
Business model/scalability/distribution						
<i>No model</i>	1	2	3	4	5	<i>Clear model</i>
Feasibility						
Solution provided is technically sound						
<i>Major technical flaws</i>	1	2	3	4	5	<i>Technically sound</i>
Team identified next steps to take						
<i>None identified</i>	1	2	3	4	5	<i>Identified next steps</i>
Feasibility of implementation in the local health system						
<i>Unfeasible</i>	1	2	3	4	5	<i>Very Feasible</i>
Equity						
Solution positively impacts individuals, institutions and/or the community						
<i>No impact</i>	1	2	3	4	5	<i>Strong Impact</i>
Solution harnesses local resources and capacities						
<i>Does not use local resources</i>	1	2	3	4	5	<i>Uses resources</i>
Solution has a perceived meaningful value						
<i>No perceived value</i>	1	2	3	4	5	<i>Strong perceived value</i>
Impact						
Positive economic impact on individuals, institutions and community						
<i>No impact</i>	1	2	3	4	5	<i>Strong, positive impact</i>
Wellness impact on individuals, institutions and community						
<i>No impact</i>	1	2	3	4	5	<i>Strong, positive impact</i>

around surgical care delivery. We found that the collaboration of multidisciplinary individuals around challenges related to surgical care not only empowered them but also enabled an institutional shift in focus and identification of talent and internal knowledge. Ultimately, some ideas from surgathons will evolve to potential solutions that can result in social and economic partnerships that address both the local and global needs in surgery. However, the

development of solutions should not be the initial metric for determining success or worthiness of the model. Value should be given to the ability to break down social and professional barriers and to encourage collaboration and consultation across disciplines for a local health challenge. This is only possible through the experiential learning format of innovation challenges such as a surgathon as they facilitate collective learning and creation

Table 3 Suggested activities/workshops for a surgathon

Suggested activity	Pitching your idea Leader: suitable faculty member	'The marshmallow challenge' Leader: any suitable	Design thinking workshop Leader: faculty member or invited guest
Description	Volunteer students practice three types of pitching: 1. Themed: pitch a product, service or concept 2. Speed: pitch in 2 min, 1 min or 30 s 3. Style: speak with a logical, emotional or persuasive tone	Teams of 6–7 work on this specific challenge involving height and a marshmallow with constrained resources and time	A discussion-based workshop on the core principles of design thinking and solution-making with an audience in mind
Intended outcome	Encourages students to condense their ideas into an impactful narrative. Skills in public speaking and communication directly apply to entrepreneurship	Learn about internal team dynamics and practice adopting 'out of the box' thinking when faced with a challenge	Motivate students to think about how to frame their problem and understanding the human behaviour that drives it

for the purpose of targeted problem solving.²¹ Surgathons have encouraged low-resource setting academic institutions to make curriculum changes so that students have time and money to pursue innovation. We have observed that as partnerships with the local private sector became stronger, the institution took tangible steps to help students develop solutions past the surgathons. If the surgathon model is to be propagated to create a surgical innovation ecosystem, and impact local patients, it is crucial that low-resource setting institutions build structured mentorship, partnership or funding mechanisms for interested faculty and students. We are actively working to capture and analyse the detailed outcomes of

our collective experiences to help facilitate this next step of the surgathon model.

The surgathon model is challenging to implement as it involves multiple stages in collaboration and local adoption. Key challenges include the time and resources required to develop relationships and trust, gaining institutional participation and navigating perceived barriers regarding the role of innovation. In addition, patience is required from those accompanying institutions if it is to be led by local champions, as there are a multitude of factors that can lead to delays and changes. A humble, learning posture is required if the aim is to develop a local surgical innovation ecosystem that is driven by local needs and priorities. The surgathon model outlines that an ethical approach can help address and prevent biases and power dynamics that may occur when well-funded and well-resourced global health teams engage in low-resource settings.²² The potential pitfalls we particularly try to mitigate include the influence of finances, status and research capacity, to name a few, on institutions as they collaborate with one another internationally. A focus on grass-roots level sustainable development and local resource optimisation translates the ethical approach to ethical action.

By engaging and accompanying local universities in surgathons, it is our hope that sustainable surgical innovation ecosystems are seeded within local health systems. If we can create the space and impetus for students from all disciplines to collaborate for a common goal with faculty, clinicians, policymakers, businesses, then we may empower them to find their roles in advancing their communities for improved surgical care and health for all.

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Table 4 Overview of the surgathon model conducted in India and Rwanda between 2016 and 2019

Category	Total
Local faculty attendees	153
Local student attendees	1598
One-day workshops	3
One-day workshop attendees	908
Surgathons	6
Surgathon participants	690
Teams formed	54
Problem statements presented	52
Winning solutions	25
Digital	10
Hardware	6
Digital and hardware combined	6
Process innovation	3
Solution developed post-surgathon	9
Patent pending	3
Patented	1

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Contributors SM compiled the manuscript and collaborated with local partners for the India surgathons. JA contributed key ideas and collaborated with local partners for the Rwanda surgathons. AM and IN executed surgathons at the University of Rwanda. IW, VS and AP worked on India surgathons through planning, partnerships and lectures. DV contributed to the Rwanda and India surgathons. OJ patented an innovation ideated during a surgathon. JG directed surgathons at Karunya University. PG executed a surgathon at Saveetha University. SA served as supervising faculty member for the surgathon model in conceptualization and in practice.

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