Review Article

Metrics without borders: advancing the global surgery agenda through data

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Abstract: The field of global surgery has matured significantly and asserted itself as a critical constituent in the landscape of global health. Various initiatives and resolutions hallmark recent momentum, summarize agenda items, and chart a path towards maximizing the impact of surgical services in healthcare systems worldwide. We appraise the global surgery literature and emphasize the role of data in propelling the field into its current space. We use three case studies to demonstrate that current global surgery data enterprises are best understood as a series of processes and practices and not merely as a summary of statistical methodologies and outcomes. First, the rapid dissemination and timely success of the COVIDSurg Project displays the utility of web-based platforms in sustaining far-reaching collaborations. Second, the iterative adoption of standardized global surgery metrics at the World Health Organization and World Bank tells the story of political integration into the broader universe of global health. Third, the early monitoring and evaluation of the World Health Organization's Surgical Safety Checklist demonstrates the central role of implementation science in taking interventions to scale. Taken together, these case studies exemplify how research prioritization, data collection, data analysis, and outcomes reporting represent windows of opportunity to advance the global surgery's reach. This perspective allows us to consider critical advances in technology and health policy in the machinery of knowledge production and how data platforms will promote an agenda of collaboration, integration, and implementation in the 21st century.

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Introduction

The field of global surgery has coalesced into a mature discipline with a far-reaching agenda in global health. According to Jim Kim, speaking as President of the World Bank in 2014, "surgery is an indivisible, indispensable part of health care" (1). The Lancet Commission on Global Surgery (LCoGS) asserted that the impact of global surgery is maximized when "surgical and anesthesia care is available, accessible, safe, timely, and affordable" (1). At the 68th World Health Assembly (WHA) in 2015, all member states of the World Health Organization (WHO) unanimously passed Resolution 68/15, which aimed to "(strengthen) emergency and essential surgical care and anesthesia as a component of universal health coverage" (2). Awareness is growing that more than half a dozen of the sustainable

development goals (SDGs) will not be achievable without surgical and anesthesia care (3,4). In order to realize its full potential, the global surgery agenda for the 21st century spans the entire spectrum of health care provision, administration, research, advocacy, and policymaking.

Data play a central role as a catalyst for change in this golden era of global surgery. Months after WHA Resolution 68.15 called for "meaningful and reliable measures" of surgical care, 13 countries in the Pacific Region mobilized to report four of the six standardized LCoGS metrics; since then, others have followed suit (5-7). As context to the significance of this achievement, of all United Nations member states currently 80% report surgical, anesthesia, and obstetric provider densities, 37% report volume of surgery per 100,000, 10% report timely access to surgery, and 5% report post-operative mortality rate (8). Furthermore, Ministries of Health of 40 countries are embedding these metrics into National Surgical, Obstetric, and Anesthesia Plans (NSOAPs) in order to identify local deficiencies and priorities pertinent to surgical care (9-12). Novel systems of information management are being constructed around the world to accommodate these data and facilitate their translation into action at the policy level.

Global surgery data have not always enjoyed a privileged position in global health. Recent systematic reviews of available literature between 1987 and 2017 by Sgro *et al.* and Pauyo *et al.* demonstrate a tenacious academic research community in the face of great odds (13,14). Global surgery research is published in over 500 peer-reviewed journals and shows an exponential growth rate despite 82% of studies being completely unfunded. This is representative of longstanding neglect of surgery in the funding of global health research (15,16). Under these conditions, the scope of projects is constrained in various ways. 89% of primary research is observational, consisting predominately of case reports and case series, connoting overall poor quality of evidence (13,14). A significant proportion of this literature (43%) lacked any outcome measures at all. 60% of articles were authored by researchers from a single country, contradicting the notion of collaborative networks and shared responsibility. This is especially worrisome since 24% of manuscripts describing research in low and Middle-income countries (LMICs) were authored exclusively by members of high-income countries (HICs), recapitulating colonial hierarchies of global health (17-19). Despite numerous ongoing challenges, data enterprises in global surgery have succeeded in gathering sufficient momentum for a seat at the table of global health metrics.

The modern appetite for global health data is tied fundamentally to the rise of large-scale initiatives (20). Data can provide critical information to all stakeholders that endeavor to maximize longevity and quality of life (21). The first international gatherings on the topic of public health were the International Sanitary Conferences aimed to control infectious diseases such as yellow fever, cholera, and plague. Participation from 12 European nation-states in 1851 established norms of engagement for more than a century to follow, including the ultimate formation of the WHO in 1946 (22). As scientific advancement led to the ability to treat and even prevent these contagions, the metrics of incidence, mortality, and the delivery of vaccinations became key drivers of funding, collaboration, resource allocation, and monitoring. For example, these metrics played a key role in the ability of the WHO's smallpox vaccination campaign in 1958 to successfully eradicate the disease by 1980. Yet early successes of this type of vertical campaign (targeting a single disease) belied the challenges inherent in the current era's cross-cutting SDGs (23). In 2015, 17 SDGs were adopted by 193 countries with 169 discrete targets and 230 health indicators. Overburdened with the scope of this data enterprise, countries began depending on non-governmental (often foreign) research groups and multilateral partnerships to gather, analyze, and report their data (24-28). This transition from state-based ownership and production of data to nongovernmental entities who often complement state-based data with data from other sources (termed 'data pluralism') marks a recent change wherein countries no longer hold a monopoly on health data of citizens (27).

The appetite for data in global surgery also rose on the waves of successive large-scale initiatives. Near the time smallpox was eradicated, vertical interventions also formed the backbone of global surgery, evidenced by the founding of Mercy Ships in 1978 and of Operation Smile in 1984 (29). The Declaration of Alma Ata shifted the focus in global health towards horizontal interventions that aligned with universal access to primary health care and subsequently the WHO launched the Global Initiative for Emergency and Essential Surgical Care (GIEESC) to address the unmet surgical burden in LMICs. A first step in assessing and monitoring surgical capacity and infrastructure was the WHO Situational Analysis Tool (30). Between 2007–2011 this survey was implemented in 35 countries to register

infrastructure, human resources, procedures, equipment, and supplies at district hospitals. Data were entered into the Emergency and Essential Surgical Care Global Database, the first centralized repository of standardized surgical information at the WHO. Later, as part of the WHO's Patient Safety Alliance, the Safe Surgery Saves Lives campaign was launched and produced the first global estimates of procedure volume, incidence of preventable perioperative errors, and distribution of safe operating rooms (31-33). In 2015, in preparation for monitoring and evaluation of SDGs, the WHA Resolution 68/15 called for the adoption of standardized surgical metrics including population-level surgical registries and risk-adjusted perioperative outcomes, neither of which has reached completion at the time of this article (2). As these datasets come to fruition the future of global surgery is bright with possibilities.

A thorough exploration of data and their effect on the global surgery agenda must begin with the acknowledgement that data are intrinsically tied to the institutions and processes that produce them. The life cycle of data includes multiple entry points for influence, namely: research prioritization, funding, data acquisition, data analysis, dissemination of results, and consumption.

Key questions remain in the global health data universe and are especially pertinent for data in global surgery, such as: 'Who should be the custodians of health data?" "How do we ensure that research prioritization and funding match the needs that patients and providers experience in diverse settings?" "How do we rapidly increase capacity of local expertise in data management and facilitate iterative shared learning in the development of information technology platforms?" "How do we ensure that data outputs are useful to both high-level policymakers and practitioners in District Hospitals?" "How do we eliminate the data gaps between technocratic modeling exercises and primary data collection?" "What is the optimal mechanism to hold governments and non-governmental organizations accountable for research integrity, transparency, and outcomes?" (34) "What role should non-governmental constituents play in complementing state-based data collection and interpretation of results?" "How might a pluralistic view of data sources augment existing metrics?" While answering each of these questions is outside the scope of a single manuscript, we present the following case studies to exhibit how data enterprises will be at the core of advancing an agenda of collaboration, integration, and implementation in the 21st century.

Collaboration

On December 31, 2019, China's WHO Country Office received notification of the first case of a novel coronavirus. Seventy days later, global cases of this novel coronavirus surpassed 118,000 in 114 countries and claimed 4,291 lives, prompting the WHO Director General to declare a global pandemic (35). Amongst healthcare workers, surgical teams were found to be at especially high risk for infection with reported deaths (36). However, initial clinical reports from Wuhan and Italy largely neglected discussion of surgical systems, surgical providers, and surgical patients (37-42). Innumerable questions arose for surgical teams worldwide, most principal among them: "how can we protect ourselves and our patients from becoming vectors of disease transmission?" and "what is the calculated risk of postoperative morbidity and mortality if a patient with coronavirus undergoes an operation?" To answer the former question, surgical societies published guidelines for personal protective equipment and safety protocols. For the latter question, the challenges of a novel coronavirus constituted a real-time test of how nimble the global surgery data enterprise could collaborate in response to an urgent threat. How can we gather evidence, analyze representative data, and disseminate results in order to inform decision-making by policymakers and providers on the front lines? The stakes could not be higher for this exercise in data management.

On March 14, 2020, three days after the WHO declared the pandemic, the GlobalSurg group launched a novel COVIDSurg collaboration via Twitter (43). Within 3 days of tweeting, over 800 surgeons from 80 countries registered to participate in an original study of postoperative outcomes (44). By March 31st, the COVIDSurg working group published the first COVIDSurg newsletter online, reporting participation of 2,836 collaborators from 231 hospitals across 115 countries (45). Using Research Electronic Data Capture (REDCap) software, a data gathering tool created by Vanderbilt University in 2004 (46), data from patients across the globe were collected for analysis. The rapid dissemination of study information via the internet along with the capability to collect data through web-based tools resulted in timely production of results. In late May 2020, the first manuscript describing outcomes of surgical patients with SARS-CoV-2 infection was published in the *Lancet* (47).

The study found that over 50% of patients with SARS-CoV-2 undergoing surgery had pulmonary complications, providing necessary evidence to justify the precautions that hospitals created to postpone elective surgeries to mitigate risk (47). Currently with over 40,000 patients from 1,000 hospitals, the COVIDSurg database continues to grow in hopes of providing more answers to the global surgery community (48). For example, cancer care has been disrupted significantly with widespread cancellations in 'elective' surgeries and many patients and providers are hard-pressed to delay extirpative surgery. The COVIDSurg group will publish a subset analysis of patients with cancer to elucidate the outcomes of elective cancer surgery across various subspecialties during the COVID-19 pandemic (48). Each of these and future studies adds immediate value to surgical and anesthesia teams while also providing evidence to guide decision-making by hospital administrators and policymakers.

The COVIDSurg project demonstrates that innovative data platforms and communication modalities can accelerate the pace of global surgery collaborations with timely, tangible results. It is worth noting that collaborations of this sort were built on a decade of successful development of online presence and web-based research tools. Over the last ten years the GlobalSurg group has successfully recruited thousands of patients from countries of all income levels to evaluate postoperative mortality and surgical site infections (49-51). Thirty years ago these data platforms did not exist, but with near certainty these models will be a component of our future.

Integration

Global surgery has long-been plagued by the challenge of integrating into the broader community of global health. Despite a rich history of surgical missions and the WHO's GIEESC program to address unmet need in underserved areas of the world, clinical data from early initiatives in surgery were neither standardized nor centralized. Meanwhile, the global health community increasingly relied on the Global Burden of Disease (GBD) project to allocate resources and prioritize targets. However, although the GBD currently reports the burden of 354 disease causes in 195 countries—making it the largest dataset of disease burden ever published—it neglected to collect any data on how often these diseases require surgery (25,52). Because surgery did not fit into the increasingly relied-upon GBD framework, it remained invisible to the global health community, earning it the moniker of 'neglected stepchild' and 'Cinderella' of global health (53). Only recently have surgical data been incorporated into large-scale initiatives to bring the field into the view of global public health.

Two major successes encapsulate the struggle and ultimate success of integrating global surgery data into prioritization frameworks of global health. The first is the Disease Control Priorities (DCP) project, an immense undertaking of over 500 scholars, policymakers, and technical experts detailing the burden and economic valuation of priority areas in global health (54). The DCP1 (1st edition) was published in 1993 and omitted any quantification of surgical burden. The DCP2 was published in 2006 and included one chapter (of 73 total chapters) discussing surgical burden. In the absence of primary data, this chapter surveyed a handful of surgical providers to identify disease categories frequently requiring surgery and estimated that 11% of global disability-adjusted life years (DALYs) could be treated with surgery. DCP3 was published in 2015 and consisted of nine volumes, the first of which was dedicated entirely to surgery (55). This third edition includes descriptions of global burden, packages of surgical interventions, cost-effectiveness analyses, guidance for policymakers, and the economic implications of surgery. The steady increase in surgical content from DCP1 to DCP3 marks the increase in visibility of global surgery.

The second example is the adoption of standardized metrics as a component of routine monitoring and evaluation of healthcare systems. As recently as 2009, 70% of countries had no information regarding the frequency of surgical procedures (56). The WHO's Safe Surgery Saves Lives campaign recommended a suite of six metrics for surveillance based on the Donabedian model of structures (volume of anesthesia and surgical providers, volume of operating theaters), processes (ratio of procedures per operating room), and outcomes (day-of-surgery mortality, and in-hospital post-operative mortality) (56). These metrics were formally adopted in the WHO Guidelines for Safe Surgery but dissemination was limited (57). In 2015, the Lancet Commission on Global Surgery (LCoGS) recommended a second iteration of six metrics: surgery-anesthesia-obstetrics (SAO) provider densities, timely access (within 2 hours), procedure volume density, post-operative mortality, catastrophic expenditures, and impoverishing expenditures (1). The WHO adopted timely access, volume density, and waiting time for elective surgery into the 100 Core Health Indicators (58). The World Bank adopted SAO densities, procedure volume, catastrophic expenditures, and

impoverishing expenditures into the World Development Indicators (59). These recent actions implant global surgery metrics into the machinery of monitoring and evaluation of health systems strengthening.

The integration of global surgery metrics into the existing universe of data in global health recapitulates the central role of surgery in the era of sustainable development. Beyond the DCP3, SSSL campaign, and LCoGS, 15 surgical metrics are now woven into the various arms of data collection machinery at the WHO (60). Additionally, the World Health Assembly confirms that the goals of global surgery dovetail with the goals of health systems strengthening, namely for the following Resolutions: WHA67.19 on strengthening palliative care, WHA67.25 on antimicrobial resistance, WHA66.10 on the prevention and control of non-communicable diseases, WHA64.6 on health workforce strengthening, WHA60.22 on emergency health systems, WHA58.23 on prevention and rehabilitation after disability, WHA56.24 on violence and health, WHA 57.10 on road safety, and WHA55.18 on quality of care and patient safety (2). The adoption of global surgery metrics marks a transition away from an orphaned past into a future of incorporation and partnership.

Implementation

Five billion people lack access to surgical care (61). Data and evidence for the efficacy of specific interventions, while indispensable, are not sufficient. This is because when evidence-based interventions (EBIs) are moved from the relative vacuum of a controlled study environment to real practice, the promising outcomes demonstrated in these studies are not necessarily replicated. The valley between the identification and successful implementation of EBIs is vast, so much so that the WHO has described the task of surmounting this valley as "one of the greatest challenges facing the global health community" (62). Similar sentiments have been expressed for the difficulties of translating known "best practice" into routine practice for surgical care (63,64). The rapidly expanding and maturing field of implementation science, which the National Institutes of Health (NIH) defines as "the study of methods to promote the adoption and integration of evidence-based practices, interventions, and policies into routine health care and public health settings to improve the impact on population health", has been identified as a means of addressing this valley (62,65). The global surgery agenda, specifically the scaling up of safe, high quality, and affordable surgical care, cannot be achieved without the tools and methodologies of implementation science.

The Surgical Safety Checklist (SSC) illustrates how implementation frameworks, outcomes, and strategies can be leveraged to improve the efficacy of implementation efforts in global surgery. The WHOs Safe Surgery Saves Lives campaign published this 19-item surgical checklist that the in 2008 (66) and demonstrated dramatic reductions in morbidity and mortality after implementing the checklist in eight hospitals from eight different countries (67). Although its use became widespread, subsequent studies demonstrated varying rates of success (68-70). This led to debates regarding whether this was a reflection of limitations in the effectiveness of the SSC itself or of limitations in implementation (71,72).

This question of intervention effectiveness versus implementation effectiveness can be interrogated through implementation research (64). First, the researcher must identify an implementation framework. For example, due to several reports of limited improvement in surgical outcomes that may have been attributed to unsuccessful implementation of the SSC, White *et al.* chose the Consolidated Framework for Implementation Research (CFIR) to guide a mixed-methods study of the approach and evaluation of the SSC in 36 hospitals in Benin (73). CFIR, one of the most frequently used frameworks, includes five domains to consider and 37 corresponding constructs consolidated from known existing implementation theories (74). Next, guided by CFIR, White *et al.* identified an implementation strategy—multidisciplinary trainings—and measured seven of Proctor's eight implementation outcomes (73). They found improvements in all measured implementation outcomes (73), and their success in nationwide checklist implementation serves as an example of how to apply and leverage the frameworks, strategies, and outcomes of implementation science.

In another example, Hannam *et al.* demonstrated drastic differences in checklist compliance between one of the eight hospitals that was a WHO pilot study center and a neighboring hospital that independently introduced the SSC; they concluded that the benefits of SSC cannot be achieved with adoption alone, but rather requires careful attention to "implementation process factors" (69). Later, Mayer *et al.* demonstrated that compliance was associated with reduction in postoperative complications, suggesting that the benefits of the SSC that Haynes *et al.* initially reported are influenced by successes or failures in implementation (75). In these two studies, Hannam

and Mayer's outcome of interest was compliance with administration of the SSC. This falls into Proctor's taxonomy of implementation outcomes as fidelity, which is defined as "the degree to which an intervention was implemented as it was prescribed in the original protocol" (76). With the implementation outcome identified, one can select and tailor implementation strategies that target the implementation outcome (e.g., educational or training strategies can be used to target fidelity) (77). Putman *et al.* demonstrate this principle: reporting improved compliance after employing a series of strategies including safety workshops, stakeholder-driven modifications to the checklist, and a report card system (78).

This case study of the SSC illustrates how the frameworks, strategies, and outcomes of implementation science can and should be used to advance the agenda of global surgery. They highlight that for successes to be achieved, both the intervention and the implementation must be data-driven and guided by strong theoretical underpinnings. Without the latter, our attempts to scale up surgical EBIs into clinical practice will only be "an expensive version of trial-and-error" (79). Of note, there are numerous other examples of EBIs (i.e., pulse oximetry, blood banks, etc.) and systems level interventions (i.e., NSOAPs) that illustrate the contributions of implementation science and the related disciplines of dissemination science and participatory action research (10,11,80-83). Leveraging implementation science to generate data that guide evidence-based implementation can substantially advance the agenda of global surgery.

Conclusions

The agenda of global surgery is fundamentally linked to the pursuit of health equity with a special emphasis on underserved populations (84). Critical advances in technology, methodology, and health policy have accelerated the pace at which these goals can be pursued. The case studies of the COVIDSurg Project, the LCoGS standardized metrics, and the WHO Surgical Safety Checklist demonstrate how the processes and politics of research prioritization, data collection, data analysis, and outcomes reporting represent windows of opportunity to elevate the visibility of global surgery and maximize its impact. Each of these examples offer a template to pursue a future that looks difference than the past. Our capacity to wield these evolving data enterprises will promote an agenda of collaboration, integration, and implementation in the 21st century.

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