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Global surgery: The next Frontier in global public health

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Global surgery: The next Frontier in global public health

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Editorial: Global surgery: the next Frontier in global public health

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Editorial on the Research Topic
Global surgery: the next Frontier in global public health

The delivery of surgical care globally represents the challenging nexus of colliding worlds in healthcare—public health, public finance, education, innovation, policy, and technology. Significant gains in controlling infectious diseases have been the banner of success of the public health world; but ecological changes with globalization, overpopulation, demographic shifts of an aging population facing an increasingly industrialized society, and more recently, the devastating effects of climate change and pandemics have awakened the community on the need to address the oft neglected issues such as health systems strengthening at the local and national level. Global surgery, in particular, has surfaced as a distinct area of work in the last 8 years. But what is Global Surgery? How and who has defined its limits?

It was with these questions that we launched this series, issuing a call for substantive work not only to reflect current paradigms and models on the ground but also to practically guide any stakeholder in designing further systems of change one wishes to undertake. And we were not disappointed. From this Research Topic we see a transition from an era of describing the scope and magnitude of need, to now piloting and implementing new systemic changes to increase quality and access to safe surgery. As we have called for systems change efforts, we now present findings in three major areas of work that we have identified previously (Henry et al.): addressing surgical site infections, including antimicrobial resistance (Khalid et al.; Naylor et al.; Liu et al.), maternal health (Sufian et al.; Negesse and Abebe; Dohmen et al.; Adugna et al.), and trauma care (Heris et al.; Du et al.). We also received insight into the development of subspecialty services such as pediatric surgery in Malawi (Monaghan et al.), and the impact of COVID on a pediatric cardiac service in South Africa (Aldersley et al.). Lastly, we present strong messages from important stakeholders that no change can happen without local leaders driving the agenda at the district level (Pittalis et al.) and showcase the largest regional action plan involving 32 countries in Sub-Saharan Africa dedicated toward strengthening surgical, obstetric, trauma, and anesthesia care in the region, driven by local leaders (M'pele et al.).

Albeit representing only a minute fraction of the breadth of activity taking place in the world of global surgical care delivery, this Research Topic provides valuable insights on the complexity of change efforts and the culturally sensitive nuances that are necessary to understand how it takes place at the grassroots level. Moreover, it provides broad overviews of relevant issues and the gaps in literature and practice that we need to address. It also

underscores several realities: that not only are there severe deficits in infrastructure and workforce capabilities at the district level, but that what it takes to improve the quality and safety of providing care is a long and arduous process of relationship-building, teamwork, and empowerment. Indeed, Pittalis et al. demonstrated that local capacity building is the key driver to addressing barriers to surgical care at the district level in Malawi, Zambia, and Tanzania. Stakeholders in this study expressed that more training, feedback, and supervision from referral centers would help non-specialized providers practice at the highest of their capability, which would subsequently relieve bottlenecks and long patient wait times at urban tertiary care centers. Although the World Health Organization (WHO) surgical safety checklist has been shown to decrease morbidity and mortality in several well-designed studies (1), widespread adoption still remain a challenge. The mixed-methods study by Khalid et al. used a behaviorally anchored rating scale to evaluate checklist use in operating rooms in Pakistan and concluded that multi-disciplinary training is effective in improving checklist adherence across healthcare worker types. Establishment of antimicrobial stewardship (AMS) programs is another effective tool to prevent injudicious use of antibiotics and development of antimicrobial resistance, key issues in surgical care management (1). Interestingly, although Liu et al. showed that publications on AMS have risen significantly over the last few decades, most of these investigations remain centered in high-income countries. For example, Naylor et al. developed a sophisticated decision tree to estimate the burden of AMR on surgical patients using national data from England. While this tool will be helpful for other settings that are refining national surgical plans, there is still a need to contextualize the data into resource-limited settings, which stresses the importance of producing generalizable and adaptable frameworks in global surgery.

This Research Topic also addresses one of the most pressing surgical public health issues, especially in LMICs: trauma care. Evidence has shown that both pre-hospital and in-hospital capacities can significantly decrease trauma morbidity and mortality with figures noted from 25 to 47%, (2, 3) more impactful in rural communities. Heris et al. reviewed existing evidence regarding trauma-informed public health emergency responses for First Nations, or indigenous, communities, identifying the six pillars of a trauma-informed and culturally—responsive public health emergency framework that should be integrated into the provision of all emergency care. The management of major trauma has also changed globally and Du et al. demonstrated emerging trends in the management of traumatic brain injury, massive hemorrhage, and neurocritical care which highlights current research hotspots on a global scale. Lastly, best practices in maternal and perinatal health have been equally emphasized. Our topic features three studies performed in Ethiopia that range in study interest from identifying modifiable risk factors in preterm labor, to assessing factors of respectful maternity care, and evaluating birth and complications readiness in male partners. On the other hand, Dohmen et al. discuss value-based maternity care in Kenya implemented through a digital exchange platform. The interconnection of community access and national policy will continue to be the meeting point for future innovations in global surgery.

In conclusion, we hope that this Research Topic plays a role in advancing the global roadmap for affordability, access, and availability of safe surgery in LMICs. Taking a step further, we offer themes such as integration, escalation, and maturation as key strategies for implementation, adherence, and scalability of surgical systems. As such, these systems can never exist in isolation as they represent a continuum of care that begins at the community level with health-seeking behavior, continues on with intermediaries to link the patient with the healthcare system (integration) and once in the system, ensures safe and affordable care (escalation), and reintegrates the patient back to their families and communities with appropriate support and rehabilitation as necessary (maturation). By turning recommendations into clinical practice and policy, we can achieve surgical excellence through evidence-based quality improvement initiatives. Collaborative efforts driven by local leadership will be the cornerstone to producing sustainable change in global surgery.

Author contributions

JH: Conceptualization, Funding acquisition, Supervision, Validation, Writing—original draft, Writing—review and editing. L-YW: Conceptualization, Project administration, Supervision, Validation, Writing—original draft, Writing—review and editing. EA: Project administration, Supervision, Writing—review and editing. CY: Conceptualization, Project administration, Supervision, Writing—review and editing. AH: Conceptualization, Formal analysis, Project administration, Supervision, Validation, Writing—review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Antimicrobial Stewardship in Surgery: A Literature Bibliometric Analysis

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Background: Antimicrobial resistance and the dwindling antibiotic development pipeline have resulted in a looming post-antibiotic era. Research related to antimicrobial stewardship (AMS) has grown rapidly in the past decade, especially in the field of surgery. We conducted a bibliometric analysis of these publications. In addition, we aimed to identify research hotspots and infer future research trends.

Methods: We screened global publications on AMS in the surgical field over ten years (between 2011 and 2020) from the Web of Science core collection database. The keywords "antimicrobial or antibiotic", "stewardship", "management", "management strategies", "programme", "surgery" and "surgical" were used to search for related papers. VOS viewer, R software, and other machine learning and visualization tools were used to conduct the bibliometric analysis of the publications.

Results: We identified 674 publications on AMS in surgical fields; "antimicrobial stewardship" (with total link strength of 1,096) was the most frequent keyword, and had strong links to "antimicrobial resistance" and "guidelines". The top 100 most cited papers had a mean citation count of 47.21 (range: 17–1155) citations, which were cited by survey research studies, clinical trials, and observational studies. The highest-ranking and most cited journal was *Clinical Infectious Diseases* with eight publications. Jason G. Newland from Washington University wrote seven papers and was cited 1,282 times. The University of Washington published 17 papers and was cited 1,258 times, with the largest number of publications by author and organization. The USA published 198 papers and cooperated with 21 countries, mainly partnering with Italy, the UK, and Canada. Published articles mainly focused on the current clinical situation regarding surgical AMS management, antibiotic prescription, and antibiotic resistance.

Conclusions: Publications on surgical AMS management have increased in recent decades, with the USA being the most prolific. Epidemiological investigations of surgical-related infections, antibiotic prescriptions, and antibiotic resistance are fast-developing research trends. However, further improvements are still needed according to the recommendations gained from the bibliometric analysis.

Keywords: surgery, bibliometric analysis, hospital management, trend, antimicrobial stewardship (AMS)

INTRODUCTION

Antibiotics have made significant contributions to the treatment of infectious diseases. For example, sulfonamides, penicillin, and streptomycin became available in the 1930s, after which mortality due to pneumonia (then the leading cause of death) declined by approximately 30% (1). However, antimicrobial resistance due to the extensive use of antibiotics in recent decades has resulted in increased morbidity, mortality, and economic burden, and is a significant global threat. Antibiotic overuse is a growing concern, and a multifaceted approach to prevent, control, and decrease antimicrobial resistance is urgently needed.

Antimicrobial stewardship (AMS), defined as "coordinated interventions designed to improve and measure the appropriate use of antibiotics by promoting the selection of the optimal antibiotic drug regimen, including dosing, duration of therapy, and route of administration", has been widely accepted in recent decades (2). The purpose of AMS is to achieve the best clinical outcomes related to antibiotics and reduce the excessive costs caused by the irrational use of antimicrobial drugs (3). Controlling infections with antibiotics has an impact on all clinical areas, especially in the field of surgery. Prophylactic antibiotic usage and post-surgical infection treatment both play prominent roles in preventing perioperative infection such as surgical site infection (SSI) (4). As such, AMS in the surgical field is particularly important and the rational use of antibiotics across hospital admissions is viewed as a fiduciary responsibility. The National Health and Family Planning Commission (NHFPC, originally called the Ministry of Health) of China issued a "Notice on further strengthening the administration of clinical application of antibiotics" in 2015, which put forward a detailed appraisal index and formal requirements for clinical application management of antibiotics (5). Since 2016, hospital AMS management has been assessed in accordance with the aforementioned document since 2016 in China.

Bibliometrics is a quantitative tool for analyzing published literature on a specific topic via mathematical methods; it qualitatively and quantitatively describes the details of document features which include the authors of articles, the journals where the works were published, and the number of times they are later cited. It is particularly suitable for scientific publication mapping when research is numerous and fragmented over a period of time (6). The Web of Science (WoS) core database is the world's most convinced publisher-independent global citation database. It also includes the most important research publications and provides analysis tools and primary data for further analysis (7). The use of bibliometrics, based on the WoS core database, is gradually extending to all disciplines.

There have been no publications utilizing bibliometric analysis of AMS in the surgical field to date. As AMS is widely used in surgery, it is important to perform a comprehensive literature analysis to obtain more knowledge on AMS developments in surgical field based on the latest research publications. Additionally, the current status of AMS management in surgery is of major significance to the rational use of antibiotics in the future. Our former studies have finished to build a management and control mode in comprehensive hospital AMS (8), however, AMS management from surgical perspective is lacking. Therefore, we performed this study to provide a structured analysis of AMS research in the surgical field both from macroscopic and microscopic aspects, to infer future trends and identify shifts in this field.

METHODS

Research Design

We used a bibliometric method to analyze publications regarding AMS in the surgical field. The aim of using the bibliometric method is to formulate a systematic evaluation of various scientific publications to gain rudimentary knowledge of antibiotic management in hospital surgical departments. Furthermore, the analysis of our study focused on various indicators related to article influence, such as publication output and citations. Data was analyzed and visualized with network maps revealing the development of AMS over time in the surgical field.

Bibliometric Analysis

The bibliometric analysis of our study followed procedural guidelines from a previous publication (9). We focused on searching for articles in the WoS core collection database using comprehensive search strategy to cover more publications. In our study, search terms included "antimicrobial/antibiotic stewardship", "antimicrobial/antibiotic management", "antimicrobial/antibiotic management strategies", "antimicrobial/antibiotic stewardship programme" and "surgery/surgical", according to previous studies (7, 10, 11). Additionally, language was restricted to English, and document type was restricted to original articles published from January 1, 2011 to December 31, 2020.

Data Analyses

The analytical tool, VOSviewer (version 1.6.10, Leiden University, Netherlands), was used to analyze the co-authorship, co-occurrence, citation, bibliographic coupling, co-citation, and themes from each publication. For all the analyzed contents except theme and trend, we choose the full counting method, binary counting method were used for theme and trend analysis. In co-authorship analysis, the included articles were with the minimum number of 5 documents and 0 citations. In co-occurrence analysis of keywords, all keywords were included and keywords occurring over 15 times were included into the photograph. In coupling and co-citations analysis, we included documents occurring over 40 times into analysis. While title and abstract were the extracted fields for theme and trend analysis, meanwhile the minimum number of occurrences of a term was 10 and top 50 terms with highest score were selected into cluster.

The online analysis platform of literature metrology (http://webofscience.com/) was utilized to determine the national publication sum and relationship network. R software (version 3.6.1; The R Foundation, Vienna, Austria) was used for further analysis of the literature. Other unspecified cases use the default parameters.

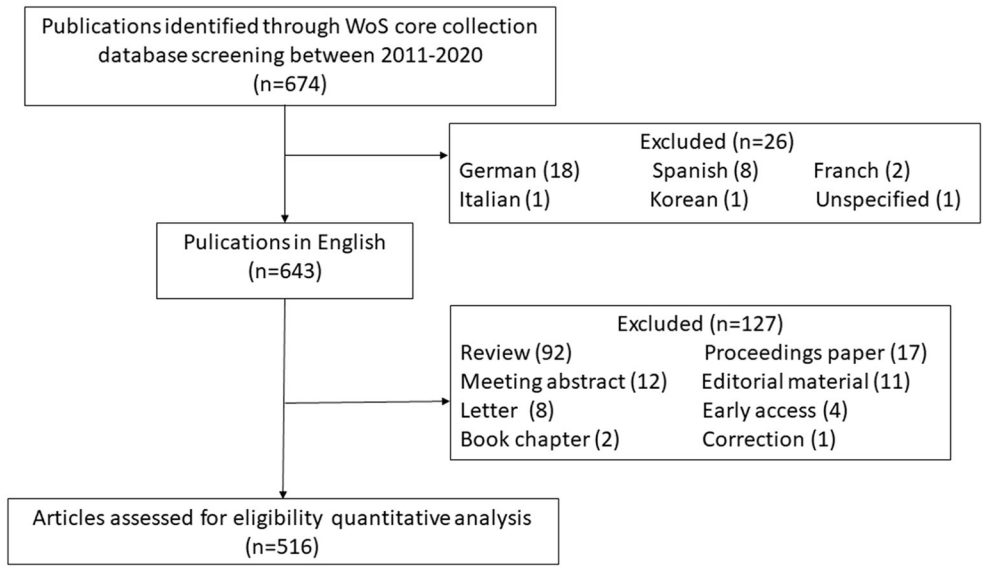

FIGURE 1 | Flow diagram of included publications. WoS, web of science.

RESULTS

Bibliometric Analysis

Two authors independently completed the retrieval strategy. Full data, including the title, authors, abstract, and keywords, were collected from publications from the WoS core collection database. **Figure 1** shows a flowchart illustrated the actions schedule.

Overview of Publications

A total of 674 publications on the topic of AMS in surgical departments were identified in the WoS database between 2011 and 2020. These publications included 544 (80.7%) articles, 87 (13.8%) reviews, 17 (2.5%) proceedings papers, 13 (1.9%) editorials, and 27 other forms of publications, including meeting abstracts, letters, and early access manuscripts. Among them, 156 (22.5%) were published in 2020, which encompassed the largest number of publications. A majority of the publications (643, 95.4%) were written in English, followed by 18 (2.7%) publications written in German and 8 (1.2%) written in Spanish. The country with the largest number of publications was the United States (253, 37.5%), followed by the UK (77, 11.4%), and Germany (63, 9.3%). In all published papers, 331 (49.1%) were open access. As show in **Figure 1**, publications were screened according to the inclusion and exclusion criteria. Finally, a total of 516 articles that were written in English, were included in the keyword analysis.

Co-authorship Analysis

A total of 3,169 authors participated in the publication of AMS related manuscripts in the surgical field. Among them, Jason G. Newland from Washington University, USA authored seven papers, which mostly focus on the impact of antimicrobial stewardship programs in children's hospitals, and is most highly cited, at 1,282 citations. The total link strength between Newland and other authors was 14. His main collaborators were Jeffrey S. Gerber from the University of Pennsylvania Perelman School of Medicine (in the USA), Adam L. Hersh from the University of Utah (Salt Lake City, USA), and Matthew P. Kronman from Washington University (USA) (**Supplementary Figure S1A**). We analyzed the manuscripts produced over time for the top 10 prolific authors. Massimo Sartelli from the Department of Surgery, Macerata Hospital, Italy was the author with the highest number of publications; he published four articles in 2018, and mainly focused on the study of surgical infections and sepsis. Herman Goossens from the Laboratory of Medical Microbiology, University of Antwerp, Belgium, had the most articles produced over time focused on antibiotic sensitivity testing. Jason G. Newland was the most cited author even with only two articles (**Figure 2A**).

According to the domestic and international literature search, it was revealed that 1,217 organizations had published relevant papers; 40 have produced more than five publications. The University of Washington, which published the largest number of related articles, had 17 related papers with 1,258 citations. Their main collaborator was the University of Utah, and most of their research mainly studied the guidelines of AMS in hospitals (link strength of 4.0). Johns Hopkins University and Children's Hospital of Philadelphia were two other important collaborators of the University of Washington (link strength of 3.0, and 3.0, respectively) (**Supplementary Figure S1B**).

A total of 73 countries have contributed to AMS research. The most productive country was the USA, with 198 publications, in which it collaborated with 21 other countries (the total link strength of the USA was 56). The USA mainly collaborated with Italy, the UK, and Canada (**Supplementary Figure S1C**). Remarkably, the UK published 64 publications and had the most collaborators (23 countries), with the strongest total link

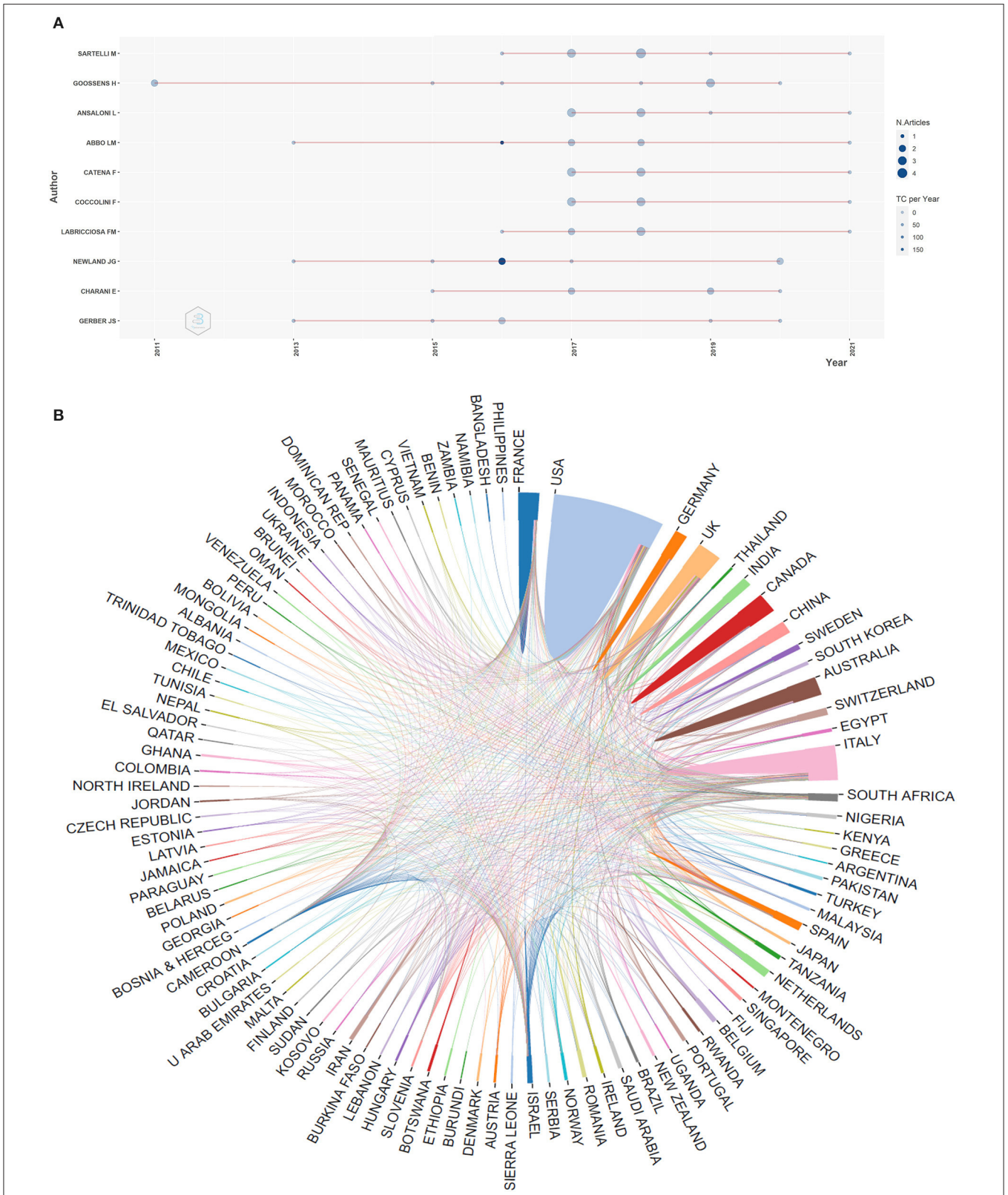

FIGURE 2 | Bibliometric analysis of authors and countries/regions. **(A)** Top 10 authors' productions over time. N. articles, Numbers of articles; TC per year, total citation per year. Among authors, Sartelli M was shortened of Massimo Sartelli, he was the author with the highest number of publications; Goossens H was shortened of Herman Goossens, he was most active author over time; Newland JG was shortened of Jason G. Newland, he was the most cited author. **(B)** Network of countries/regions cooperation. USA was the largest producer.

strength of 84. The main partners of the UK were the USA and Italy. **Figure 2B** displays the cooperative relationship among countries/regions, in which, the USA had a greater interaction with other countries. The top ten most active countries and organizations studying AMS in surgery were listed in **Table 1**.

Keywords

A total of 516 articles that were written in English, were included in the keyword analysis. Keywords in the articles were provided by the authors and those that occurred more than fifteen times in the WoS core database were enrolled in our analysis. Among 1,854 keywords, 49 keywords met the threshold. The top three most frequently used keywords were "antimicrobial stewardship" (total link strength of 693), "antimicrobial resistance" (total link strength of 410) and "guidelines" (total link strength of 396). The link strength between "antimicrobial stewardship" with "antimicrobial resistance" and "guidelines" was 55 and 56, respectively. After this, "Antibiotic prophylaxis", "risk-factors", "management", "surgical site infection" (SSI) and "impact" were the next most frequently used keywords. The total link strength of all included keywords was greater than 3000 (**Figure 3A**). Keywords that occurred more than 15 times were then used to create a word cloud (**Figure 3B**).

TABLE 1 | The top 10 most active countries, organizations of AMS in surgery publications.

Subject	Number of publications	Count of citations
Countries		
USA	198	3307
UK	64	1032
Italy	38	373
Australia	33	278
Canada	30	612
Germany	29	412
France	26	472
Peoples Republic of China	23	179
India	21	110
Switzerland	17	186
Organizations		
University of Washington	17	1258
Johns Hopkins University	13	1360
University of Toronto	11	419
University of Pennsylvania	11	198
Children's Hospital of Philadelphia	11	179
The University of Melbourne	11	123
University of Antwerp	10	269
Harvard Medical School	9	65
Karolinska Institutet	9	58
University of Utah	8	1305
Imperial College London	8	137
University of Colorado	8	106
Monash University	8	51

Citations and Publications

The top 100 most-cited articles written in English about AMS in the surgery field are shown in **Supplementary Table S1**. Most were clinical studies, including survey research, clinical trials, and observational studies. Other articles included guidelines or expert consensus publications. A majority of research articles have focused on the clinical application of antibiotics, the current situation regarding antimicrobial resistance and epidemiology, and the impact of AMS in surgical management. The studies which successfully implemented AMS and deferred antimicrobial resistance (AMR) were shown in **Supplementary Table S2**. Meanwhile, guidelines and expert consensus mostly concentrated on ways to improve the rational use of antibiotic prescriptions. The mean citation count of the top 100 most-cited articles was 47.21 (range: 17–1155). Most of the top 100 cited papers were published between 2011 and 2017; 42 of them were written by USA scholars.

A total of 190 journals have published papers on AMS in the field of surgery, and 21 of them have published more than five articles. There were 162 articles published in the top ten active journals, accounting for 31.4% of the total published papers in the WoS core database. The highest-ranking journal is *Clinical Infectious Diseases*, which had an impact factor (IF) of 9.079 in 2020, and eight papers were published in this journal during the study period. It is also the most cited journal, with 1,348 citations (**Figure 4**). The journal *Antibiotics Basel and Clinical Infectious Diseases* shared the first place of the most productive journal with 8 articles. A total of 198 papers from the USA have been cited 3,307 times, and the total link strength of this is 149 (**Figure 5**).

Coupling and Co-citations

The results of the bibliographic coupling analysis are presented in **Figure 6A**. Seven clusters with 31 documents were obtained from the document analysis. Cluster 4 (in yellow) includes four items, and its research area was the impact of antimicrobial stewardship. The representative paper in Cluster 4, published in *Clinical Infectious Diseases*, provided a guideline for implementing an antimicrobial stewardship program, with 1,109 citations and a total link strength of 46.

Three clusters were obtained from the analysis of sources that were colored in red, green, and blue (**Supplementary Figure S2A**). Four clusters of co-cited references were obtained through bibliometric analysis (**Supplementary Figure S2B**). In co-citations analysis, there were four clusters represented the source journals with different research fields: the assessment of AMS policies to reduce SSI and its endemic burden, the relationship between antibiotic prescribing practices with antimicrobial consumption or antibiotic resistance, the current status of antimicrobial use in surgical departments, and the effect of AMS management (**Figure 6B**).

In our co-cited source analysis, the largest cluster (colored in red) contained 20 items, and the representative journal were the *Clinical Infection Disease* (link strength of 21,597,972

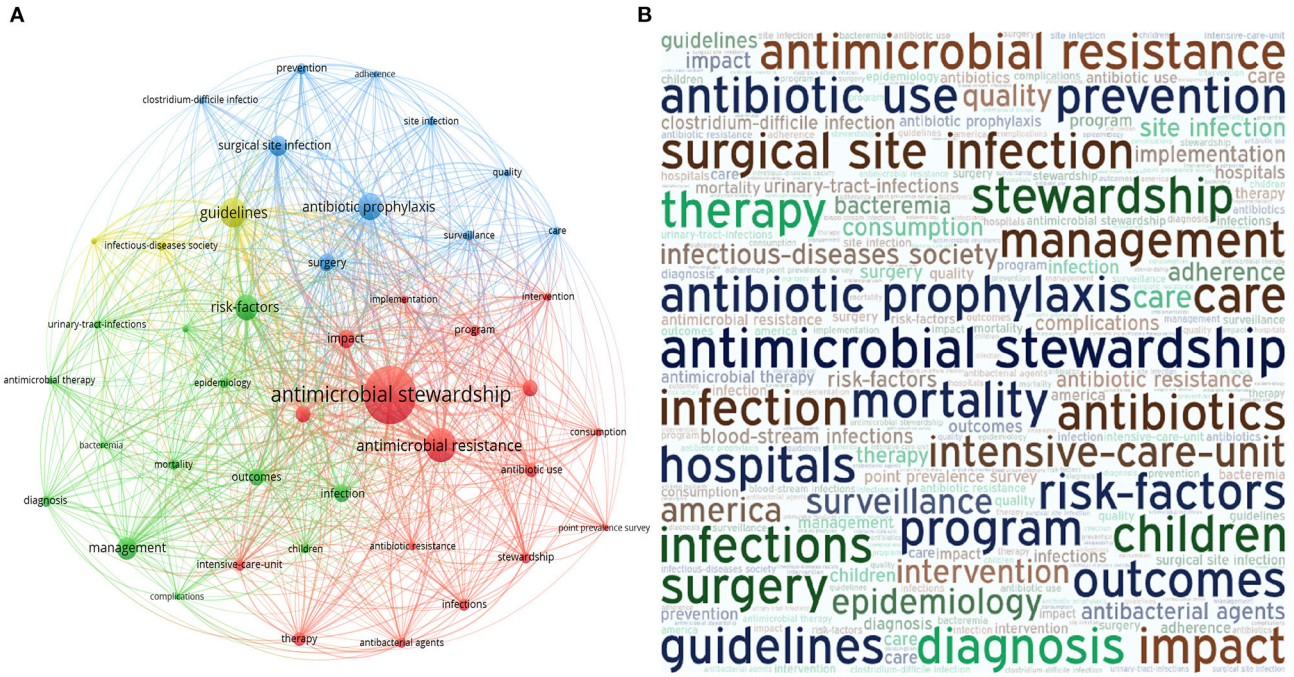

FIGURE 3 | Bibliometric analysis of the keywords in publications of AMS in surgery. **(A)** Co-occurrence of keywords. Various nodes represent the frequency of different keywords occurrences. Curves between the nodes reveal their co-occurrence in the same publication. When the greater the number of co-occurrence in two keywords, the distance between two nodes are shorter. Among all keywords, "antimicrobial stewardship" linked with 718 other keywords (total link strength: 3,137) was the most frequency keywords. **(B)** Word cloud. 49 keywords which occurred more than 15 times were enrolled. Font size indicate the frequency of keywords occurrence. "Antimicrobial stewardship", "antimicrobial resistance" occurred most frequently.

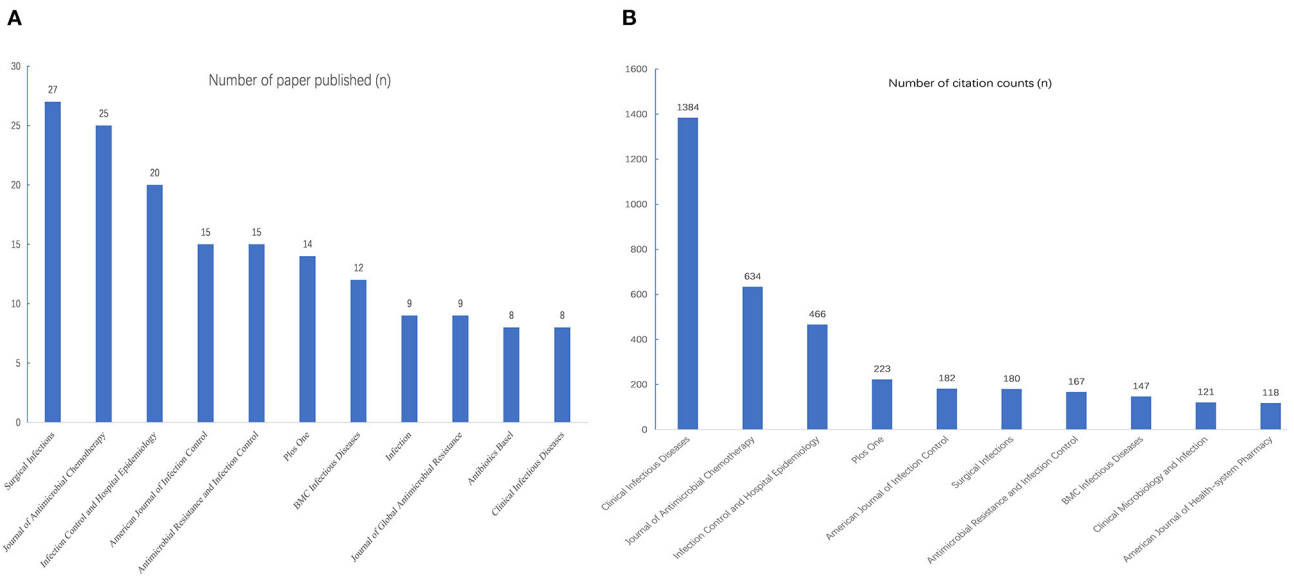

FIGURE 4 | The top ten most active journals. **(A)** The top ten journals with most-cited publications of AMS in surgery; **(B)** The top ten journals with most published papers of AMS in surgery.

citations) and *Journal of Antimicrobial Chemotherapy* (link strength of 13,580,602 citations). Although Cluster 2 (colored in blue) was contained less items (16 items), the representative journal *Infection Control and Hospital Epidemiology* (link strength of 17,573,632 citations) was highly significant cited.

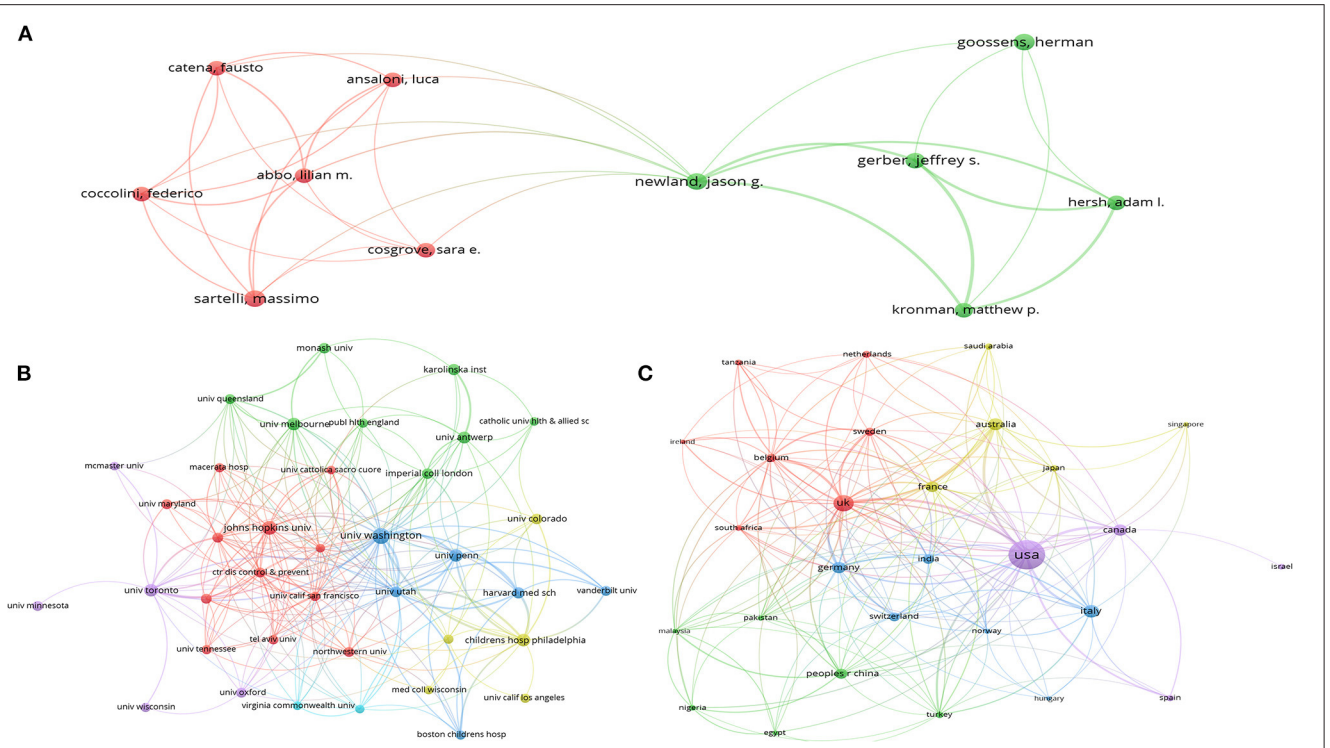

FIGURE 5 | Bibliometric analysis of the citations. **(A)** The citations of authors. Two clusters with different colors were shown. Jason G Newland in green cluster was the most cited author (1,284 times). **(B)** The citations of organizations. J University of Washington in blue cluster (cited 1,258 times) has the largest number of published articles. **(C)** The citations of countries. Five clusters with different colors indicate were shown and USA in purple was cited most (cited 3,307 times). The size of circles indicates the counts of citations.

Themes and Trend Topics

As shown in **Figure 7A**, four theme clusters of AMS were found in surgical studies. The green cluster showed the impact of AMS management in clinical practice, including the consumption of antibiotic, carbapenem usage and the result of AMS application such as significant reduction in one particular field. The blue cluster represented where and how AMS management applied. The yellow cluster indicated investigation of AMS management in surgical specialty was the other important themes. While the green cluster mainly focused on the epidemiology of pathogenic microorganism and the complexity in surgical AMS, such as the isolated pathogens isolated and related surgeries. **Figure 7B** showed the trends of these topics. A variety of color ranging from purple to yellow illustrated different publication times. Recently, studies have mainly focused on reducing SSI, AMR in ICUs and interviews about surgical specialty.

DISCUSSION

Our study used a bibliometric analysis to draw a comprehensive picture of AMS in surgery research over the past decade. In our current study, 516 articles from the WoS core database were analyzed, and the research output in this area increased every year. The published articles were mostly produced by three countries: the US, the UK, and Italy. The total link strength of AMS with "antimicrobial resistance" and "guidelines" was 11.78 and 13.74, respectively, which demonstrated that the literature mainly focused on strategies to minimize antibiotic resistance. Additionally, the clinical status of infection during surgery and antibiotic usage were also primary study fields. AMS was essentially about optimizing antimicrobial use, however, the expenditure for public health and medical health service system varied from different counties and regions, which implied that implementation strategies for AMS should be modified to adapt local medical environment. We conducted several AMS strategies according to the combination of whole articles reading and AMS experiences of our hospital (**Supplementary Figure S3**).

Top-Cited Contributors of AMS in the Surgery Field

AMS can successfully enhance the rational application of antibiotics and has been widely adopted by hospital administrations. However, the current situation of AMS in the surgical field remains perturbing because of some reasons as follows: First, standardized antibiotic recommendation for surgical infection was lack; second, there were limited researches on patient-centered effective AMS interventions; third, most of the studies were single center trial or observational study, therefore evidence of high quality was absent. Our study showed that the affiliated hospital of university (such as the University of Washington and its partner) have contributed extensive research literature to provide useful recommendations for

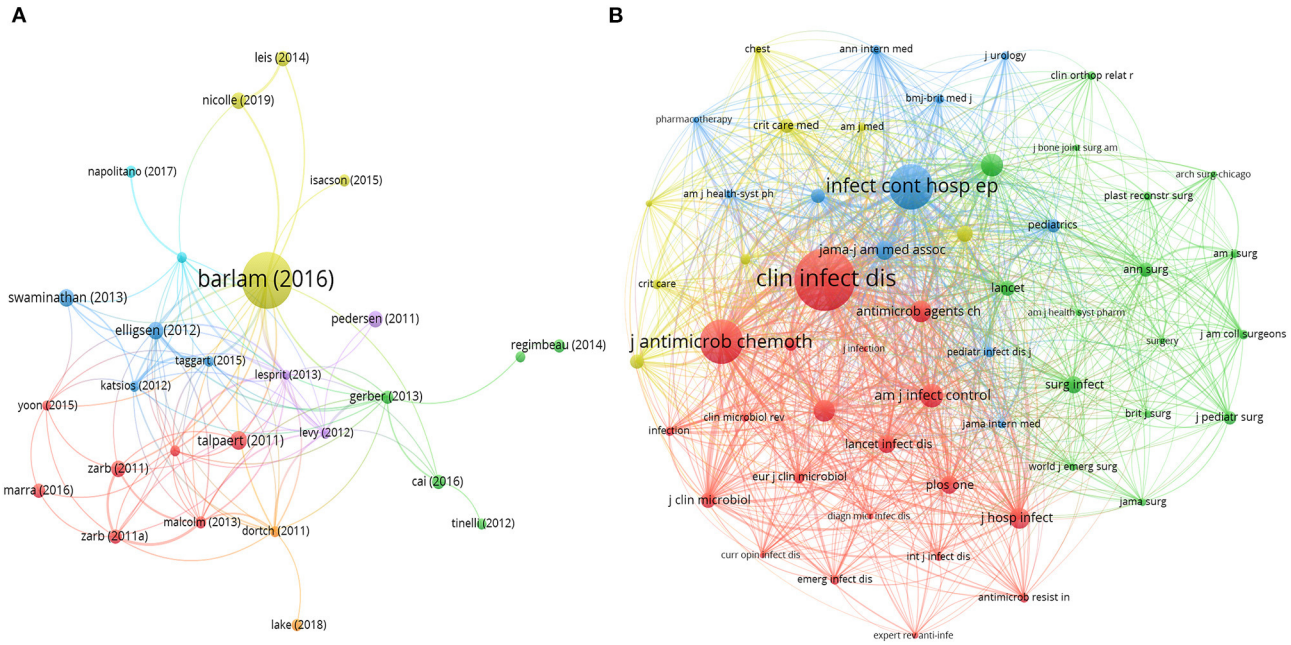

FIGURE 6 | Bibliometric analysis of the bibliographic coupling and co-citation. **(A)** Bibliographic coupling map of documents, 8 cluster with different color represent the different study area and node indicate different articles included. The largest node was barlam (2016) with 1,109 citations and 55 total link strength in cluster 6; **(B)** co-citation map of sources, 4 cluster with different color represent source journals included in different study area. The largest cluster (cluster in red, 20 items) included the largest node ("clin infect dis" with 972 citations and 54 links with other source journals). In both figures, the size of the nodes indicates the counts of co-citations and the distance between two nodes represent their correlation.

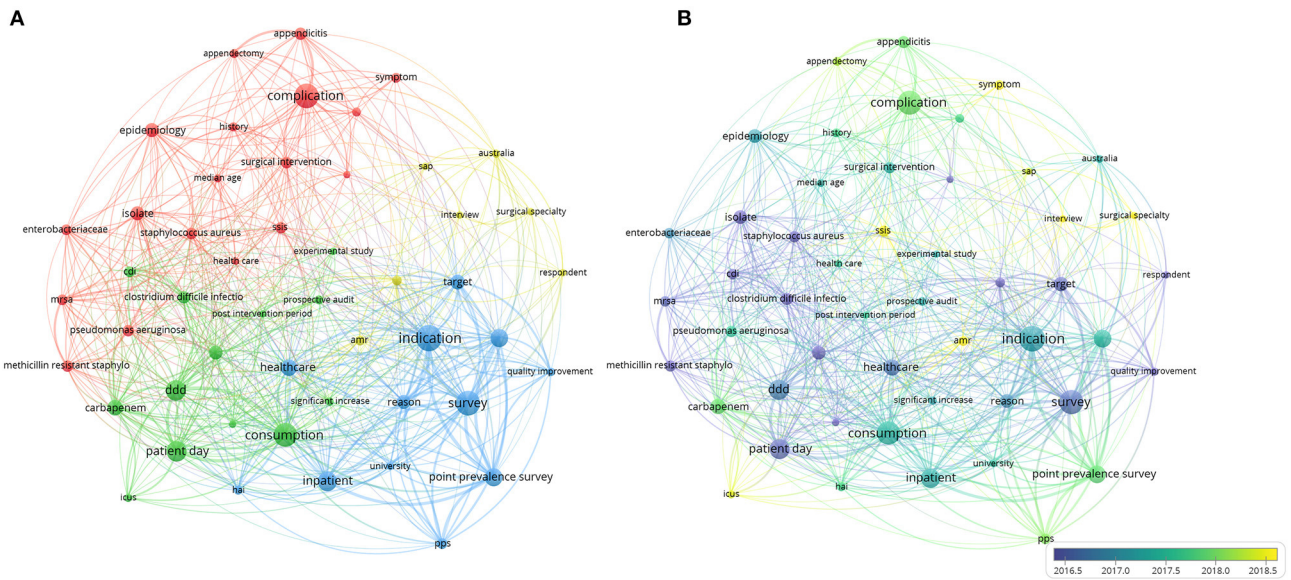

FIGURE 7 | Bibliometric analysis of themes. **(A)** Distribution map of the themes. Four clusters in green, bule, red and yellow were shown in the map, the nodes with same color represented a similar topic according to titles and abstracts. **(B)** Network map of the trend topics. The current publications in different color from purple to yellow. The size of the nodes demonstrates the frequency of appearance as the keywords and the distance between the two circles indicates their correlation.

AMS management in surgery. The phenomenon demonstrated that management research and innovation were important work in an affiliated hospital of a comprehensive university

Dr. Jason G. Newland, from St. Louis Children's Hospital at Washington University, was the top cited author (with a citation count of 1,282). His investigative research concentrated on the

dissemination and implementation of AMS for hospitalized children, which provided sufficient evidence to improve antibiotic use in pediatric surgery (12–14). Meanwhile, guidelines for implementing AMS, such as those written by Barlam et al., had the highest number of citations (1,150 citations), and this advocacy work promoted appropriate antibiotic use in surgery (2). Most research of AMS in surgical field cited this guideline as an authoritative document to complete specific details in hospital management. The majority of the top 10 most-active institutions and authors were located in the USA, where we assumed the influential associations at AMS in surgical field were most located.

International Collaborations

Organizations in the USA, which produced the most publications of any country, were established as leaders of good practice in the field of AMS surgical management. The USA and the UK maintains a cooperative relationship with 21 and 23 other countries, respectively. Most of their cooperators were from anglosphere countries due to the close association in healthcare. In addition to European countries, such as France and Germany, other developing countries have also played important roles in this field. The countries that study AMS in surgery are concentrated in North America and Europe, while other regions such as Pacific Asia are less involved in studying AMS. This phenomenon might associate with that the level of economic development played important role in healthcare expenditure therefore affect AMS research. Developing countries may not have as much energy as developed countries to invest in surgical AMS. However, the participation of countries at different levels of economic development emphasizes the importance of AMS worldwide and demonstrates that they are taking responsibility to improve the rational use of antibiotics.

Research Hotspots and Trends

Current Clinical Status of Infection in Surgery

Overuse and misuse of antibiotics have been proven to lead to an increase in bacterial resistance (15–17). The incidence of SSIs varies due to the complex interaction of many factors, such as the type of surgery, the number and virulence of contaminating bacteria, and the physical state of patients (18). Therefore, implementing AMS in the surgery department is particularly important to reduce the incidence of resistant pathogens and efficiently improve SSI prevention. (4). The current literature in this field mainly focuses on the epidemiological investigation of pathogens and their antibiotic resistance after surgery. Other studies that have investigated risk factors for SSI and antibiotic prophylaxis management also play an important role in AMS research in the surgical field.

Practical Issues in AMS Management

There was not consistent recommendation of antibiotics for different infections related to surgery. This is because the best guides for antibiotic therapy are based on local antibiograms and resistance patterns. However, such information is not readily available, and general principles governing the judicious use of antibiotics should be applied (19). Usually, antibiotic recommendations are based not only on the surgical site and clinical severity of illness, but also on the cost of antibiotics (20). Inappropriate initial administration of antibiotics may result in longer hospital stays, higher mortality rates, higher prevalence of drug-resistant pathogens, and higher cost implications (for example, using an agent to which causative pathogens are not susceptible). Therefore, AMS in different surgery wards is widely accepted, leading to significant reduction in the abuse of antibiotics and patient care costs (1, 2, 4, 18, 21, 22). In our study, we found that the literature focused on the complexity of AMS, because it varied among different diseases and populations. Hence, the topic was scattered into many branches and was primarily concerned with improving the quality of healthcare institutions.

The Influence of AMS in Surgery

Prolonged, improper, and unregulated use of antibiotics is a key factor in the rapid rise in resistant pathogens, which further leads to the failure of surgery-related infection treatment (19). Surveillance of antibiotic usage and AMS management in healthcare institutions is crucial to inform and evaluate AMS strategies in surgery. Our results showed that articles were primarily focused on two fields: (1) the effective evaluation of antibiotic use in different inpatient wards. The majority of the articles in this field were concerned about prescription behavior in different wards; (2) the impact of AMS management in clinical practice, researchers were especially interested in how AMS can improve the quality of medical treatment in intensive care units (ICUs) and how to evaluate the economic effect of antibiotics with AMS. The explanation for this phenomenon might be that the ICU and surgical department both have a high incidence of all kinds of infections, and therefore use antibiotics extensively (23–26). It was also demonstrated that these departments were taking action to reduce antibiotic use and limit the emergence of resistance.

Future Recommendation

An interdisciplinary team targeting to optimizing antibiotic use in surgery was the key determinant of success in implementing AMS. We suggested medical institutions should establish an AMS team including trained administrators, surgeons and nurses, pharmacists, microbiologist, and others if necessary. Moreover, the main procedure of AMS in surgery involved the expert consultation, prior authorization for restricted antibiotics, prospective-audit-with-feedback, and the education in antibiotic use. These AMS procedures required a huge and powerful execution and we emphasized more on interdisciplinary cooperation based on communication. Finally, restricting excess antimicrobial use through AMS team raised a question for the doctors' right to prescribe and we recommended AMS team should balance the reduction excess antibiotic use between without impeding access to antibiotics.

Strengths and Limitations

Our study is one of the first bibliometric analysis to evaluate publications on AMS in surgery. Results of the bibliometric analysis of citations, co-authors, and other factors illustrated the

current research status, hotspots, and future concerns of surgical AMS studies. Nevertheless, this study has several limitations. First, although our study enrolled articles published in English, a small portion of other types of literature, such as guidelines and meta-analyses, were not fully removed. Thus, the results may have a slight inaccuracy due to the impact of repetitive citations. Another significant limitation is the lack of implementation research in this area. Little effort and research funding have been allocated to study how best to achieve large-scale implementation of AMS. Moreover, having few high-quality prospective cohort studies, may limit the quality of the bibliometric analysis.

CONCLUSION

Our study is one of the first bibliometric analysis to evaluate publications on AMS in surgery using the WoS core database. These studies emphasized the details of AMS management in surgery, which aims to decrease surgical-related infections and reduce antibiotic resistance. Professionals have identified AMS programs as a key element in the rational use of antibiotics in surgical departments. For now, the management of AMS in surgical gained rapid attention but still needs further refinement.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

Z-CG and HZ are the guarantors of the entire manuscript. Y-XL and YY contributed to the study conception and design, critical revision of the manuscript for important intellectual content, and final approval of the version to be published. K-JL, Z-LZ, and MC contributed to the data acquisition, analysis, and interpretation. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.847420/full#supplementary-material

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Husbands' Plan to Participate in Birth Preparedness and Complication Readiness in Haramaya Health and Demographic Surveillance System Site, Eastern Ethiopia: A Community-Based Cross-Sectional Study

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Background: Partner involvement in maternal health services utilization remains a major public challenge in the developing world. Strategies of involving men in maternal health services are a critical and proven intervention for reducing maternal and neonatal mortality by ensuring safe delivery and reducing complications during childbirth. Moreover, the husbands' involvement during pregnancy helps their spouses to make timely decisions and avoid maternal delays, especially first and second delays. Although birth and complication readiness have been studied in developing countries such as Ethiopia, almost all previous researchers were focused primarily on women participants. Therefore, we aimed to investigate factors associated with husband involvement in birth preparedness and complication readiness plan in Haramaya Health and Demographic Surveillance site, Eastern Ethiopia.

Methods: A community-based cross-sectional study was conducted from March 1 to 30, 2020 among men whose wives were pregnant in Haramaya Health and Demographic Surveillance (HDSS) site in Eastern Ethiopia. The calculated sample size was 653, however while contacting 653 husbands only 630 had given the full interview, hence 630 respondents were remained in the analysis. Participants were approached through a systematic sampling technique. Data were collected using a pre-tested structured questionnaire through a face-to-face interview, and entered into Epidata version 3.1 and analyzed using SPSS version 22 (IBM SPSS Statistics, 2013). The prevalence was reported using proportion with 95% Confidence Interval (CI) and summary measures. Predictors were assessed using a multivariable logistic regression analysis model and reported using an adjusted odds ratio (AOR) with 95%CI. Statistical significance was declared at $p < 0.05$.

Results: Overall, the prevalence of the husband's plan to participate in birth preparedness and complication readiness was 59.6% (95%CI:56–64%). In the final model of multivariable analysis, predictors like husband's knowledge of birth preparedness and complication readiness [AOR = 4.18, 95%CI:2.05, 8.51], having a discussion with spouse on the place of delivery [AOR = 6.84, 95% CI: 4.17, 11.22], husband's knowledge of danger signs during labor and delivery [AOR = 3.19, 95 % CI: 1.52, 6.71], and making a postpartum plan[AOR = 2.30, 95 % CI: 1.38, 3.85] were factors statistically associated with husband's plan to participate in birth preparedness.

Conclusions: This study pointed out that two in every five husbands failed to plan birth preparedness and complication readiness. As a result, all stakeholders should emphasize male partners' education in terms of birth preparedness and complication readiness, as well as knowledge of danger signs during labor and delivery. They should also encourage male partners to discuss a place of delivery and have a postpartum plan in place to reduce potential complications related to labor and delivery.

Keywords: husband participation, birth preparedness, complication readiness, associated factor, Ethiopia

INTRODUCTION

Globally, approximately 287,000 mothers die each year as a result of pregnancy and childbirth complications. The vast majority of these maternal deaths (99%) occur in developing countries, with Sub-Saharan Africa alone accounting for 66% (1). These deaths are the result of complications during pregnancy, childbirth, or postpartum. Studies have shown that making a birth plan that includes birth-preparedness and complication readiness measures for pregnant women, their spouses, and their families are found to be a key strategy that can reduce the number of women dying from such complications (1, 2).

Birth preparedness and complication readiness (BPCR) is a comprehensive package aimed at promoting timely access to skilled maternal and neonatal services, as well as encouraging pregnant women and their families to actively prepare for and make decisions about delivery (2). This stems from the fact that every pregnant woman is at risk of unexpected and life-threatening complications that could result in death or injury to herself or her infant (3). According to various research reports, pregnancy and childbirth are still regarded solely as women's issues in Sub-Saharan Africa because husbands have tremendous control over the women's decision process both socially and economically (4–7). On the contrary, evidence has shown that involving men in maternal health care has positive outcomes such as reduced maternal morbidity and mortality due to a sufficient birth plan, thereby avoiding care-seeking delays due to obstetric emergencies (8–11), increased institutional deliveries (5, 9, 10) and postnatal service utilization (9, 12). With these all interventions, three phases of maternal delay can be averted.

Literature has shown that numerous factors affect the husband's involvement in the process of BPCR planning during pregnancy and childbirth. For instance, previous research report identified local factors (societal perception such as considering childbirth as a natural process, pregnancy and childbirth are women's role, preference for traditional birth attendance's care and novelty of the idea of husband's involvement in pregnancy and birth care) as barriers of husband's plan to participate in BPCR (13–15). In Sub-Saharan Africa like Ethiopia, despite its public health importance for birth outcomes, male participation in maternal and child health (MCH) remains low, and having a male partner (MP) present in the labor room during delivery is utterly impossible in many settings (9, 11, 16), even in a limited area like urban setting, where male partners have been supportive to their spouses, there are unwelcoming, intimidating, and unsupportive health systems, presenting a missed opportunity, which embarrasses their commitment (13, 17). Similarly, researchers have reported that factors such as poor timely action by family, which leads to a great deal such as looking for a source of money and potential blood donors in case of emergency, finding for transportation, and reaching the appropriate referral facility remain a major challenge in Africa (14, 18).

In Ethiopia, husbands have strong decision-making power over their spouses both at the community and at the household level, and traditionally women have little independence in decisions making process. Cultural barriers, knowledge of recognizing potential complications, and facility service factors all contribute to the husband's involvement in birth preparation and complication readiness planning (19). According to previous studies conducted in limited areas of Ethiopian regions, husband disapproval for antenatal care accounts for 15.5% of the factors influencing antenatal care, and only 21% of pregnant women were accompanied by their husbands to visit the ANC clinic (13). As a result, male participation in birth preparation and complication preparation will be critical in reducing maternal mortality (20). Male involvement allows men to encourage their wives to use obstetric services, and the couple will be better prepared for birth complications. This would result in a reduction in all three phases of delay: delay in deciding to seek care, delay in getting to care, and finally delay in receiving care. In developing countries, the male partner can play an important

role, particularly in the first and second stages of delay, and thus positively impact birth outcomes (21–23).

In Ethiopia, in the last decade, various studies have been conducted to assess the practice of birth preparation and complication readiness among mothers; with little attention have been given to the level of the husband's involvement in birth preparation. Moreover, although numerous factors associated with male involvement in BPCR have been identified in the various research report (13, 14, 24, 25), in Ethiopia, husbands' participation in the BPCR received little policy attention (23). In addition, the majority of the previous studies were facility-based and primarily focused on emergency obstetric care and other routine services (26). Therefore, this study was aimed to investigate husbands' participation in BPCR and its associated factors among husbands whose wives were pregnant in the Haramaya HDSS site, Eastern Ethiopia.

METHODS AND MATERIALS

Study Design, Setting, and Period

A community-based cross-sectional study was conducted from March 1 to March 30, 2020, in four kebeles (the smallest administrative unit) in Ethiopia, namely Biftu-Geda, Ifa-Oromia, Gobe-Chala, and Kuro found in Haramaya districts, which were located 500 km away from Addis Ababa, capital city Addis Ababa. The 2007 national census reported the total population for this District is 271,018, of whom 138,282 were men and 132,736 were women (27). The Haramaya Health and Demographic Surveillance Site which is maintained by Haramaya University was established in the year 2018 GC. The site was established on 12 rural kebeles of Haramaya district. The site constitutes 93,363 residents and 1,712 pregnant women (28).

Study Participants

All husbands whose wives were pregnant in the Haramaya HDSS site during the study period were considered as source population. The study population consisted of all systematically selected husbands whose wives were in their third trimester of pregnancy in the Haramaya district HDSS site's selected kebeles. Husbands who were not staying with their wives during pregnancy and childbirth and, those who were critically ill and unable to provide the required information during data collection were excluded from the study.

Sample Size and Sampling Procedure

In this study, the maximum required sample size was calculated using the single population proportion formula by considering the following assumptions. Taking the prevalence of husband involvement in BPCR (45%, P=0.45) from previous a study conducted in Wolaita Sodo town, Southern Ethiopia (23), a 95% confidence level ($Z_{\alpha/2}$ =1.96), to increase the representativeness of the sample size and to boost the precision, 4%($\alpha = 0.04$) tolerable margin of error was considered. Thus,

$$n = \frac{za/2^2\, p(1-p)}{d^2} = \frac{(1.96)^2(0.45)(1-0.45)}{0.04^2} = 594$$

By adding a 10% contingency for the non-response rate, the calculated sample size was 653, however while contacting 653 husbands only 630 had given the full interview, hence 630 respondents were remained in the analysis.

In this study, two-stage sampling was used. Initially, a simple random sampling technique was used to select four kebeles from a total of 12 rural kebeles of the Haramaya HDSS site. To do so, the Haramaya HDSS database maintained by Haramaya University was used as a sampling frame to identify a list of pregnant women in each kebele. The total number of pregnant women who are living with their spouse in these four kebeles is 1,332, of which Biftu-Geda, Gobe-Chala, Kuro, and Ifa Oromia have 343, 364, 351, and 274 pregnant women respectively (28). Then, the house of pregnant women was traced to identify the study participants (Households with the husbands of pregnant women). The calculated sample size was proportionally allocated to the four selected kebeles. The systematic sampling technique was employed to select the households, and the first house was selected using lottery methods. For absent participants, rescheduling was done to conduct the interview again. If the selected household does not fulfill the inclusion criteria, the next household was substituted for our study and if more than one candidate was available in the single household, one of them was interviewed by lottery method. Accordingly, a total of 653 sample sizes was proportionally allocated to each kebele to obtain the required numbers of an individual to be included in the estimated sample from each aforementioned kebeles. Then, the K^{th} interval was calculated for all selected kebeles (K^{th} = 1,332/653 = ≈2). The sequence of the "k^{th}" interval was 2 for all selected kebeles. Therefore, every second eligible participant was interviewed, and data were collected until the required sample size was obtained (**Figure 1**).

Data Collection Tool and Procedure

The data were collected through a face-to-face interview with a pretested structured questionnaire developed after a review of the literature (29). The questionnaires asked about socioeconomic and demographic information, knowledge of danger signs during pregnancy, labor and delivery, and postnatal care, knowledge of BPCR, and plans to participate in birth preparedness and complication readiness. Ten Bachelor of Science (BSc) nurses were collected the data after a five-day training on the tools and survey methods.

Study Variables and Measurements

Dependent variable: In this study, the outcome variable was husbands' plan to participate in birth preparedness and complication readiness (Yes/No). The outcome variable was dichotomized as 1 and 0. Thus, it was recoded into binary outcomes as "good participation = 1" and "poor participation = 0". **Independent variables:** In this study, the explanatory variables were categorized as: demographic and socioeconomic characteristics (age, religion, number of children and occupation, level of education, and marital status), **obstetric related factors**: Knowledge of husbands on key danger signs of pregnancy, labor and the postpartum period, knowledge of husbands on birth preparedness and complication readiness.

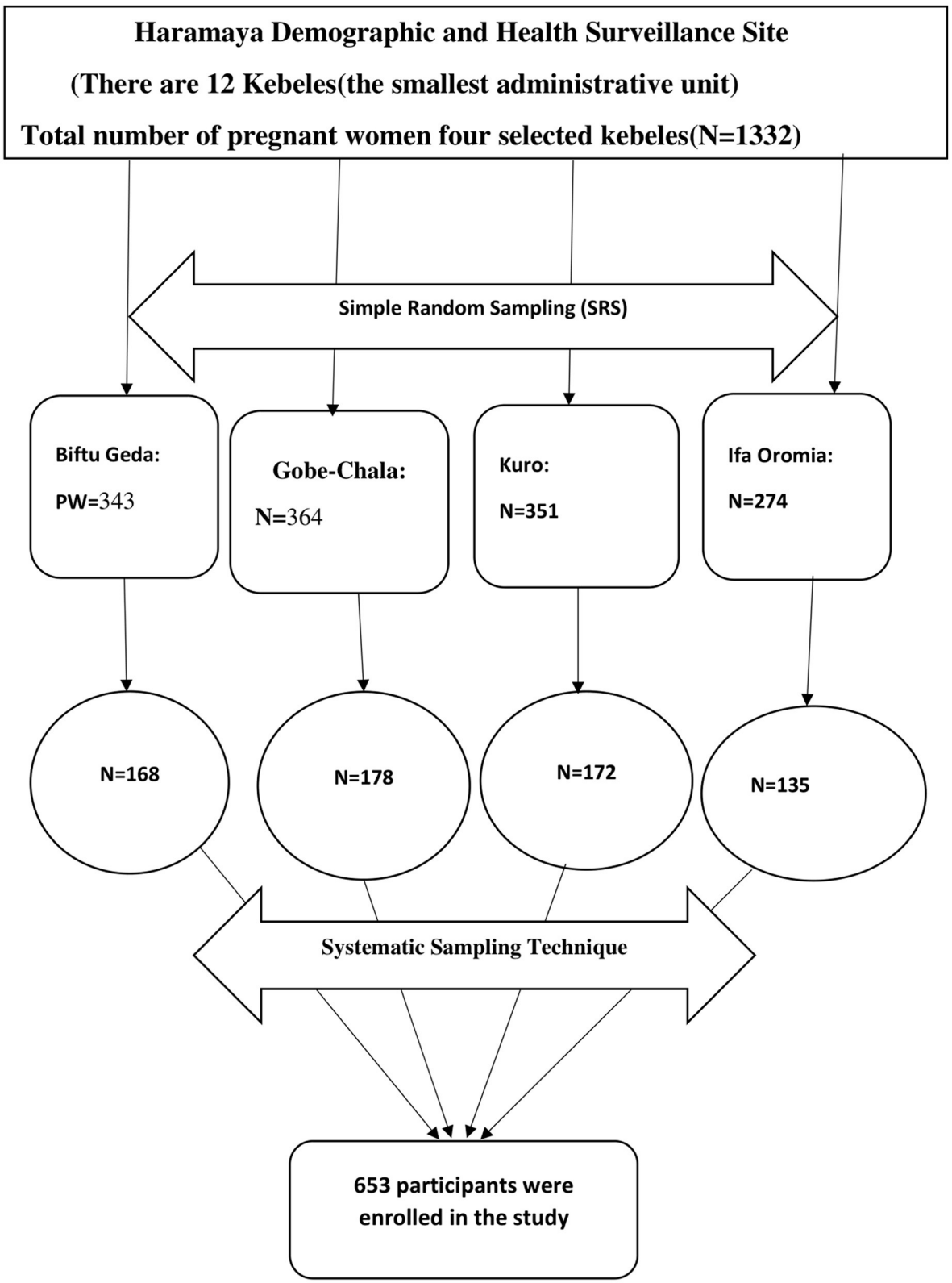

FIGURE 1 | The schematic diagram of the sampling procedure for the study on husbands' plan to participate in birth preparedness and Complication Readiness in Haramaya Health and Demographic Surveillance System Site, Eastern Ethiopia.

Operational Definitions and Measurements

Birth preparedness and complication readiness: is a strategy to encourage husbands to know the signs of obstetric complications and emergencies, to choose a preferred birthplace and attendant at birth, to arrange for transportation to the skilled care site in the event of emergence, to save or arrange alternate funds for the cost of the emergence, and to accompany her to the emergence care. identifying a blood donor and preparing clean clothes for the mother and child (30). **Husbands' plan to participate in BPCR**: was measured by nine items, those who responded 'yes' scored 1 and if 'No' scored 0 then the respondents who were scored above the mean value of the indicators of BPCR (23). Good participation in BPCR: Those husbands who practiced five and above elements of nine items (23). Poor participation in BPCR: Husbands who practiced four or fewer elements of nine items (23).

Knowledge of danger signs: According to WHO, there are 10 danger signs of pregnancy, delivery, and postnatal period. **Better knowledge**: In this study, the respondents who knew greater than or equal to five danger signs during pregnancy, delivery, and postnatal period which is above the mean value (danger signs assigned from 1 to 10) were categorized as 'have better knowledge" (31). **Good knowledge**: The respondent who knew below the mean value (<5 danger signs) were considered as "have a good knowledge" (31). **Poor knowledge**: In this study, the husband's poor knowledge about danger signs can be defined as if the respondent did not know any listed danger signs, they were considered as "poor knowledge" (31).

Husband's knowledge of BPCR: According to the WHO, there are 9 items to assess the components of BPCR. **Better knowledge**: In this study, if the husbands mentioned five and above components of BPCR items, which is the mean value (component assigned 1- 9), they categorized as "have better knowledge" (31)**. Good knowledge**: The respondents who knew below mean value (<5 components) of the nine BPCR items, they considered as "have good knowledge" (31). **Poor knowledge**: In this study, if the respondents did not know any components of Birth preparedness and complication readiness, we categorized them as " have poor knowledge" (31).

Data Quality Control

The questionnaire was initially prepared in English and then translated into the local languages by a bilingual expert (Afaan Oromoo language). Then, it was translated back into an English version to ensure its consistency. The data collectors and field supervisors received training on the data collection tool and procedures. Before the actual study data collection, the pretest was conducted among 3% of husbands whose wives were pregnant in similar settings. The investigators and experienced field research supervisors provided regular supervision.

Data Processing and Analysis

First, the collected data were checked for completeness, consistency. Then, they were cleaned, coded, and entered into EpiData version 3.1 for further analysis. The entered data were exported to SPSS version 22 for analysis. Descriptive and summary statistics were conducted and reported using frequency tables and figures. The outcome variable was recoded into binary outcome as "good participation = 1" and "poor participation = 0". A binary logistic regression model was fitted to check for an association between independent variables and the outcome variable. The model fitness was checked by Hosmer-Lemeshow statistics and Omnibus tests. A multivariable analysis was performed to identify the true predictors of the husband's plan to participate in the BPCR plan. A multi-collinearity test was carried out to check the presence of correlation between independent variables by using the standard error and co-linearity statistics, and no collinearity effects were detected. Thus, the value of the Variance Inflation Factor (VIF) was 0.951. The direction and strength statistical association was measured by odds ratio (OR) along with the 95% confidence interval (CI). A $p < 0.05$ was considered to declare statistical significance both in bi-variable and multivariable analysis.

RESULTS

Socio-Demographic Characteristics of the Respondents

A total of 630 husbands were enrolled in this study, with a response rate of 96.5 %. The age of the study participants ranged from 18 to 60 years with a mean age of 31.7 (SD = ±7.4). The majority of the study participants, 387 (61.4%) were between the ages of 30 and 39 years. Four hundred-thirty (68.3%), two hundred-forty (38.1%), and five hundred-eight-four (92.7%) of the husbands were farmers, had no formal education, and were married in monogamous marriages, respectively. More than half of the participants, 356 (56.5 %) had 1–4 children in their family (**Table 1**).

Husband's Knowledge Status on Key Danger Signs During Pregnancy, Labor and Delivery, Postnatal Period

Regarding obstetric danger signs, more than half of the respondents, 352 (55.9%) mentioned five and more danger signs during delivery and around 195(31.0%) of them listed five and more danger signs during the postnatal period. Similarly, nearly half 272(43.2%) of the husbands had responded to five and more BPCR components. Five hundred ninety-seven (94.8%) of the participants had awareness of the significance of ANC during pregnancy (**Table 2**).

Husband's Source of Information About Birth Preparedness and Complication Readiness Plan

In this study, the respondents were also assessed for their source of information about birth preparation and complication readiness. Accordingly, of the total 630 study participants enrolled in this study, more than half (57.16%) of them were heard from health care providers followed by media (Radio/TV) (18.53%), family/friends (12.41%), reading printed materials (7.17%), and the remaining 4.73% of the heard from other sources in their life (**Figure 2**).

TABLE 1 | Socio-demographic characteristics of husbands whose wives were pregnant in Haramaya HDSS site, Eastern Ethiopia, 2020.

Characteristics	Categories	Frequency(*n*)	Percentage (%)
Husband's age (years)	18–29	38	6.0
	30–39	387	61.4
	40–49	177	28.2
	≥ 50	28	4.4
Religion	Muslim	611	97
	Orthodox	15	2.4
	Protestant	4	0.6
Number of children	Have no children	85	13.5
	1–4	356	56.5
	>4	189	30.0
Husband's educational level	No formal education	240	38.1
	Primary (1–8)	194	30.8
	Secondary (9–12)	92	14.6
	College and above	104	16.5
Husband's occupation	Farmers	430	68.3
	Merchant	97	15.4
	Government employee	69	11.0
	Other*	34	5.3
Marital status	Monogamous	584	92.7
	Polygamous	46	7.3
Wife's educational level	No formal education	344	54.6
	Primary (1–8)	160	25.4
	Secondary (9–12)	62	9.8
	College and above	64	10.2

**Daily laborer, private employees.*

TABLE 2 | Knowledge of obstetric danger signs related factors among husbands whose wives were pregnant in Haramaya HDSS site, Eastern Ethiopia, 2020.

Characteristics	Categories	Frequency (*n*)	Percentage (%)
Husband's knowledge status on danger signs during pregnancy	Poor knowledge	58	9.2
	Good knowledge	248	39.4
	Better knowledge	324	51.4
Husband's knowledge status on danger signs during labor and delivery	Poor knowledge	79	12.5
	Good knowledge	199	31.6
	Better knowledge	352	55.9
Husband's knowledge status on danger signs during postnatal care	Poor knowledge	151	44.0
	Good knowledge	284	45.1
	Better knowledge	195	31.0
Husband's knowledge status on components of BPCR	Poor knowledge	130	20.6
	Good knowledge	228	36.2
	Better knowledge	272	43.2
Husband's knowledge on importance of ANC follow-up	Yes	597	94.8
	No	33	5.2

Husband's Plan to Participate in Birth Preparedness and Complication Readiness Plan

In this study, the husband's status of birth preparation and complication readiness plan during labor, delivery, and postpartum were assessed. Accordingly, of the 630 husbands who participated in the study, nearly half, 334(53.0%) of the respondents were made a plan for the place of delivery, and three hundred-four (48.3%) of them identified skilled birth attendants during labor and delivery. Nearly two-thirds (64.9%) of the

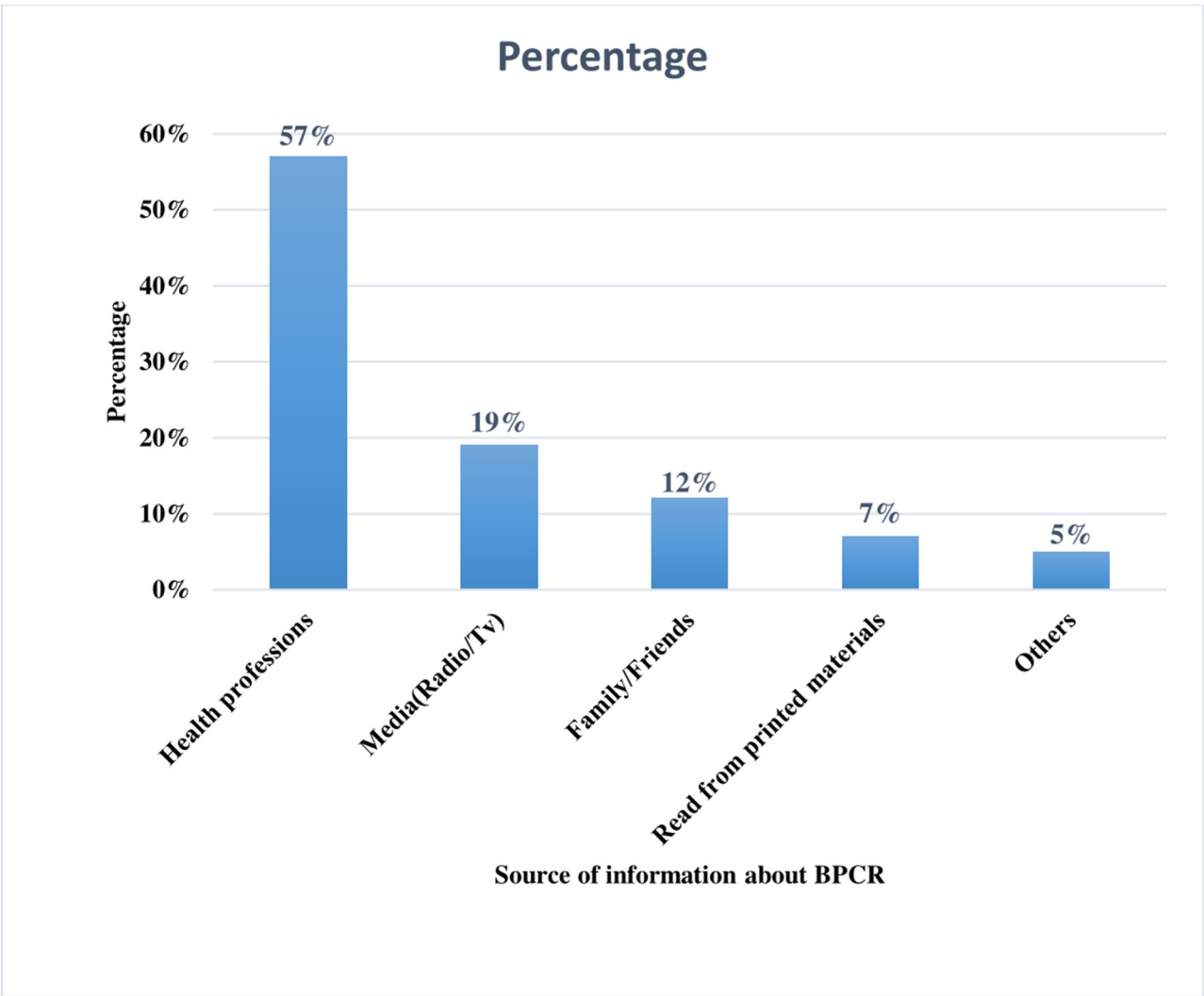

FIGURE 2 | Source of information about birth preparedness and complication readiness Haramaya Health and Demographic Surveillance System site, Eastern Ethiopia, 2020.

respondents stated that they save money for delivery. Almost one-third (33.0%) of husbands had a plan for blood donation and 302 (47.9%) had a plan to accompany their wives during labor and delivery. Likewise, two hundred sixty-seven (42.4%) of the husbands made a transportation plan, and nearly half (49.7%) of them made a postpartum plan during their current pregnancy (**Table 3**).

Moreover, in this study, only 379(60.2%) of husbands had a plan for birth preparedness and complication readiness in the current pregnancy. Of 379 husbands who had birth preparedness and complication readiness plan, around 226 (59.6%) of the husbands had a good participation plan while the remaining 153 (40.4%) of them had a poor participation plan. Thus, the overall proportion of husbands' plans to participate in birth preparedness and complication readiness was 59.6% (95%CI:56–64%) (**Figure 3**).

Factors Associated With Husband's Plan to Participate in Birth Preparedness and Complication Readiness

In the bi-variable analysis, predictor variables such as: husband's educational level, husband's occupational status, the importance of ANC, husband's knowledge status on BPCR, knowing danger signs during pregnancy, husband's knowledge of BPCR, husband's knowledge of danger signs during labor and delivery, having a discussion with spouse on the place of delivery, having government support in BPCR and making a plan for PNC follow-up were significantly associated with husband's plan to participate in BPCR in the current pregnancy.

However, in the final model of multivariable logistic regression analysis, predictor variables like husband's knowledge of BPCR,

TABLE 3 | Husband's plan to participate in birth preparedness and complication readiness plan in Haramaya HDSS site, Eastern Ethiopia, 2020.

Characteristics	Category	Frequency (*n*)	Percentage (%)
Identify a place of delivery	Yes	334	53.02
	No	296	46.98
Discussed with spouse on place of delivery	Yes	360	57.7
	No	270	41.3
Identify skilled birth attendants at delivery	Yes	304	48.25
	No	326	51.75
Save money for delivery	Yes	409	64.93
	No	221	35.07
Identify potential blood donors	Yes	209	33.17
	No	421	66.83
Identify birth accompany for delivery	Yes	302	47.93
	No	328	52.07
Prepare mode of transportation during labor	Yes	267	42.38
	No	368	57.62
Make a postpartum plan following delivery	Yes	318	50.47
	No	312	49.53
Save money for emergency during labor and delivery	Yes	231	36.67
	No	399	63.33
Identify need of ANC during pregnancy	Yes	597	94.7
	No	33	5.3

ANC, Antenatal Care.

husband's knowledge status of danger signs during labor and delivery, having a discussion with spouse on the place of delivery, and making postpartum plan following delivery were factors remained significantly associated with husband participation in BPCR. Accordingly, husbands who had better knowledge about BPCR were 4.2 times more likely to participate in BPCR than those husbands who had poor knowledge (AOR = 4.18, 95% CI: 2.05, 8.51). Similarly, the likelihood of participating in the BPCR plan was nearly four times higher among husbands who had good knowledge about BPCR than those husbands who had poor knowledge (AOR = 3.99, 95% CI: 2.20, 7.25).

Moreover, the odds of participating in the BPCR plan were 3.19 times higher among husbands who had better knowledge about birth preparedness and complication readiness plan than their counterparts (those husbands who had poor knowledge) (AOR = 3.19, 95% CI; 1.52, 6.71). Likewise, husbands who had good knowledge of danger signs during labor and delivery were nearly three times more likely to participate in BPCR than those who had poor knowledge of birth plan (AOR = 2.84, 95% CI; 1.34, 6.02). Additionally, participants who discussed with their spouse the place of delivery were 6.8 times more likely to participate in BPCR than those who did not discuss the place of delivery with their wives (AOR = 6.84, 95% CI; 4.17, 11.22). Moreover, husbands who had a postpartum plan with their wives were 2.3 more likely to participate in BPCR than those who did not make plans anymore (AOR = 2.3, 95% CI: 1.38, 3.85) (**Table 4**).

DISCUSSION

This study assessed the husband's plan to participate in birth preparedness and complication readiness and its associated factors in the Haramaya district HDSS site, Eastern Ethiopia. It revealed that the overall prevalence of husbands' plans to participate in BPCR was 59.6%. Thus, approximately two out of every five husbands failed to plan for BPCR. Husband's knowledge of BPCR, husband's knowledge status on danger signs during labor and delivery, having a discussion with spouse on the place of delivery and making postpartum plan were identified as predictors of husband's plan to participate in BPCR.

In this study, around 59.6% of husbands were intended to participate in BPCR during the current pregnancy. Similar findings were reported in a study conducted in the Tigrai region of Northern Ethiopia (60.4 %) (20) and Mekelle Town of Northern Ethiopia (60.9%) (31). The similarities could be due to the fact that the two studies use a similar strategy for safe motherhood and have a similar social structure. However, the current prevalence of husband's plan to participate in BPCR was much higher than previous studies conducted in different settings like Axum, Northern Ethiopia (46.6 %) (18), Bale, Southeast Ethiopia (41.6 %) (32), Nepal (44.36 %) (33), and secondary analysis of DHS data in selected African countries (45.7 %) (5). The possible justification for these disparities might be attributed to differences in sample size, methods of assessment, and the time gaps of the study period. Another possible explanation is that the current study population has better access to information on maternal health care. On contrary, this

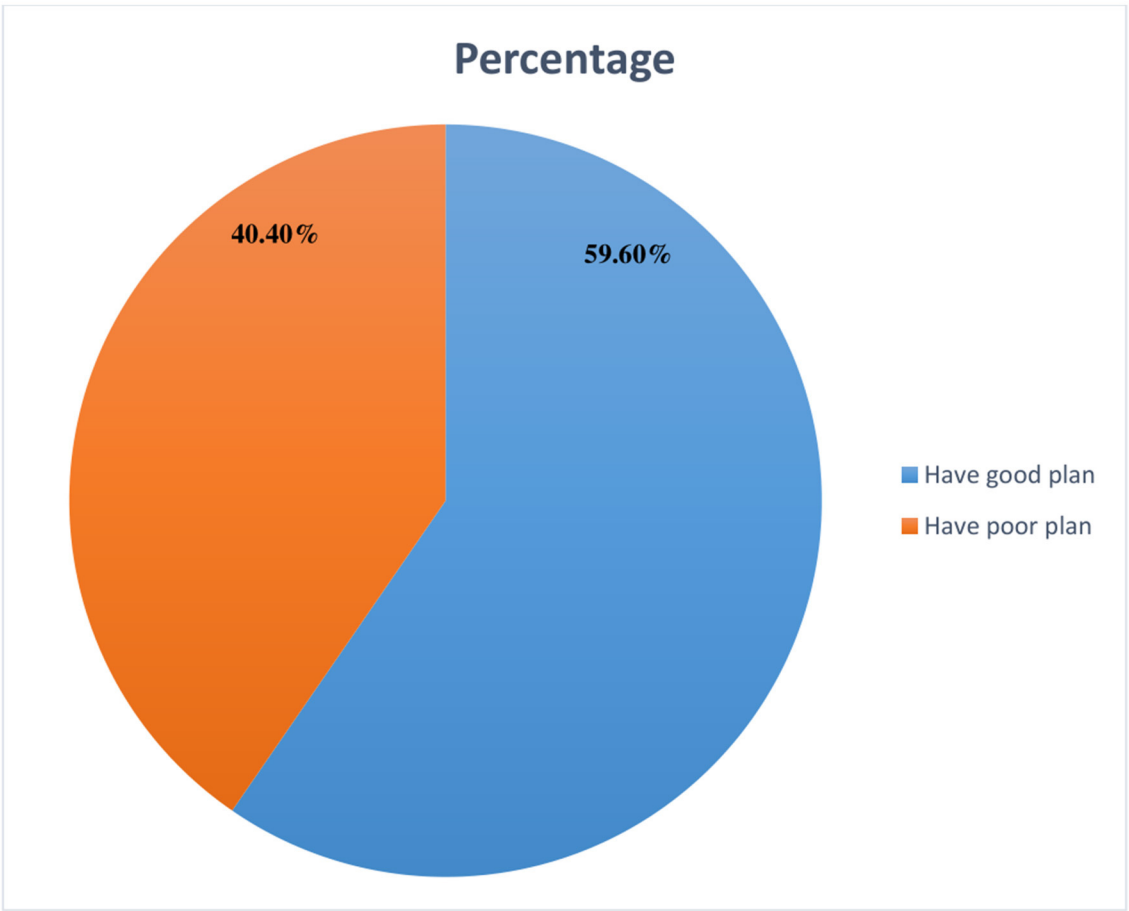

FIGURE 3 | Husband's plan to participate in birth preparedness and complication readiness plan in Haramaya Health and Demographic Surveillance System site, Eastern Ethiopia, 2020.

finding was relatively lower than studies conducted elsewhere such as Gulu district (65.4 %) (12), India (81%) (34), and Nepal (82.6 %) (35). The possible reasons could be due to a variety of socio-demographic factors in the current study setting such as a low level of educational status and socio-economic status of the study participants.

In the final model of multivariable analysis, the husband's knowledge of danger signs during labor and delivery was found to be associated with the husband's plan to participate in BPCR. Thus, those husbands who had a good and better knowledge of danger signs during labor and delivery were 3.19 and 2.84 times more likely to participate in the BPCR plan than those who had poor knowledge, respectively. These results are supported by findings from previous studies conducted in Ethiopia like Burayu (26), Jimma (36), Kofele (37), and other countries such as Nepal (35), and India (38). The possible justification is because knowing about danger signs encourages husbands to seek healthcare service and to participate in BPCR; as improving husbands' awareness and skills could make them involved more in their wives' health status. Moreover, having awareness about potential danger signs of pregnancy may help the husbands to accompany their wives to visit health facilities earlier (39). Moreover, men who are aware of the danger signs of pregnancy and childbirth may become gatekeepers, ensuring that their spouse receives appropriate care in pregnancy-related emergencies (15). Furthermore, when men can recognize danger signs, it makes it easier for women to access health care services, especially in emergencies (9, 12).

Furthermore, in this study, the husband's knowledge status of the birth plan was found to be an independent predictor of BPCR. Accordingly, those husbands with good and better knowledge of BPCRs were 4.18 times and 3.99 times more likely to participate in BPCR than those husbands with poor knowledge respectively. These findings are also supported by studies conducted in Burayu (26) and Nepal (40). This could be because knowing the process of birth preparedness and complication readiness enables husbands to participate in the issues that are beneficial to their spouses. Similarly, the husband's discussion status with their spouse was significantly associated with the husband's plan to participate in BPCR. Thus, those participants who discussed with their wives the place of delivery were 6.84 times more likely to participate in BPCR than those who did not involve

TABLE 4 | Bi-variable and multivariable logistic regression analysis of factors associated with husband's participation in BPCR in Haramaya HDSS site, Eastern Ethiopia, 2020.

Factors	Categories	Participated in BPCR		COR (95% CI)	AOR (95% CI)
		Yes (%)	No (%)		
Husbands' education level	No formal education	102 (42.5)	138 (57.5)	1	**1**
	Primary (1–8)	129 (66.5)	65 (33.5)	2.68 (1.81, 3.98)	1.59 (0.95, 2.67)
	Secondary (9–12)	70 (76.1)	22(23.9)	4.30 (2.50, 7.41)	1.33 (0.62, 2.87)
	College & above	78 (75.0)	26 (25.0)	4.06 (2.43, 6.77)	0.63 (0.29, 1.38)
Husbands occupation	Farmer	241 (56.0)	189 (44.0)	1	**1**
	Merchant	64 (66.0)	33 (34.0)	1.52 (0.96, 2.41)	0.86 (0.44, 1.67)
	Gov't employee	49 (71.0)	20 (29.0)	1.92 (1.10, 3.34)	0.55 (0.22, 1.37)
	Private employee	25 (73.5)	9 (26.5)	2.18 (0.99, 4.78)	0.80 (0.29, 2.23)
Identify need of ANC during pregnancy	No	6 (18.2)	27 (81.8)	1	**1**
	Yes	373 (62.5)	224 (37.5)	7.49 (3.05, 18.43) *	2.04 (0.63, 6.58)
Have knowledge on danger signs of pregnancy	Poor knowledge	15 (25.9)	43 (74.1)	1	**1**
	Good knowledge	122 (49.2)	126 (50.8)	2.78 (1.47, 5.25)*	0.62 (0.25, 1.59)
	Better knowledge	242 (74.7)	82 (25.3)	8.46 (4.47, 16.03)*	1.11 (0.40, 3.10)
Have knowledge on BPCR plan	Poor knowledge	23(17.7)	107(82.3)	1	1
	Good knowledge	159 (59.6)	92 (40.4)	6.88 (4.08, 11.60)*	3.99 (2.20, 7.25)**
	Better knowledge	220 (80.9)	52 (19.1)	19.68 (11.44, 23.86*	4.18 (2.05, 8.51)**
Have knowledge of danger signs during L & D	Poor knowledge	20 (25.3)	59 (74.7)	1	1
	Good knowledge	109 (54.8)	90 (45.2)	3.57 (2.00, 6.37) *	3.19 (1.52, 6.71) **
	Better knowledge	250 (71.0)	102 (29.0)	7.23 (4.14, 12.62) **	2.84 (1.34, 6.02)*
Discussed on a place of delivery with spouse	No	75 (27.8)	195 (72.2)	1	**1**
	Yes	304 (84.4)	56 (15.6)	14.11 (9.56, 20.85) *	6.84 (4.17, 11.22)**
Made post natal plan with spouse	No	164 (45.6)	196 (54.4)	1	**1**
	Yes	215 (79.6)	55 (20.4)	4.67 (3.25, 6.71) **	2.30 (1.38, 3.85) **

*$p < 0.01$, **$p < 0.001$, L & D, Labor & Delivery; BPCR, Birth Preparedness and Complication Readiness; DS, Danger signs; COR, Crude Odds Ratio, AOR, Adjusted Odds Ratio; CI, Confidence Interval; Bold values are used as reference to determine association in the model.*

in the discussion process. This is in harmony with the findings of the study conducted in Wolaita Sodo, Southern Ethiopia (23). The possible reasons that might be attributed to the household's joint decisions are more powerful because discussing with the husbands could have a positive impact on maternity care services.

Finally, the study pointed out that participants who had made a postpartum plan with their wife were 2.30 times more likely to participate in BPCR than those who had not made a plan. The findings are also in line with a study conducted in Wolaita Sodo, Southern Ethiopia (23), where a higher proportion of husbands who participated in the process of BPCR were observed in those husbands who had no postpartum plan. The possible explanation is that having no postpartum plan was a significant risk factor that endangered or led to the mother's death due to the first two delays in providing care, which is seeking care and reaching a health facility. As a result, preparing for delivery and postpartum care, as well as dealing with unexpected problems, as soon as possible can save the mother's life. Finally, it is very crucial to give more emphasis on BPCR as pregnancy-related complications continue to be a major cause of maternal deaths in Sub-Saharan Africa. Appropriate preparation for birth preparedness and complications readiness by women, male partners, families, and the community has the potential to lower these preventable risk factors. Moreover, policies, programs, and practices could focus on improving male partners' level of knowledge about complications related to pregnancy and childbirth, and the importance of preparing, and planning for childbirth (9, 14).

Limitations of Study

In this study, due to the nature of the study design, it would be impossible to determine the causal relationship between the variable and the outcome in the analysis. Moreover, as it only involves a participant from rural residences, conclusions for urban could be drawn.

CONCLUSION

According to this study, approximately two out of every five husbands failed to plan for BPCR. Husband participation in BPCR was significantly associated with knowledge of BPCR, knowledge of danger signs during labor and delivery, discussion status on the place of delivery, and making a postpartum plan. Therefore, all stakeholders should give more emphasis on male partners' education in terms of birth preparedness and complication readiness, as well as knowledge of danger signs during labor and delivery. It is also very crucial to encourage male

partners to discuss a place of delivery and have a postpartum plan in place to reduce potential complications related to labor and delivery. Moreover, we also recommend further community-based longitudinal studies triangulated by qualitative methods to identify and explore predictors of a husband's involvement in BPCR.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by ethical approval was obtained from Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University, College of Health and Medical Sciences. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas, took part in drafting, revising, or critically reviewing the article, gave final approval of the version to be published, have agreed on the journal to which the article has been submitted, and agree to be accountable for all aspects of the work.

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Quantifying the primary and secondary effects of antimicrobial resistance on surgery patients: Methods and data sources for empirical estimation in England

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Antimicrobial resistance (AMR) may negatively impact surgery patients through reducing the efficacy of treatment of surgical site infections, also known as the "primary effects" of AMR. Previous estimates of the burden of AMR have largely ignored the potential "secondary effects," such as changes in surgical care pathways due to AMR, such as different infection prevention procedures or reduced access to surgical procedures altogether, with literature providing limited quantifications of this potential burden. Former conceptual models and approaches for quantifying such impacts are available, though they are often high-level and difficult to utilize in practice. We therefore expand on this earlier work to incorporate heterogeneity in antimicrobial usage, AMR, and causative organisms, providing a detailed decision-tree-Markov-hybrid conceptual model to estimate the burden of AMR on surgery patients. We collate available data sources in England and describe how routinely collected data could be used to parameterise such a model, providing a useful repository of data systems for future health economic evaluations. The wealth of national-level data available for England provides a case study in describing how current surveillance and administrative data capture systems could be used in the estimation of transition probability and cost parameters. However, it is recommended that such data are utilized in combination with expert opinion (for scope and scenario definitions) to robustly estimate

both the primary and secondary effects of AMR over time. Though we focus on England, this discussion is useful in other settings with established and/or developing infectious diseases surveillance systems that feed into AMR National Action Plans.

KEYWORDS

antimicrobial resistance, secondary effects, surgical site infection, surgery, burden

Introduction

Surgical site infections (SSIs) place a substantial burden on healthcare systems (1). SSIs, known to be "infections of superficial or deeper tissue occurring within 30 days of non-implant surgery, or within 1-year for implant-related procedures" (2), are costly to the National Health Service (NHS) in England, creating prolonged hospital stays for patients and increased costs for hospitals (3). When considering the additional costs of lost productivity and reduced workforce, the economic burden could be substantially more.

Antimicrobials have allowed us to develop safe patient-care pathways that would previously have put patients at a high risk of SSIs, by the integration of protocols of antibiotic prophylaxis into these pathways. Consequently, the threat of antimicrobial resistance (AMR) goes beyond a reduction of treatment effectiveness for acute infections. Increased AMR reduces the effectiveness, and therefore benefits, of the antimicrobial prophylaxis currently protecting patients from potential infections. For example, increasing the risk of SSIs for those undergoing surgery (4, 5). AMR then has the potential to disrupt the care of these patients through multiple processes, often referred to as the "secondary effects" of AMR (4, 6). Incorporating all such potential future costs for different evaluations of associated interventions is key for efficient policy making. To quantify the burden of these secondary effects of AMR from healthcare system and societal perspectives, potential patient health outcomes, payer and provider cost, and socio-economic data are needed (4).

Primary use of health and economic data can be defined as "use for intended clinical, public health, societal and/or research purposes stated *a priori*," and secondary for purposes other than those stated as primary (7). The primary and secondary use of such data has been highlighted as a key way to tackle AMR through increased knowledge of epidemiology and economic burden, subsequently helping shape the allocation of finite resources. For example, the Global Antimicrobial Resistance Surveillance System was launched in 2015 to promote the collecting of not just microbiological but also outcome data associated with AMR (8), whilst the Wellcome Data Re-use Prize promoted the secondary use of similar AMR data in generating policy recommendations (9).

Though there have been discussions on the importance and use of SSI surveillance data in terms of preventing and improving quality of care in relation to SSIs and surgery patients correspondingly (10), the use of such data in informing the quantification of the secondary effects of AMR has not yet been discussed in detail. There have been reviews that include the quantification of AMR burden in relation to SSIs (11, 12). However, these focus on narrow definitions of AMR burden in relation to SSIs, namely the direct effectiveness of AMR in preventing and treating infections in past or current cohorts of surgical patients. As we have seen from the recent COVID-19 pandemic, there are potentially major costs borne through a capacity or risk threshold being met. There may be an implicit or explicit "occupancy of hospital beds" or "risk of death" threshold being met in unmitigated AMR scenarios. As such, broader treatment behaviors for many patients, and the general population, may need to be changed. For instance, canceling elective procedures in hospitals could in turn can lead to other health and economic burdens to society (13).

We aim to provide a practical discussion of approaches and data sources that have been and/or could be used to estimate the total primary and secondary effects of AMR in relation to surgery, based on literature and available data. In England there is a wealth of national-level data on SSIs, AMR, hospital admissions, population demographics and economic measures (2, 14–16), and as such, this will be the setting utilized. The objectives of this study are to; (i) discuss previous methods used to estimate the primary and secondary effects of AMR in relation to surgery, (ii) discuss potential health and economic data sources available in England, and (iii) based on the methods and data described, propose a conceptual model for quantifying the potential total burden of AMR on surgery patients in England.

Abbreviations: AMR, antimicrobial resistance; HES, hospital episode statistics; NHS, national health service; ONS, office for national statistics; PROMs, patient reported outcome measures; SGSS, second generation surveillance system; SSI, surgical site infection; SSISS, SSI surveillance service.

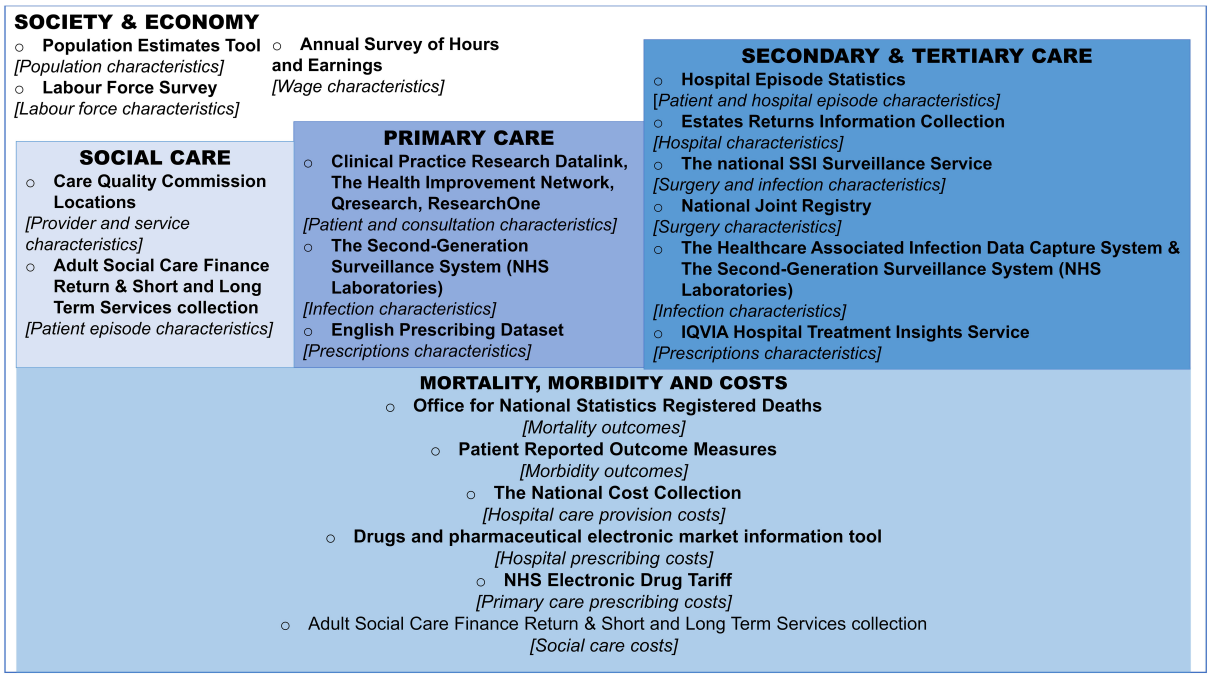

FIGURE 1
Overview of datasets for the estimation of antimicrobial resistance impact on surgery patients in England. Boxes represent the setting and/or type of the data, bullet points represent the name of the dataset, followed by a high-level description the use of the dataset in square brackets, for the purposes of Surgical Site Infection and Antimicrobial Resistance research. For more information on data sources (see Supplementary Table A1). NHS, national health service; SSI, surgical site infection.

Potential health and economic data in england for quantifying total secondary effects

Figure 1 (expanded in Supplementary Table A1) summarizes some of the key datasets available for epidemiology and health economics research for AMR and SSIs in England, highlighting the large breadth of data sources across the healthcare system and wider economy.

In regards to health data, England has a centralized administrative data capture and processing system for hospital admissions and care, known as Hospital Episode Statistics (HES) (16). Secondary use of HES data has, in the past, included the linkage of HES data to other datasets such as to those listed in Figure 1 under "Primary Care" and "Mortality, morbidity and costs." This can be done to have a more complete picture of patients and their care. For example, as HES collects only data based on what happens within hospitals, further information might be needed on post-discharge mortality. Therefore, HES has been linked with Office for National Statistics (ONS) mortality data to incorporate post-discharge mortality (17). Additionally, HES data can be linked to Second Generation Surveillance System (SGSS) data to get more information about infection characteristics (such as microbe type and susceptibility to antibiotics), whilst antibiotic prescribing data and hospital characteristics may be available through linkage with related datasets (see Supplementary Table A1). This is possible due to granularity of these data capture systems, namely the inclusion of patient-level identifiers (such as unique NHS numbers, names, and date of birth) and hospital identifiers (unique provider codes). A patient-level data set, linked across these sources, therefore could be used to estimate the transition probabilities of patients acquiring types of infections, undergoing revision surgery, and the subsequent impact of these different treatment pathways on mortality, as done previously (18).

A previous review suggests the use of prospective, matched cohort studies to estimate the burden of SSIs by infection type (12). However, such studies are resource intensive and can have low external validity unless conducted on a national/international scale. Secondary use of these national microbiology and HES data sources paired with appropriate statistical methods have been utilized in the past to estimate associated mortality from healthcare-associated infections (19–21), and this could be further expanded to capture post-discharge mortality rates (17).

Linkage of hospital patient data to primary care data (see Figure 1) could allow for exploration on the need for additional

patient pathways, such as increased primary care identification of infections, treatment and/or visits following certain infections or procedures. However, although post-discharge Surveillance is encouraged through the national SSI Surveillance Service (SSISS) (2), there can be a delay from the initial procedure to the time that the associated infection is detected, making it harder to define case exposures. For example, there could be up to 1 year from surgery to infection for surgeries requiring the placement of an implant, e.g., artificial joints. When such patients do require hospitalization there is no guarantee that patients will return to the same healthcare facility in which they underwent the related surgery, so any records of infections and surgical procedures need to be cross-referenceable within and between healthcare facilities. This means long-term surveillance of SSIs is required. If basing such estimates on established primary care administrative systems, all three of the primary-care-based administrative systems rely on voluntary inclusion from GP practices and patients, with varying degrees of sample sizes and representativeness across the three systems (22). However, these have still been used for previous analyses of primary care healthcare utilization and population health outcomes within England (23).

Given the median age of elective-surgery patients covered within the national surveillance reports ranges from ∼50 to 85 years old (2), long-term care facility data may also be useful, with a Care Quality Commission directory highlighting post-codes of such facilities that can be matched to patient postcodes (24). Additionally, other social care data sources listed in Figure 2 (and described further in Supplementary Table A1) provide information on long and short-term forms of social care that could be useful for costing purposes, if/when applicable to the patient groups of interest.

The cost-of-illness impact, from the NHS (payer and provider) perspective, of surgery, SSIs and drug-resistant infections can be estimated using the aforementioned linked surveillance-administrative datasets to estimate length of stay and/or "Health Resource Group" (HRG) impact (1, 19). If working directly with patient data, the National Costing Grouper, which confers a core Health Resource Group (HRG) to patients' hospital stays, can be used alongside the National Costing Collection workbook (which provides monetary unit costs per HRG) to calculate patient level costs. If working with excess length of stay estimates, the acute patient level activity and costing for 2019–2020 unbundled-activity gives, by speciality within critical care, the total number of days and total cost (£) submitted to the PLICs Acute collection (25), which could hypothetically be used to estimate applicable proxy costs of an excess bed day [e.g., using "Surgical adult patients (unspecified specialty) had a total of 31,807 days and £47,911,153.33 costs across all data submitted"]. For any additional costs of antibiotic prophylaxis or treatments in the hospital or community, unit costs are readily available across the "drugs and pharmaceutical electronic market information tool" (eMIT), the English Prescribing Dataset and the NHS Electronic Drug Tariff for NHS Trust-hospitals, General Practices and community providers, respectively (26).

For AMR and SSI burden estimation from a societal perspective, utilizing standard methods (e.g., human capital methods where each year of life lost is costed to be equivalent to average annual earnings), the use of labor activity and earnings to estimate lost wages through illness and death is needed, and is available (see Supplementary Table A1) (27). However, with these data, those over 60+ and/or 65+ are grouped making it hard to disentangle contributions across cohorts of interest concentrated above 60 years of age, though of course assumptions can be made on the distribution of wage values across ages 60 and 100. Other methods for calculating a value for a statistical life year, which are broader in scope and/or more nuanced in calculation, are available but require more primary data collection in the English context (27).

As well as monetary costs, policy/AMR-scenario impact on population utility, is an important outcome, necessary for cost-utility analyses utilized by national policy makers (28). Such outcomes are generally a function of mortality impacts (as discussed above) and morbidity impacts. Patient-reported outcome measure data, collected by NHS Digital, have been previously linked to other patient data (such as SSISS) to estimate QALY impacts of different infection prevention strategies for primary hip prothesis in England between 2009 and 2012, with more updated data now available (18, 29).

In terms of data access, although all the patient-based data sources outlined in Figure 1 are not fully open-access due to patient identifiable data and subsequent data safeguarding, summary statistics are published openly. Such summary data are often published through annual reports or summary Excel files downloadable from government websites (see Supplementary Table A1), and could be used to estimate incidence rates at a national-level. Access to patient-level data may be permitted subject to asset owner approval processes, allowing for linkage across systems if appropriate data protection protocols are in place.

In the future there may be an increased ease of secondary use of the data sources outlined in Figure 1 for burden estimation purposes through systems similar to Open SAFELY (30). OpenSAFELY was created to allow for urgent research involving electronic health records in primary care (using TPP SystmOne software and EMIS), SGSS, ONS data and A&E attendance data for COVID-19 (30). Researchers write and test code on dummy versions of health data locally, then the code is submitted to be run on secure servers which hold the real versions of the health data, checked in terms of "disclosivity" before then being released for publication purposes (30).

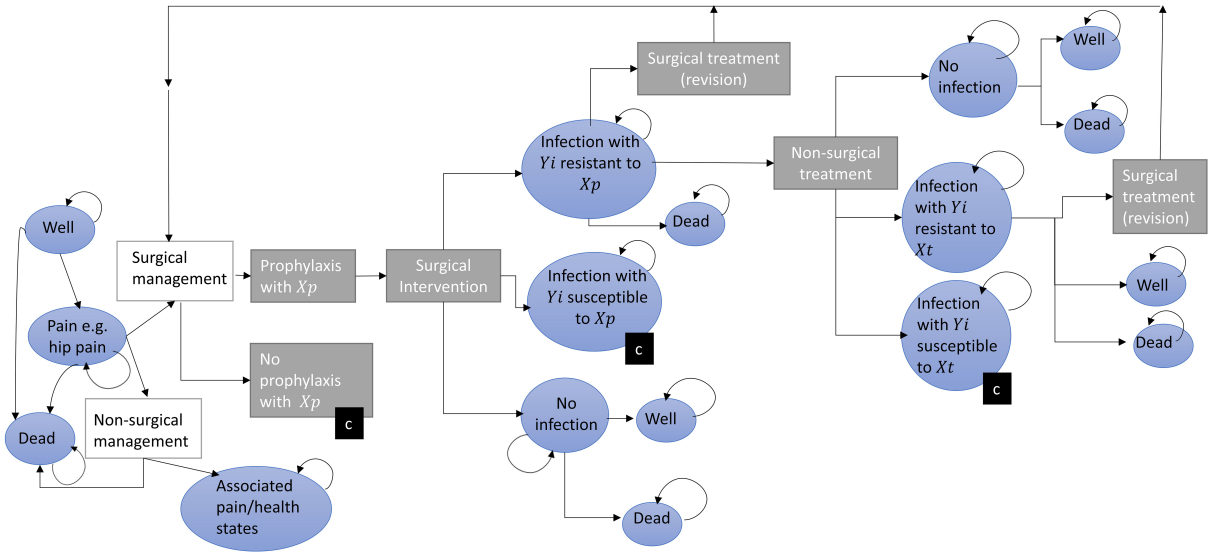

FIGURE 2
A conceptual model for estimating the impact of antimicrobial resistance on surgery patients. The progress of patients through a surgical management pathway with the potential for infection is depicted following from left to right. Patients initially start (far left) in one of three health states (blue circles) and progress through treatment decisions (rectangles). Circles represent health states, rectangles represent pathway treatment decisions, (c) represents a collapsed branch that mirrors that of another branch within that level (for example the pathway following "No Prophylaxis" includes the same transitions and states as "Prophylaxis." *Yi* represents microbes where $i = 1,...,m$ different microbes of clinical importance; *Xp,t* represents antibiotics given for prophylaxis ($p = 1,...,n$) at time *t*, *Tx* represents antibiotics given for treatment of SSI ($t = 1,....,q$). It may be that $p = t$. The length of time patients spends in each state (indicated by a curved returning arrow) is variable.

A conceptual model for estimating the secondary effects for surgery patients

Based on both (i) the existing AMR and SSI literature, and (ii) the data available described above, we propose a state-transition model estimating the primary and secondary effects of AMR, incorporating decision-trees outlining treatment strategies and Markov models outlining potential health states (Figure 2).

For the primary effects, i.e., the direct burden of increased AMR in patients who get surgery and develop SSIs, these pathways can be parameterised with the secondary use of surveillance, administrative and economic data available in England. If outcome data are available at the patient level across hospital stays, statistical models can be utilized to estimate transitions along the patient pathways, adjusting for patient, provider, and socioeconomic characteristics. There are methods available to account for potential sources of bias when dealing with healthcare-associated infections, such as time varying confounding, and other complexities that may occur regardless of study design, such as competing events (19, 21, 31, 32). This allows for more robust patient outcome inclusion, such as cost-of-SSI and mortality impacts (see Supplementary Figure A1 for more detail).

Across the prophylaxis pathway depicted in Figure 2, we highlight that there are the potentially numerous patient pathways with different drug regimens and potential for infection with different organisms. Figure 2 highlights the complexity of this issue, with transition rates and outcomes potentially heterogenous for different drug and bacteria combinations (Supplementary Figure A2 gives a simple example of one drug-bacterial combinations for a portion of this pathway). In practice there is even variation in the antibiotics used across hospitals, with gentamicin and flucloxacillin used for prophylaxis by 57 out of 147 NHS Hospital Trusts and other (differing) antibiotics used across others (33). In a previous cost-effectiveness analysis of strategies to reduce risk of infection following hip replacement therapy, where AMR effects were not incorporated into the equations, a weighted average of the cost of different prophylaxis guidelines between Trusts was used to account for this (18). At an individual level, the specific microbe that caused the infection and type of antimicrobial used to treat it could be important in terms of pathways (and subsequently outcomes and costs), thus the scope of different combinations of prophylactic and therapeutic drug-pathogen exposure definitions (of *Yi* and *Xp,t* in Figure 2 representing different microbes, prophylaxis and treatment antibiotics, respectively) warrant consideration by experts in SSIs depending on the scale of the research question (e.g., local, regional or national).

Inclusion of primary care pathways, in terms of direct effects of AMR on post-surgery patients could be parameterised through linkage of patient data across primary and secondary care settings. Health states presented can have utility values, hospital costs and societal costs attached from Patient Reported Outcome Measure, National Cost Collection and Office for National Statistics datasets, respectively, as discussed in the above section (29, 34, 35). However, expert opinion would be needed to define appropriate case definitions (e.g., time of GP consultation post-surgery/discharge and associated diagnoses "Read" codes). However, for hip surgeries (and other similar, short-stay procedures) it was estimated half of SSIs were captured through readmission surveillance, therefore post-discharge surveillance and linked-HES data to follow (and cost) patients within and across hospitals across the shown post-surgery pathways is key. Average adjusted-wage losses per excess death and days unable-to-work could be estimated through ONS data on employment and wages, and combined with excess deaths and days (e.g., in hospital) counted through (Figure 2) (35).

In a situation of the datasets described in the above section not being accessible at the patient-level, given their coverage they can still be useful in quantifying probabilities of acquiring SSIs. As an example, for hip replacement surgery is under the mandatory surveillance for SSIs, under which 60% undertook continuous surveillance for 2019/20, SSIS reports the incidence of SSI from surveilled hip surgery patients, and the distribution of causative microbes across these SSIs (14). Such reports can therefore be used to estimate transition probabilities across Figure 2 for contracting microbe-specific SSIs following hip replacement surgery in England, alongside assumptions of prophylaxis impact, in the absence of more granular data (see Supplementary Figure A2 for a worked example).

As England has access to longitudinal microbiology data, trends can be determined using these data. Examples of such techniques include simple linear regression or random-walk models, whilst more complex transmission and forecasting modeling methods including seasonality and non-linearity can also be utilized (36). These trends can be included as potential AMR and infection risk scenarios run through the conceptual model (37). However, to parameterise the case of a pan- or extensive-drug-resistant world where current patients would stay in the "no-surgery"/"secondary-effects" pathway, previous cost-effectiveness analyses of the actual surgeries would need to be utilized [for example previous economic evaluations of hip replacement surgeries (38–41)]. There is also the challenge of the increased cost of requiring long-term assisted living for individuals with non-operative management of end-stage osteoarthritis in the elderly population, these costs could be incorporated into Figure 2 by separating out non-surgical management of hip pain and non-surgical treatment of SSIs by settings of care, potentially parameterised by the social care and society demographic data highlighted by Figure 1.

Though previous cost-effectiveness analyses can tell us the general transition probabilities, cost, and utility estimates for a non-surgery scenario, they can't tell us under what AMR and patient-characteristic situations they would occur. Moreover, current SGSS and SSISS data report data on AMR and microbes currently circulating within the healthcare system: a wider scope of scenarios is needed to include microbes and associated drug resistances that may be important in the future, but that aren't currently seen in the data due to low or no numbers (e.g., colistin resistance in Gram-negative infections or a multi-drug resistant *Candida auris*) (6). For this we need expert elicitation of resistance cut-off levels to determine when the "no-surgery scenario" would take effect. Additionally epidemiological forecasting of AMR and infectious disease trends incorporating expert elicitation of predictions for future microbe and AMR importance could be utilized.

Discussion

We first highlight that there are three potential ways for AMR to impact surgery patients including increasing SSI risk, treatment failure risk and risk of operations being unavailable altogether. Highlighted literature indicates that secondary effects could play a substantial role in the burden of AMR in the future, with estimates for lessening antimicrobial effectiveness including an additional 6,300 deaths per year in the USA and a loss of 2% of world Gross Domestic Product, across different scenarios (4, 42). However, many of the discussed estimates of burden did not sufficiently incorporate uncertainty and/or did not use an explicit mathematical modeling framework that can be practically used and adapted, according to need. A conceptual model utilizing decision trees and Markov models could be used in estimating the potential impacts of AMR on surgery patients, if scoped appropriately and parameterised robustly. The conceptual model constructed within this study highlights the nuance of AMR for SSIs across all pathways, through the acknowledgment of the different potential antimicrobial usage exposures, microbe exposures and treatment options.

The scope for the secondary use of health data in establishing SSI and AMR burden for parameterising transition probabilities, costs and mortality for associated infections occurring in a health system is large. The retrospective use of such data may allow for reduced research burden in parameterising our proposed conceptual model. Even national-level, aggregated data can be used in estimating transition probabilities if data are externally valid. This, in turn, highlights another benefit to SSI surveillance, which already has been shown to reduce SSI rates themselves through benchmarking and outlier identification functions (10). The secondary use of such data, as described here, may be a consideration in the cost-benefit case of public health surveillance itself. Additionally, many of the data sources collated and described within this study are of use in estimating

impacts of AMR on other syndromes and clinical specialities, such as respiratory or bloodstream infections treated in primary and secondary care settings.

Earlier published studies have highlighted the need for standardized SSI surveillance protocols such as defined follow up length and data entry methods (12). Our review highlights the benefits of established surveillance systems being able to be readily linked across microbe-, susceptibility- and mortality-surveillance and administrative datasets at the patient-level. Such linkage allows for a greater understanding of the impact of AMR and SSIs on patient outcomes and health system costs, with this being feasible in the NHS through the capture of consistent patient identifiers (unique NHS number, date of birth, sex) across systems (43, 44). However, with patient identifiable and confidential data comes a responsibility to have robust information governance and data protection protocols in place (7, 44). For example, for the surveillance system within England, there is strict adherence to handling patient data in accordance with the Data Protection Act 2018, General Data Protection Regulations (GDPR) and the Caldicott Guidelines (45). Examples of processes that aid this include establishing policy on how long data are held for, who can access the data and how data can be shared. It has been suggested that specifying ethical and privacy principals, and linking these to governance and data access can help with public trust in data capture systems (46), a key factor in having robust data for primary and/or secondary use. With new data access frameworks being explored, such as OpenSAFELY (30), there is increased scope for a reduction in the transfer of patient-level data across parties for research purposes in the future.

However, even with access to current data, data completeness needs to be reviewed. Taking completeness to be in terms of documentation (i.e., are all the available fields filled in and available for use) (47), about 80% of patients in SSISS had a NHS number in a previous analysis, even after doing additional patient tracing to retrieve some missing numbers, and therefore patient-level linkage across numerous datasets may bias subsequent estimates of transitions and outcomes if there are systematic reasons for data non-completeness (18). The completeness of patient data in the SSISS is high for mandatory surveillance in terms of case identification (2), though it is only mandatory to carry out surveillance "for a minimum of 3 consecutive months per financial year in at least one of 4 orthopedic categories: hip replacement, knee replacement, repair of neck of femur or reduction of long bone fracture" (2). This means data for other surgeries may not be fully representative of English surgical patients and SSIs. This could include cesarean or lower bowel surgery patients, who represent a large proportion of the overall burden to the NHS (1, 48). However, the number of operations submitted for 2019/20 for voluntary SSI surveillance showed a 9% increase in comparison to 2018/19, with 27,877 procedures submitted voluntarily in 2019/20 (2). Furthermore, one could use weighting or post-stratification techniques to obtain representative estimates if variables determining selection into the sample are available (49).

Only a few infection types, mainly bacteraemia and notifiable infections, are listed as mandatory surveillance within relevant data capture systems, and as such the epidemiological data for other pathogens could be biased. However, such data has been routinely used to present AMR data at the national level in England (14) and a 2020 report comparing mandatory and voluntary submissions found a high ascertainment rate comparing across the systems (for bacteria present in both systems) (50). In the absence of surveillance systems, routinely collected HES data may be useful for infection rates and patient outcomes, with routinely collected data to estimate rates of SSIs being found to have sensitivities ranging from 60 to 98% (10, 51), though this would likely not provide information on microbe or AMR.

Though PROMs data are theoretically available for certain patients, it is only available for certain surgeries (hip and knee replacement) (52). Moreover, even when these data are available, they may not be useful for our intended purpose. A previous analysis had to revert to using literature as PROM's data weren't available for their SSI case definitions (e.g., within 14 days of the date of infection) (18). For international comparisons where Disability-Adjusted Life Years may be wanted (instead of Quality-adjusted life years), a large European study is available, where disability weights for SSI states are based on previous observational studies which have elicited utility values (53). From a patient perspective, administrative datasets in NHS England described in this review do not account for patient-level costs, though these data may be available in insurance-based healthcare systems (7).

Regarding the HRG and excess length of stay unit costing, England is currently undergoing the NHS England and NHS Improvement's Costing Transformation Programme. This was piloted in 2016 and had annual stages of increased implementation subsequently. Therefore, currently such data come with potential data quality issues given these are the first few years of the new Patient-Level Information and Costing system, though this bias should decrease over time if systems and processes remain unchanged (54).

Even with complete and secure data systems in place, this review deduces that the secondary use of health data cannot be used solely to parameterise a secondary effects model for AMR and SSIs. Prospective trials of SSI prevention measures, patient and public elicitation for utility values, alongside expert elicitation studies for "post-antibiotic" scenario understanding are needed. A 2019 literature review calls for more evidence from primary studies on the intervention effectiveness of different SSI prevention techniques (12). Such data normally come from randomized-control trials rather than secondary use of health data, although even trials are now making use of routinely

collected data to inform primary trials and/or for longer follow-up period (55).

Additionally, the model currently depicts a simplified picture of "prophylaxis" vs. "no prophylaxis" comparison of surgical management pathways, as in addition to antimicrobial prophylaxis, there are several interventions to prevent SSIs, such as using sterile gowns or changing surgical instruments prior to wound closure (12), many of which are recommended for surgery undertaken in England (56). These pathways can be added to the core framework outlined here as and when necessary, with scope of the model pathways best extended based on expert opinion for specific surgeries or settings. As has been done in more general AMR burden estimation models (37). The proposed conceptual model recommends AMR scenario dynamics be included through external trend analyses and expert elicitation to then feed epidemiological parameters directly into the state transition model, which has been done in more general AMR burden estimation models (37). The conceptual model could be expanded into incorporate transmission dynamics but would require more health states (representing other reservoirs of antibiotic usage and resistance) and therefore potentially more data. The model can also be run for different intervention scenarios related to antimicrobial stewardship and/or SSIs, subsequently comparing costs and effects across scenarios to determine the cost-effectiveness of such interventions.

While here we do not make specific recommendations related to the general health economic approach of quantifying our conceptual model, general guidelines are available elsewhere for health economic modeling (28, 57), the reporting of which is currently lacking from some studies that have attempted to quantify secondary effects of AMR (4, 42). Based on standard guidelines, the England case study should take an NHS perspective [as recommended by NICE for the base case (28)], cover the lifetime of a hypothetical cohort to capture the potential long-term impacts, and use a 3.5% discount rate for future costs and a 1.5% discount rate for quality-adjusted life years declining over 30 years as recommended by the Treasury (58). Using this approach, parameter and methodological uncertainty can be tested by varying parameter values, discount rates and time horizon through one-way and probabilistic sensitivity analyses. Structural uncertainty and heterogeneity could also be explored in further iterations of Figure 1, by adapting pathways and including specific subgroups if sufficient data are available. With such modeling approaches, a broader perspective is enabled through the inclusion of labor productivity cost proxied by national wage and employment data (59). However, there may be a need in the future to explore the effects of presenteeism impacts (i.e., incorporate not only loss of work productivity through hospital stay or death, but also general loss of work productivity for patients along different pathways) (60), and also explore informal market production impacts (27, 59).

Though we have currently focused on the secondary use of health data in the NHS, the findings are applicable to settings where similar datasets are available. A 2018 review found 56 healthcare-associated infection and AMR surveillance systems from 20 countries within Europe, with 32 SSI surveillance systems included (61). This indicates that there is already a large potential resource for understanding the secondary effects of AMR considering the proposal outlined in our review. We have also focused on SSIs, but secondary use of cancer patient data may be explored in a similar manner; through national cancer registration data linked to other surveillance and administrative data (44).

In conclusion, AMR is a complex phenomenon which has the potential to alter health outcomes for patients who contract drug resistant SSIs and change surgery patient pathways due to secondary effects. Though the secondary use of health data, in the English setting, has the potential to parameterise models quantifying the former, it falls short of being able to quantify the latter in isolation. However, such data can be combined with expert elicitation to parameterise a health state transition model that incorporates primary and secondary impacts of AMR on surgery patients over time. With growing SSI and AMR surveillance systems globally, alongside expert elicitation and investigations into potential future epidemiological scenarios, we can begin to understand the potential secondary effects of AMR through the application of the proposed conceptual model in other settings, and therefore understand how to deal with this phenomenon more efficiently.

Author contributions

NN and SE reviewed the literature, reviewed the datasets, constructed the conceptual model diagram, and wrote the initial drafts of the manuscript. JR managed the project and contributed to study design. JR and RA secured funding for the project. KP, RT, TL, BM-P, and GK provided technical guidance on data and methods and/or literature cited. All authors aided in drafting the manuscript and approved the submitted manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Dynamic structures and emerging trends in the management of major trauma: A bibliometric analysis of publications between 2012 and 2021

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Objective: Major trauma is currently a global public health issue with a massive impact on health at both the individual and population levels. However, there are limited bibliometric analyses on the management of major trauma. Thus, in this study we aimed to identify global research trends, dynamic structures, and scientific frontiers in the management of major trauma between 2012 and 2021.

Methods: We searched the Web of Science Core Collection to access articles and reviews concerning the management of major traumas and conducted a bibliometric analysis using CiteSpace.

Results: Overall, 2,585 studies were screened and published by 403 institutions from 110 countries/regions. The most productive country and institution in this field of research were the USA and Monash University, respectively. Rolf Lefering was the most prolific researcher and Holcomb JB had the most co-citations. *Injury* published the highest number of articles, and the *Journal of Trauma* was the most co-cited journal. A dual-map overlay of the literature showed that the articles of most publications were confined to the areas of medicine/medical/clinical and neurology/sports/ophthalmology. Document clustering indicated severe traumatic brain injury, traumatic coagulopathy, and resuscitative endovascular balloon occlusion as the recent hot topics. The most recent burst keywords were "trauma management," "neurocritical care," "injury severity," and "emergency medical services."

Conclusion: The dynamic structures and emerging trends in the management of major trauma were extensively analyzed using CiteSpace, a visualization software. Based on the analysis, the following research hotspots emerged: management of severe traumatic brain injury and massive hemorrhage, neurocritical care, injury severity, and emergency medical service. Our findings provide pertinent information for future research and contribute toward policy making in this field.

KEYWORDS

major trauma, management, bibliometric analysis, visualization, CiteSpace

Introduction

Major trauma is a life- or limb-threatening injury caused by a blunt force, penetrating injury, or burn injury. The Injury Severity Score (ISS) is a crucial element of the trauma system evaluation, with ISS scores ≥ 16 indicating major or severe trauma (1, 2). In the United States, the mortality rate of people with major trauma is 20%, and many survivors remain permanently disabled (3). Major trauma is currently a global public health issue (4), the main cause of death in the first four decades of life, and a major cause of potential loss of years of life (5). Efficient management of major trauma is of paramount importance in improving care quality and decreasing mortality (6). Many laboratory studies and clinical trials on the management of major trauma have been conducted over the last decades (7–10). However, there is a lack of summary and evaluation of publishing output trends; influential countries, regions, institutions, and authors; the current state of knowledge; and frontier trends in research related to the management of major trauma.

A bibliometric analysis is a quantitative analysis tool to examine the characteristics of literature, recent developments, and research hotspots (11). The bibliometric methodology has become popular and is increasingly being used in medical research (12). Contrary to systematic reviews and meta-analyses, bibliometric analyses aim to construct a citation network by summarizing publications using performance analysis and science mapping. Consequently, bibliometric analyses contribute toward bridging gaps in current knowledge and facilitating the creation of new directions (13). CiteSpace is an extensively used scientific software that identifies and visualizes the current knowledge domain, detects trending topics in the literature, and indicates future research directions (14). Though other popular tools such as Vosviewer and Biblioshiny exist, CiteSpace was one of the main tools used in several bibliometric analyses (15–17). Therefore, the aim of this study was to conduct a bibliometric analysis using CiteSpace to analyze the current state of knowledge, explore the evolutionary path of severe trauma management, and identify emerging trends in the management of major trauma.

Materials and methods

Data acquisition

Data were retrieved from the Web of Science Core Collection (WoSCC), and the search strategy was as follows: (TI = "management") and (TI = "major trauma*" OR "severe trauma*" OR "severe injur*"). The symbol "*" was used as a wildcard, representing one or more letters. First, two researchers (ZZW and FZG) independently searched the original data on a single day (July 15, 2022) and then discussed the possible differences. Next, the search string was finally determined and confirmed by the two researchers. The final agreement level reached 0.95, showing substantial consistency. The period of interest was 2012–2021. The publication types were confined to original articles and reviews, and only studies published in English were included (18). The screening process is illustrated in Figure 1.

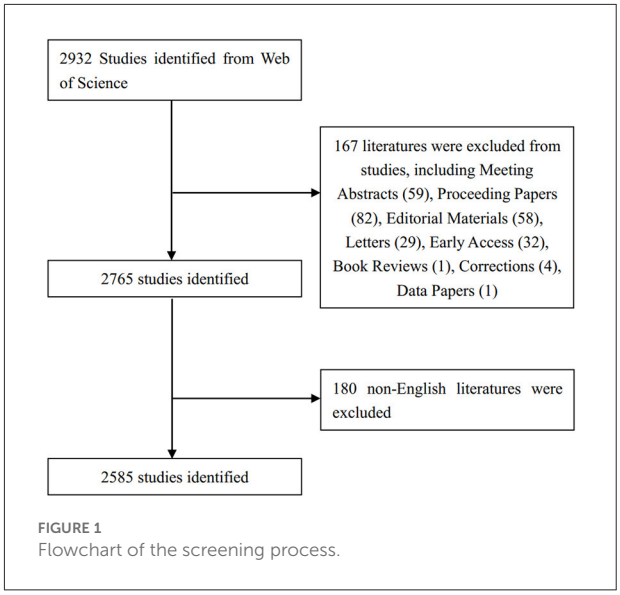

FIGURE 1
Flowchart of the screening process.

Data analysis and visualization

The CiteSpace software (5.8. R3), developed by Chen Chaomei from Drexel University (18), was used to visualize collaboration networks (countries/regions, institutions, and authors), analyze co-citations (authors, journals, and references), create dual-map overlays, and determine reference citation bursts and keyword co-occurrences. The specific parameters were as follows: time slicing (from January 2012 to December 2021; years per slice = 1), text processing (title, abstract, author keywords, and keywords plus), node type (one option chosen at a time from a country, institution, author, co-cited journal, co-cited author, keywords, and co-cited reference), link strength (cosine), link scope (within slices), selection criteria (g-index, $k = 25$), and pruning (none).

The journal citation reports (JCR), 2021 impact factor (IF), and JCR division of analyzed journals were obtained from the Web of Science.

Results

Analysis of publications and citations

In total, 2,585 papers related to the management of major trauma were screened for subsequent visualization and analysis.

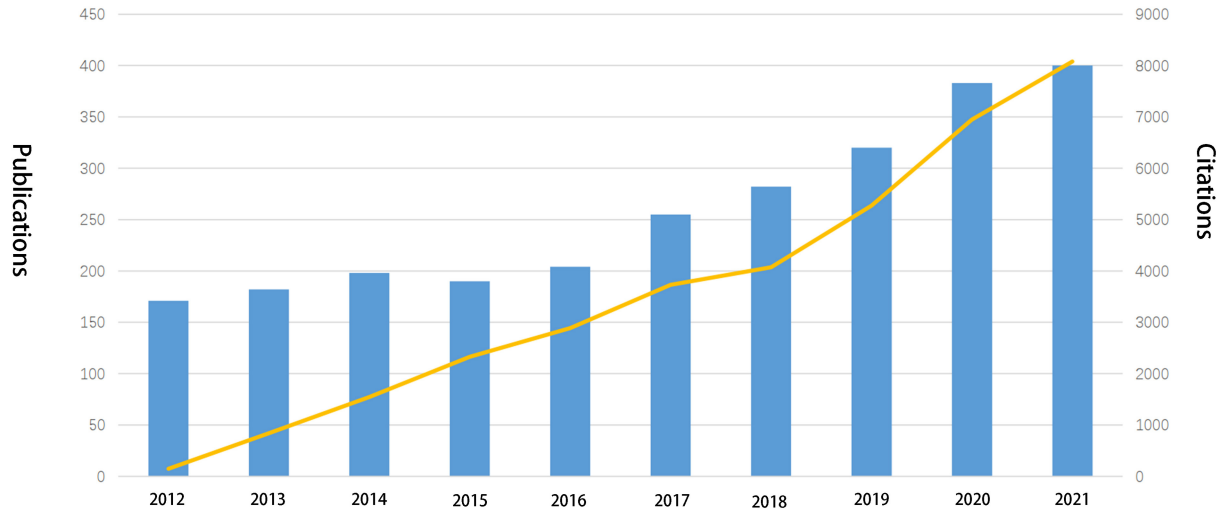

FIGURE 2
Temporal distribution map of publications and citations.

TABLE 1 The top 10 productive countries/regions and institutions.

Rank	Countries/regions	Count	Centrality	Year	Rank	Institutions	City	Count	Centrality	Year
1	USA	753	0.3	2012	1	Monash Univ	Melbourne	90	0.1	2012
2	England	446	0.11	2012	2	Univ Washington	Seattle	77	0.14	2012
3	Australia	225	0.09	2012	3	Alfred Hosp	Melbourne	52	0.04	2012
4	Germany	183	0.05	2012	4	Univ Pittsburgh	Pittsburgh	48	0.15	2012
5	Peoples R China	155	0.08	2012	5	Univ Sydney	Sydney	43	0.06	2012
6	Canada	150	0.09	2012	6	Univ Toronto	Toronto	42	0.06	2012
7	Italy	135	0.06	2012	7	Univ Cambridge	Cambridge	40	0.06	2016
8	France	135	0.06	2012	8	Univ Maryland	Washington	37	0.05	2012
9	Japan	75	0.04	2013	9	Univ Witten Herdecke	Cologne	32	0.06	2012
10	Netherlands	73	0.03	2012	10	Uniformed Serv Univ Hlth Sci	Bethesda	31	0.04	2013

There was generally a growing trend in the numbers and citations of publications from 2012 to 2021, with the lowest in 2012 ($n = 171$, citations = 148) and the highest in 2021 ($n = 400$, citations = 8,079) (Figure 2). Consequently, it is indicated that major trauma is gaining continuous attention and more research is being conducted in this field.

Distribution map of countries/regions and institutions

A total of 403 institutions from 110 countries/regions contributed to the research on the management of major trauma. As shown in Table 1, the most productive countries were the USA (753), followed by England (446) and Australia (225). The top three institutions were Monash University (90), the University of Washington (77), and Alfred Hospital (52). In Figure 3, the purple ring indicates the centrality of literature (19). Some countries and institutions had high centralities, such as the USA (0.3), England (0.11), the University of Pittsburgh (0.15), the University of Washington (0.14), and Monash University (0.1). Links between nodes signify relationships of collaboration (19), and dense connections indicate active cooperation among countries and affiliations.

Visual analysis of authors and co-cited authors

Each node is labeled by the corresponding author, and the linkage between the two nodes indicates that the two authors cooperated to conduct the research, the details of which were

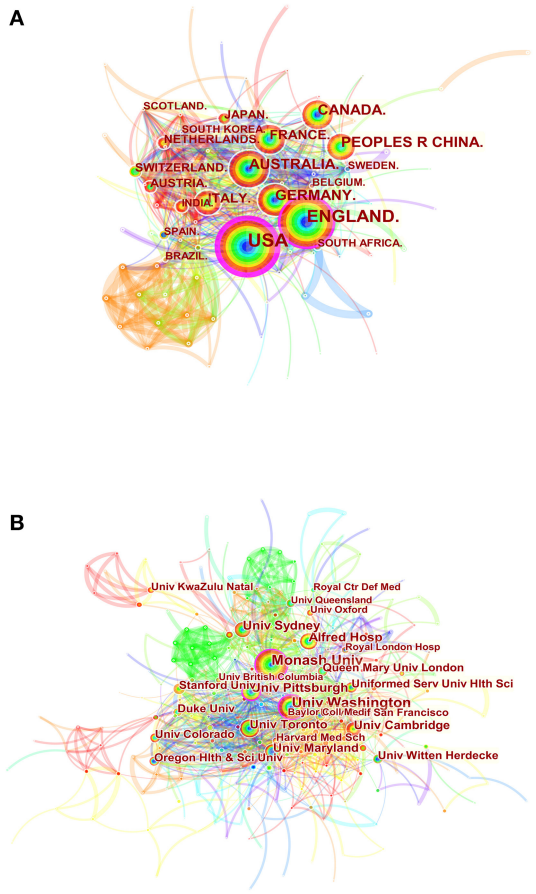

FIGURE 3
Spatial distribution map of countries/regions **(A)** and institutions **(B)**. Each circle in the diagram represents a nation/institution, with the size of the circle indicating the country/institution's publishing output. The lines that connect the circles represent international collaboration, and the broader the lines, the stronger the cooperation. The colors of the node and line represent different years, and the warmer the color, the more recent the time of publication.

documented in the same paper (20). As shown in Figure 4A and Table 2, 474 authors contributed to the research on the management of major trauma. The most productive author was Rolf Lefering (26), followed by Kenji Inaba (19), Marc Maegele (17), and Mark Fitzgerald (17). The density of the network was 0.0104, indicating that the authors had not formed strong collaborative relations. There are only two authors, for whom the betweenness centrality was more than 0.1: Kenji Inaba (0.15) and Randall M. Chesnut (0.13).

When two scholars are cited in the same publication, an author co-citation relationship occurs. The closer the linkage between the two nodes, the more frequently the two authors are cited in the same paper (20). As shown in Figure 4B and Table 2, the top three most highly cited authors were Holcomb JB (201 citations), Maas Air (194 citations), and Baker SP (178 citations). However, betweenness centralities were relatively low among them (<0.1).

Visual analysis of journals and co-cited journals

In this study, 2,585 papers concerning the management of major trauma were published in 200 journals, the top 10 of which are listed in Table 3. The most productive journal was *Injury* that published 134 related papers, followed by the *Journal of Trauma and Acute Care Surgery* (92), and the *European Journal of Trauma and Emergency* (61). The journals with the most citations included the *Journal of Trauma* (1,546 citations), *Injury* (1,028 citations), the *Journal of Trauma and Acute Care Surgery* (1,546 citations), *The Lancet* (1,546 citations), and the *New England Journal of Medicine* (1,546 citations). All journals were categorized as Q1 or Q2 in the JCR 2021, except for *Injury*.

The dual-map overlay of the literature is shown in Figure 5. In the visual representation, the left clusters represent where the retrieved records are published, whereas the right clusters indicate where they are cited (21). As shown in the figure, our dataset contained four main citation paths. The domains most frequently covering the records were: (1) 2. medicine, medical, clinical and (2) 8. neurology, sports, ophthalmology. The literature was mostly influenced by the following domains: (1) 8. molecular, biology, agents; (2) 5. health, nursing, medicine; and (3) 7. psychology, education, social. Publications from multiple domains contribute to the citation landscapes, indicating a multidisciplinary aspect of opinion mining (21).

Analysis of co-citation and clustering network

The generation of reference co-citation map resulted in 761 nodes and 3,382 links (Figure 6A). The first article was published in 2017 by Nancy Carney in terms of citation frequency (22). This article synthesized the available evidence and provided recommendations for the management of severe traumatic brain injury. Another guideline published by Donat R. Spahn in 2013 ranked second (23). The retrospective analysis published by Herbert Schöchl in 2010 (24) ranked third; it pointed out that ROTEM® -guided hemostatic therapy, with fibrinogen concentrate as first-line hemostatic therapy and additional prothrombin complex concentrate, was goal-directed and fast. More details pertaining to the top 10 cited references are presented in Table 4.

The network has a modularity value of 0.727 and an average silhouette score of 0.9026 that is considered very high, suggesting that the clustering is highly reliable (Figure 6B).

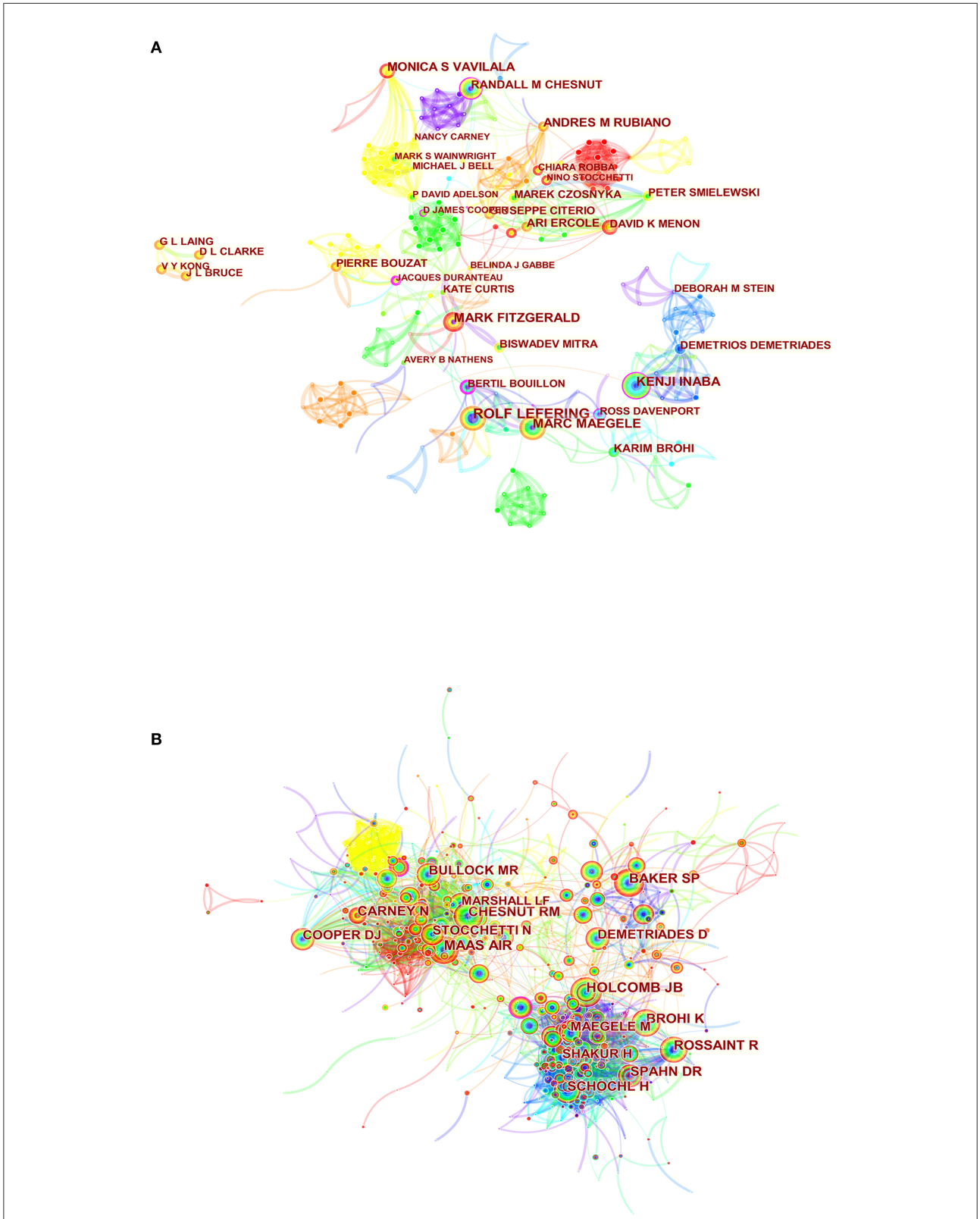

FIGURE 4
Visual analysis of authors **(A)** and co-cited authors **(B)**. The node size represents the number of studies published by the author, with larger nodes representing a higher number of publications. The closer the collaboration between two writers, the shorter the distance between two nodes. The purple nodes represent early published articles, while the red nodes represent recently published articles.

TABLE 2 The top 10 authors and co-citation authors.

Rank	Authors	Institutions	Count	Centrality	Year	Rank	Authors	Institutions	Citations	Centrality	Year
1	Rolf Lefering	University of Witten/Herdecke	26	0.03	2012	1	Holcomb JB	University of Alabama at Birmingham	201	0.02	2012
2	Kenji Inaba	University of Southern California Medical Center	19	0.15	2013	2	Maas Air	Antwerp University Hospital and University of Antwerp	194	0.03	2012
3	Marc Maegele	University of Witten/Herdecke	17	0.03	2012	3	Baker SP	Johns Hopkins University Bloomberg School of Public Health	178	0.01	2012
4	Mark Fitzgerald	The Alfred Hospital	17	0.03	2012	4	Chesnut RM	University of Washington	176	0.03	2012
5	Andres M Rubiano	El Bosque University	16	0.04	2013	5	Schochl H	AUVA Trauma Center Salzburg	170	0.02	2012
6	Monica S Vavilala	University of Washington	15	0.05	2014	6	Spahn DR	University Hospital of Zurich	165	0.01	2012
7	Randall M Chesnut	University of Washington	14	0.13	2012	7	Brohi K	Queen Mary University of London	158	0.01	2012
8	Ari Ercole	Addenbrooke's Hospital	13	0	2016	8	Carney N	Oregon Health and Science University	158	0.01	2017
9	Karim Brohi	The Alfred Hospital	13	0.03	2012	9	Rossaint R	Rhineland-Westfalen Technical University Hospital	153	0.07	2012
10	Demetrios Demetriades	University of Southern California Medical Center	12	0.02	2013	10	Cooper DJ	Monash University	127	0.05	2012

TABLE 3 The top 10 journals and co-cited journals.

Rank	Journals	Count	JCR	IF	Co-cited journals	Co-citations	JCR	IF
1	Injury	134	Q3	2.687	The Journal of trauma*	1,546	-	-
2	Journal of trauma and acute care surgery	92	Q2	3.697	Injury	1,028	Q3	2.687
3	European journal of trauma and emergency	61	Q3	2.374	Journal of trauma and acute care surgery	800	Q2	3.697
4	Scandinavian journal of trauma resuscitation	52	Q2	3.803	Lancet	734	Q1	202.731
5	Journal of neurotrauma	45	Q2	4.869	The New England journal of medicine	723	Q1	176.079
6	World neurosurgery	42	Q4	2.21	Critical care medicine	713	Q1	9.296
7	Emergency medicine journal	35	Q3	3.814	Critical care	685	Q1	19.334
8	Critical care	31	Q1	19.334	Journal of neurotrauma	630	Q2	4.869
9	PLOS one	30	Q3	3.752	Annals of surgery	602	Q1	13.787
10	BMJ open	28	Q4	3.006	Journal of neurosurgery	555	Q1	5.408

*This journal was continued by Journal of trauma and acute care surgery since 2011.

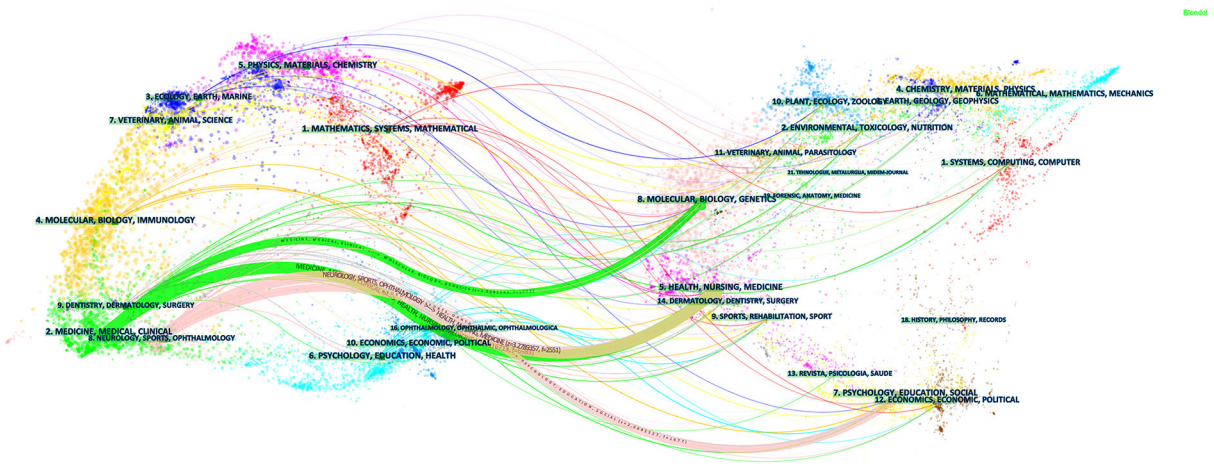

FIGURE 5
A dual-map overlay of the science mapping literature. The citing journals are on the left, the cited journals are on the right, and the colored path represents the citation relationship. Citation trajectories are distinguished by citing regions' colors. The thickness of these trajectories is proportional to the z-score-scaled frequency of citations.

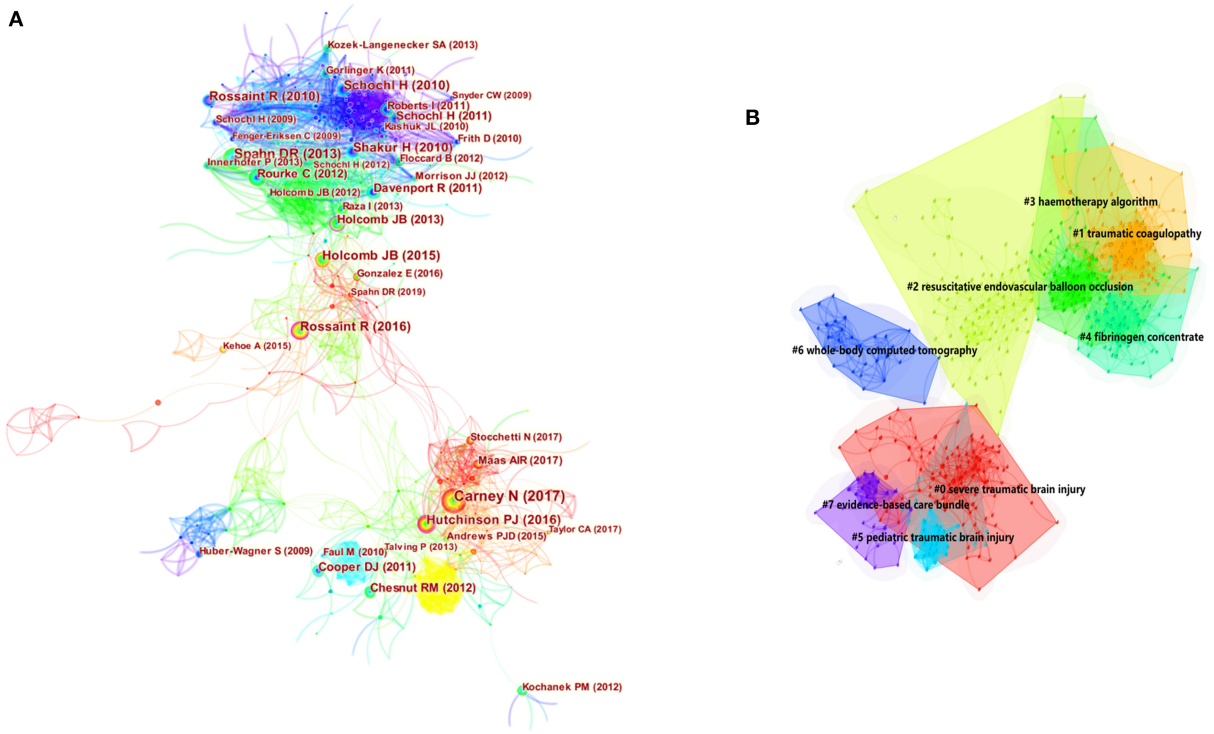

FIGURE 6
Visual analysis of co-citation **(A)** and clustering network **(B)**. Each circle represents a reference. The size of the circle is proportional to the citation frequency. The link between the two circles represents two references cited in the same article among the citing articles. Line thickness is positively correlated with co-citation frequency.

The areas of different colors represent the time when the co-citation links appeared for the first time. The brighter the color, the closer the average year of one cluster was to the present (20, 25). Clusters were labeled with title terms extracted from the citing articles, using the log-likelihood ratio (LLR) algorithm. Figure 6B shows eight clusters, including #0

TABLE 4 Top 10 co-cited references.

Rank	Year	Title	Journal	Co-citations
1	2017	Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition	Neurosurgery	146
2	2013	Management of bleeding and coagulopathy following major trauma: an updated European guideline	Critical care	104
3	2010	Goal-directed coagulation management of major trauma patients using thromboelastometry (ROTEM)-guided administration of fibrinogen concentrate and prothrombin complex concentrate	Critical care	72
4	2015	Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs. a 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial	JAMA	65
5	2010	Management of bleeding following major trauma: an updated European guideline	Critical care	65
6	2016	The European guideline on management of major bleeding and coagulopathy following trauma: fourth edition	Critical care	61
7	2016	Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension	The New England journal of medicine	61
8	2010	Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant hemorrhage (CRASH-2): a randomized, placebo-controlled trial	Lancet	61
9	2012	A trial of intracranial-pressure monitoring in traumatic brain injury	The New England journal of medicine	55
10	2012	Fibrinogen levels during trauma hemorrhage, response to replacement therapy, and association with patient outcomes	Journal of thrombosis and hemostasis	50

severe traumatic brain injury, #1 traumatic coagulopathy, #2 resuscitative endovascular balloon occlusion, #3 hemotherapy algorithm, #4 fibrinogen concentrate, #5 pediatric traumatic brain injury, #6 whole-body computed tomography, and #7 evidence-based care bundles. The color of the convex hull of each cluster indicates recent research topics, including cluster #0 severe traumatic brain injury, #1 traumatic coagulopathy, and #2 resuscitative endovascular balloon occlusion.

The top 30 references with the strongest citation bursts between 2012 and 2021 were identified (Figure 7). References with strong values in the strength column tend to be significant milestones in science mapping research. For instance, in this study, the first milestone paper was a guideline for the management of bleeding and coagulopathy following a major traumatic injury (23), and the next milestone was a guideline for the management of severe traumatic brain injuries (22).

Visual analysis of keywords

We generated a network map of keywords consisting of 514 nodes and 4,223 links (Figure 8A). In the top 20 keywords listed in Table 5, the popular keywords were "management," "traumatic brain injury," "mortality," "major trauma," and "injury," all of which had high citations.

The keyword "timezone view" displays the evolution of high-frequency keywords. Figure 8B shows the research hotspots in the management of major trauma. From 2012 to 2016, research keywords focused on "management," "trauma," "risk factor," "trial," and "emergency department". These keywords indicate the research mainly involved in clinical practice or trials. From 2017 to 2021, the primary terms were "model," "trauma management," "neurocritical care," "emergency medicine," and "biomarker." These results indicate that researchers may pay more attention to advanced technology, newer methods, strict administration, and fundamental research.

The top 30 keywords with the strongest citation bursts are shown in Figure 9. The keyword "fresh frozen plasma," emerging in 2012, showed the strongest citation burst of 11.72. The most recent burst keywords were "trauma management," "neurocritical care," "injury severity," and "emergency medical service," revealing research trending over time and reflecting future hotspots (26).

Discussion

General information

Major trauma considerably affects health at both the individual and population levels (27). Previous literature

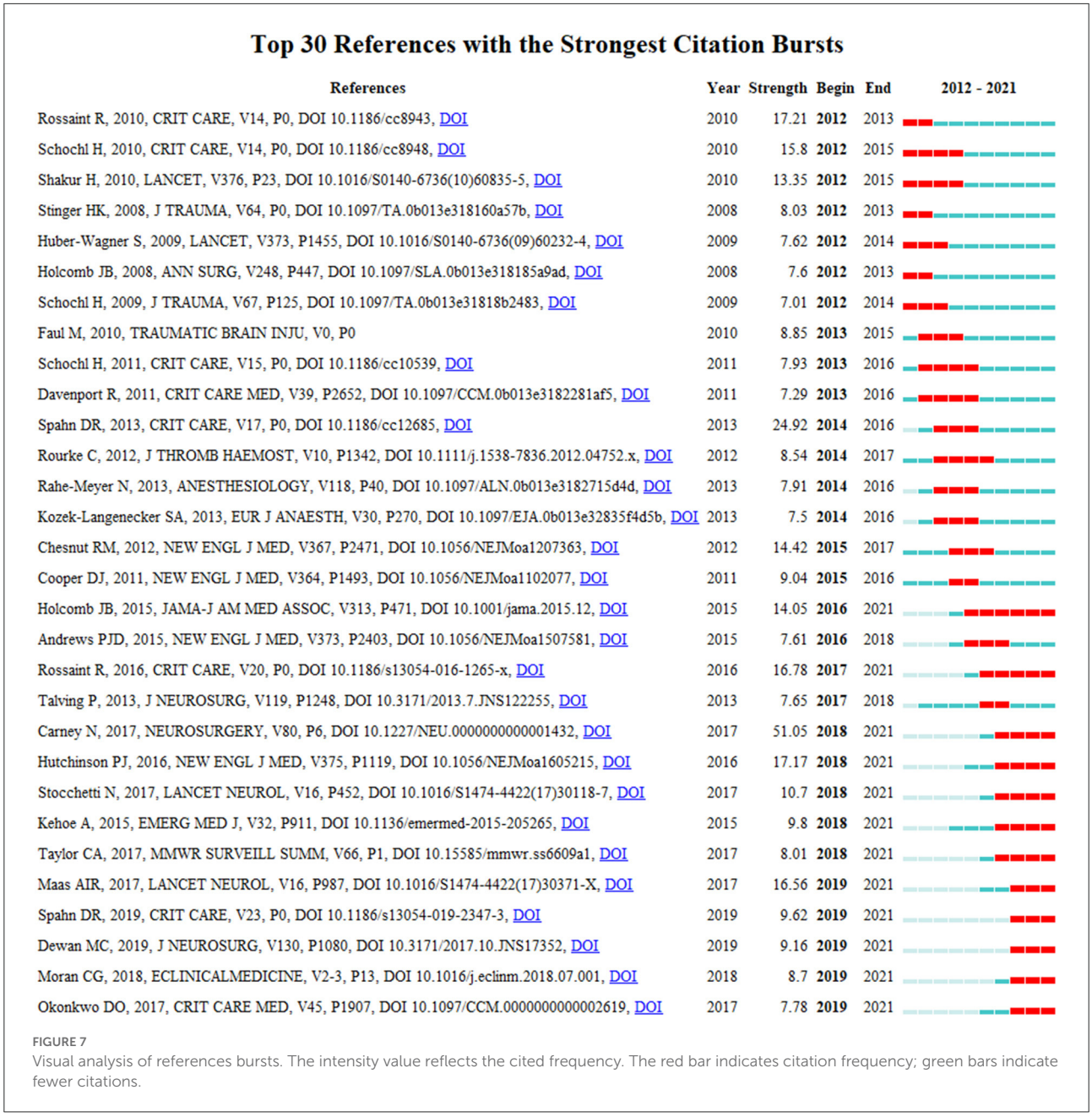

FIGURE 7
Visual analysis of references bursts. The intensity value reflects the cited frequency. The red bar indicates citation frequency; green bars indicate fewer citations.

reported bibliometric analysis of severe traumatic brain injury (28), spinal cord injury (29), traumatology (30), etc. As bibliometric studies concerning major trauma are scarce, this study, to the best of our knowledge, is the first bibliometric analysis of the dynamic structures and emerging trends in the management of major trauma between 2012 and 2021. After the screening process, we found that over the last decade, a total of 474 authors from 403 institutions in 110 countries published 2,585 papers related to the management of major trauma in 200 academic journals. We used CiteSpace to evaluate the networks of co-authors' countries/institutions, co-authorship, author co-citations, journal co-citations, document co-citations, and co-occurring keywords, to identify the knowledge domain and frontier trends in the management of major trauma.

The analysis of the network of co-authors' countries/regions and institutions (Table 1; Figure 3) showed that the USA, England, and Australia were the top three nations in terms of the number of publications related to the management of major trauma. The USA has the highest betweenness centrality (0.3), indicating that it plays

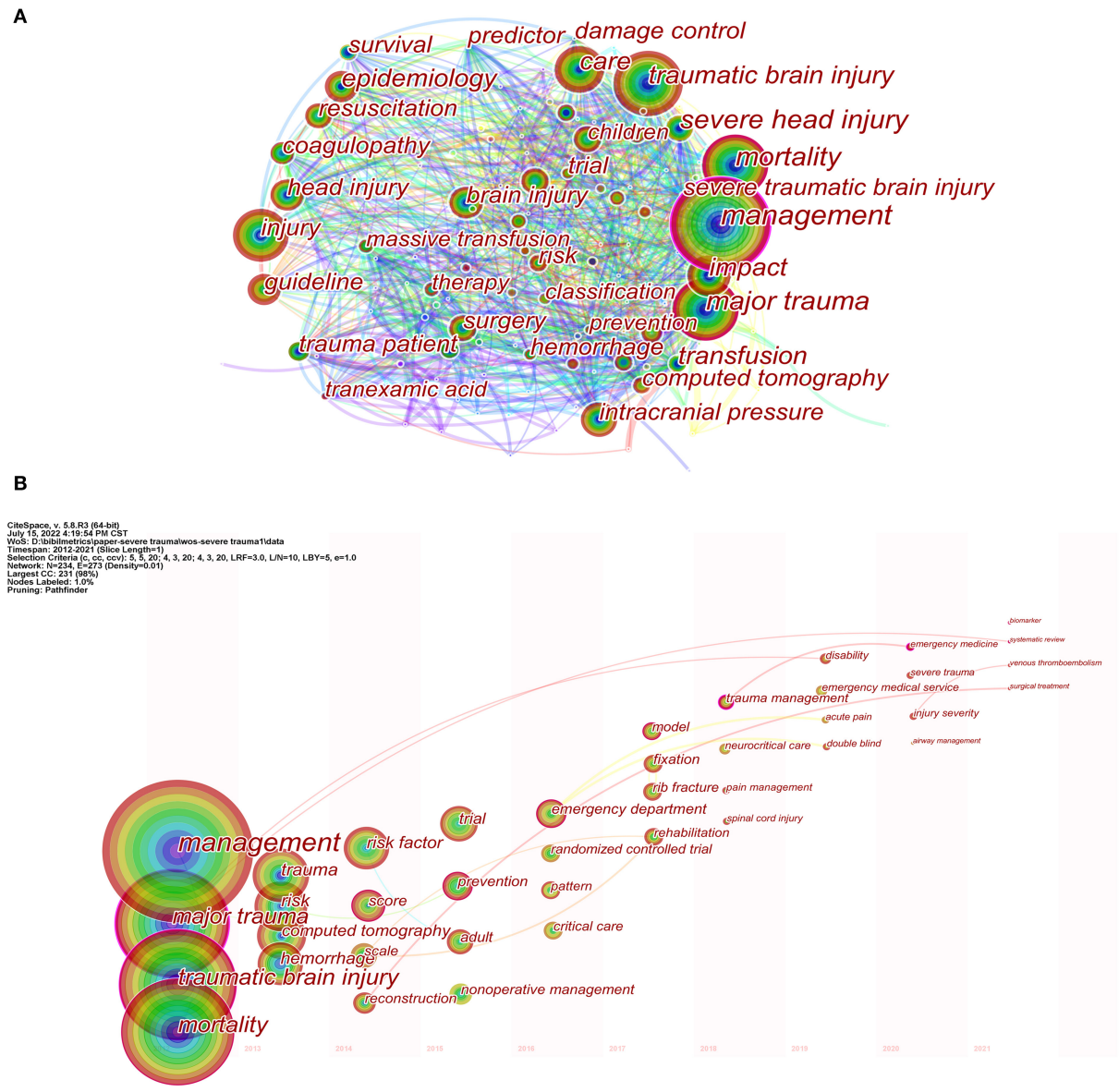

FIGURE 8
(A) Keyword co-occurrence network. Different colors of the circles indicate the average year of the studies according to the bar on the lower right corner. **(B)** Keywords "timezone view" in management of major trauma research.

a key role in bridging national cooperation networks worldwide. Meanwhile, only two Asian countries—China and Japan—were ranked among the top 10 productive countries, indicating that Asian countries need further investment in the field of research on severe trauma. Monash University published the highest number of papers. We also found extensive connections between institutions, indicating significant collaborative contributions to this research field.

In the analysis of authors and co-cited authors, Rolf Lefering, a researcher from the University of Witten/Herdecke, made the most contributions with 26 published studies, followed by Kenji Inaba from the University of Southern California Medical Center, with 19 articles. These two authors have been extensively involved in the clinical research of severe trauma, such as whole-body CT in polytrauma (31), the administration of tranexamic acid and fibrinogen concentrate in patients with trauma (32, 33), intracranial pressure monitoring in severe head

TABLE 5 The top 20 keywords.

Rank	Keywords	Citations	Centrality	Year
1	Management	983	0.22	2012
2	Traumatic brain injury	372	0.07	2012
3	Mortality	370	0.12	2012
4	Major trauma	320	0.2	2012
5	Injury	249	0.06	2012
6	Outcome	242	0.11	2012
7	Care	216	0.07	2012
8	Impact	173	0.06	2012
9	Guideline	150	0.05	2012
10	Epidemiology	144	0.06	2012
11	Intracranial pressure	142	0.02	2012
12	Head injury	141	0.05	2012
13	Severe head injury	126	0.08	2012
14	Brain injury	119	0.04	2012
15	Children	119	0.02	2012
16	Surgery	103	0.03	2012
17	Resuscitation	100	0.05	2012
18	Decompressive craniectomy	96	0.01	2012
19	Trauma	87	0.01	2012
20	Risk	86	0.04	2012

injury (34), massive transfusion protocol (35), and emergency operation (36). Holcomb JB from the University of Alabama at Birmingham received the most co-citations (201 citations) and is active in the field of severe trauma research (37–39).

As shown in Table 3, *Injury* published the highest number of papers, followed by the *Journal of Trauma and Acute Care Surgery* and the *European Journal of Trauma and Emergency*. Papers published in high-IF journals, such as *The Lancet*, the *New England Journal of Medicine*, and *Critical Care*, had more co-citations and the findings of this study provide a theoretical basis for future research (26). As shown in Figure 5, there are four main citation paths in our dataset, indicating a multidisciplinary aspect of this field, as publications in multiple domains have contributed to the citation landscape.

As shown in Table 4, the top 10 co-cited references mainly focused on the management of traumatic brain injury (22, 40) and trauma hemorrhage (4, 23, 24, 41). To automatically label the clusters of cited references, we extracted candidate terms from the titles and abstracts of the citing articles. The labels extracted by the LLR tended to reflect a unique aspect of the cluster. The purple and blue nodes represent early clustering labels that included pediatric traumatic brain injury (#5), whole-body computed tomography (#6), and evidence-based care bundle (#7), whereas the red and yellow nodes represent recent clustering labels, such as severe traumatic brain injury (#0), traumatic coagulopathy (#1), and resuscitative endovascular balloon occlusion (#2).

Research hotspots and emerging topics

Reference clusters and citation bursts can characterize the emerging topics in the discipline. The two main themes indicate the current hot topics in major trauma research.

In cluster #0, the literature largely reported on the management of severe traumatic brain injury (42–47). The management of traumatic brain injury (TBI) has changed over the past decade; a multimodal approach is now being applied in detecting and treating the pathophysiological derangements. The theoretical highlights include initial pre- and in-hospital resuscitation, secondary injury management (management of elevated intracranial pressure, management of cerebral perfusion pressure, and multimodality monitoring), and extracranial complications (respiratory management, fluid management, nutrition management, mobilization and rehabilitation, etc.) (48, 49). The increasing availability of big data and computational science pave the way toward more accurate neuroprognostication (50). Experimental efforts to promote repair in TBI have been made including cell-based or gene therapies (51), acellular scaffolds (52), endogenous growth-related factors (48), etc.

In clusters #1 and #2, the literature focused on management of massive hemorrhage, specifically traumatic coagulopathy and resuscitative endovascular balloon occlusion. Management of massive hemorrhage over the past decade has evolved to now deliver a package of hemostatic resuscitation including surgical or radiological control of bleeding; regular monitoring of hemostasis; advanced critical care support; and avoidance of the lethal triad of hypothermia, academia, and coagulopathy (53). Resuscitative endovascular balloon occlusion of the aorta (REBOA) is growingly utilized in trauma resuscitation for patients with life-threatening hemorrhage below the diaphragm (54), and is also available in a few pre-hospital critical care teams (55). Traumatic coagulopathy describes abnormal coagulation processes that are attributable to trauma. In the early hours of traumatic coagulopathy development, hypocoagulability is typically present, resulting in bleeding, whereas later traumatic coagulopathy is characterized by a hypercoagulable state associated with venous thromboembolism and multiple organ failure (56).

Keyword analysis helps identify research hotspots and predicts developing trends in the field (57). As indicated in Figures 8B, 9, the following keywords may indicate the recent focus and research hotspots: "trauma management," "neurocritical care," "injury severity," and "emergency medical service."

Neurocritical care forms an essential component of trauma management and an emerging field within critical

10.3389/fpubh.2022.1017817

Keywords	Year	Strength	Begin	End	2012 - 2021
fresh frozen plasma	2012	11.72	**2012**	2014	
fibrinogen concentrate	2012	4.88	**2012**	2015	
receiving massive transfusion	2012	4.79	**2012**	2013	
endotracheal intubation	2012	4.65	**2012**	2014	
concentrate	2012	4.39	**2012**	2016	
transfusion	2012	4.22	**2012**	2014	
red blood cell	2012	4.2	**2012**	2013	
advanced life support	2012	3.99	**2012**	2014	
hypothermia	2012	3.72	**2012**	2013	
death	2012	3.54	**2012**	2013	
protocol	2012	3.46	**2012**	2013	
survival	2012	5.96	**2013**	2015	
blunt abdominal trauma	2012	3.55	**2013**	2014	
hypotension	2012	3.44	**2013**	2014	
replacement	2012	4.74	**2014**	2015	
level	2012	3.69	**2014**	2015	
1st line therapy	2012	3.48	**2014**	2016	
prothrombin complex concentrate	2012	5.02	**2015**	2016	
disseminated intravascular coagulation	2012	4.97	**2015**	2017	
cardiac surgery	2012	4.15	**2015**	2016	
health	2012	5.32	**2017**	2018	
infection	2012	4.9	**2017**	2018	
trauma management	2012	4.6	**2018**	2021	
intubation	2012	4.14	**2018**	2021	
safety	2012	3.79	**2018**	2021	
neurocritical care	2012	3.78	**2018**	2021	
prevalence	2012	5.51	**2019**	2021	
injury severity	2012	5.03	**2019**	2021	
acute pain	2012	4.61	**2019**	2021	
emergency medical service	2012	3.66	**2019**	2021	

FIGURE 9
Top 30 keywords with citation burst (sorted by the beginning year of the burst).

care medicine. Intracranial pressure monitoring is now frequently discussed in the clinical care of many life-threatening brain insults; however, related technologies and management remain a high priority in neurosurgery and neurocritical care (58). Electroencephalography (EEG) is an extremely sophisticated brain monitoring tool that is extensively employed in neurocritical care; the emerging applications of EEG include seizure detection, ischemia monitoring, detection of cortical spreading depolarizations, assessment of consciousness and prognostication (59). Brain injury in children is a major public health problem; pediatric neurocritical care involves assessment, monitoring, and protection of the brain (60). More practice guidelines and establishment of multidisciplinary services are needed for improving healthcare for brain injuries (61).

The severity of injury is assessed by ISS that is associated with methods and description of studies concerning major trauma. In recent years, it is universally employed in scientific research related to major trauma. For instance, Versluijs et al. (62) reviewed the association between trauma severity and post-injury symptoms of depression; Santos et al. (63) predicted the severity of crash injury by investigating machine learning algorithms.

Emergency medical service (EMS) and pre-hospital rescue management are now globally confronted with challenges, including rising number of calls, overcrowding in emergency departments, difficulty in human resource management, etc. (64, 65). However, new EMS resources such as community paramedics and telemedical support systems offer opportunities to strengthen competencies in patient care (66). Consequently, increasing academization and research in this field are welcomed.

Limitations

This study had the following limitations. According to a study, it is acknowledged that WoSCC is the recommended database for bibliometric analysis (18). Consequently, data were collected from the WoSCC database, whereas data from other sources such as PubMed, Google Scholar, and Embase were not included. As several newly published and potentially high-impact studies may not have been included in our study, the emerging hotspots and trends in major trauma research may vary with bibliometric data updates.

Conclusion

In conclusion, this bibliometric study provides a comprehensive analysis of dynamic structures and emerging trends in major trauma research using the visualization software, CiteSpace. Based on our findings, the leading countries are the United States, England, and Australia, while Asian countries need more investment in the research field. Management of severe traumatic brain injury and massive hemorrhage, neurocritical care, injury severity, and emergency medical service are emerging and promising research hotspots. Though current information is crucial for future research and policy making in this area, more evidence-based guidelines are needed for clinical practice in the management of major trauma.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

ZD and TW: design of this study and supervision. ZW: literature search and data analysis. FG, ZD, and TW: manuscript writing and editing. All authors approved the final version of the article.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Implementing value-based healthcare using a digital health exchange platform to improve pregnancy and childbirth outcomes in urban and rural Kenya

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Maternal and neonatal mortality rates in many low- and middle-income countries (LMICs) are still far above the targets of the United Nations Sustainable Development Goal 3. Value-based healthcare (VBHC) has the potential to outperform traditional supply-driven approaches in changing this dismal situation, and significantly improve maternal, neonatal and child health (MNCH) outcomes. We developed a theory of change and used a cohort-based implementation approach to create short and long learning cycles along which different components of the VBHC framework were introduced and evaluated in Kenya. At the core of the approach was a value-based care bundle for maternity care, with predefined cost and quality of care using WHO guidelines and adjusted to the risk profile of the pregnancy. The care bundle was implemented using a digital exchange platform that connects pregnant women, clinics and payers. The platform manages financial transactions, enables bi-directional communication with pregnant women *via* SMS, collects data from clinics and shares enriched information *via* dashboards with payers and clinics. While the evaluation of health outcomes is ongoing, first results show improved adherence to evidence-based care pathways at a predictable cost per enrolled person. This community case study shows that implementation of the VBHC framework in an LMIC setting is possible for MNCH. The incremental, cohort-based approach enabled iterative learning processes. This can support the restructuring of health systems in low resource settings from an output-driven model to a value based financing-driven model.

KEYWORDS

value-based healthcare, MNCH, cohort-based implementation, digital health, outcome measurement, LMIC

Introduction

Over the past decade, investments in improving maternal, neonatal and child health (MNCH) in low- and middle-income countries (LMICs) have largely focused on reducing financial and geographical barriers to access skilled delivery and incentivizing adherence to antenatal guidelines improving scale, scope and quality of healthcare delivery and stimulating utilization by reducing financial barriers (1, 2). Despite these investments, maternal mortality rates (MMR) and neonatal mortality rates (NMR) are still high in LMICs. The latest figures show an MMR of 253 per 100,000 live births (3) and an NMR of 22 per 1,000 live births (4) in LMICs, while the United Nations Sustainable Development Goal 3 (SDG 3) targets specify an MMR of 70 (target 3.1) and an NMR of 12 (target 3.2) in 2030. This raises the question what more is required to meet patients' needs and to achieve the targets of SDG 3? Research shows that improving accessibility and adherence alone does not guarantee better outcomes and that a broader set of interventions aimed at quality of care is needed (2, 5, 6).

Transforming health systems toward a quality health system is a complex and long-term process that requires a multifaceted approach (7–9). Kruk et al. (1) argues that to achieve better outcomes in LMICs, health systems are needed that focus on patient-centeredness, resilience, equity and efficiency. A complicating factor is that in most LMICs, the organization and financing of healthcare is supply driven (10). To create high-quality health systems, scholars and practitioners argue that health systems should transition from a supply-driven model toward a value-driven model (11–13). In high-income countries (HICs) this approach is gaining momentum and some countries are implementing delivery models that embrace a value-driven approach (14, 15). However, in LMICs, value-driven service delivery models are not common and experiments with value-driven models are scant (16). This is remarkable as financial resources are limited in LMICs, and models that incentivize high-quality care at lower costs could be an answer to the question "how to do more with less" to improve MNCH outcomes.

Research on implementation and evaluation of MNCH service models in LMICs focusses mainly on output-based interventions, addressing single components or subsets of the VBHC framework, such as outcome measurements (16–18), performance-based payments (19, 20), (data-driven) quality improvements (21–23) or redesigns of referral systems (24, 25). In this paper we describe the development and implementation process of a value-based healthcare (VBHC) based digital MNCH care bundle called MomCare, developed by the international non-governmental organization (NGO) PharmAccess Foundation (PAF) specifically designed for LMICs.

The conceptual framework of MomCare is based on the concept of VBHC introduced by Porter and Teisberg (11). Value is defined as outcomes that matter to patients relative to the total costs of care delivery (26). In VBHC there is a strong focus on comprehensive outcome measurements (both clinical outcomes as well as patient-reported outcomes) and reimbursement systems that incentivize providers to maximize value (27). Importantly, value is created at the level of medical conditions or specific subpopulations, over full care cycles and providers should structure their organizations around patients' needs (26). VBHC is becoming a trend in transforming health systems in HICs as the first results of VBHC implementations seem to be positive (28–32). However, there are methodological and operational challenges to overcome when implementing VBHC in other settings. For example, the VBHC framework does not provide an implementation methodology (33, 34), patient-reported outcome measurements (PROMs) are sensitive to cultural variation and context-specific conditions (35), VBHC requires a cultural change within organizations with physicians becoming accountable for the full cycle of care (36) and a successful implementation requires leadership, clinical and managerial support, as well as substantial investments to enable data collection and analysis (16, 35).

Context

In Kenya, 1.4 million babies were born in 2019 (37). The MMR is 342 and the NMR is 21 (4). Of pregnant women, 96% attended at least one antenatal care visit, and 58% attended antenatal care at least four times while 62% attended a skilled delivery (38). However, MNCH services remain highly inequitable (39). Healthcare services are provided by six levels of facilities, ranging from community services (level 1) to national referral hospitals and large private teaching hospitals (level 6). Antenatal and postnatal care services, including immunizations, are provided by most level 2–6 facilities such as dispensaries, maternity clinics and hospitals. Delivery services, including cesarean sections (C-sections), are mainly provided by maternity health centers (level 3), (sub)county referral hospitals and medium and large-sized private hospitals (levels 4 and 5) (40).

The penetration of mobile phones in Kenya is among the highest in African countries. As many as 97% of adults report to own or share a mobile phone (41). A large share (40%) of these however own a basic phone which cannot connect to the internet (41).

The MomCare program

MomCare started in Kenya in 2017 (42). The MomCare program is composed of six elements: standardized care bundle, provider network, digitale exchange platform, health wallet, patient engagement and outcome measurements and provider feedback and improvement.

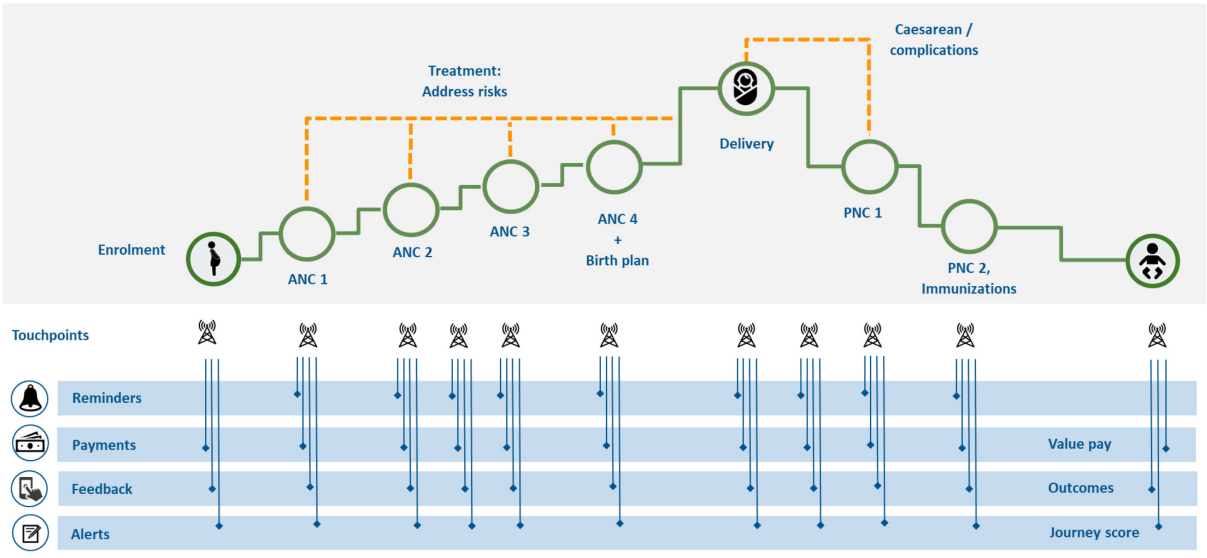

FIGURE 1
MomCare care pathway.

Standardized care bundle

MomCare follows a predefined and standardized care pathway, which is based on internationally agreed standards for MNCH, quality standards and predetermined costs (43), aligned with the risk profile of the pregnant woman. It covers a bundle of necessary services and interventions such as: antenatal care, essential delivery services and postnatal care. By incentivizing both clinics as well as pregnant women to adhere to the care pathway, MomCare aims to improve MNCH outcomes, including morbidity and mortality. Figure 1 presents the standardized care bundle of MomCare that all participating clinics follow. At various points along the pathway there are interactions between the platform, the enrolled women, and the clinics.

Provider network

At the start of MomCare, clinics were selected and contracted by PAF to create a network of MNCH providers. The network enables protocol based referrals between clinics. Selection of clinics was based on SafeCare accreditation levels, mobile money readiness and prices. SafeCare is a standard-based care quality improvement methodology (43). The selected clinics were connected to the digital exchange platform, were trained on how to use the platform and received support through SafeCare. PAF started with contracting three clinics in Nairobi and ultimately expanded to 18 clinics across urban and rural areas in 2019. Participating clinics vary from level 2 to 4, covering essential MNCH services.

Digital exchange platform

MomCare is supported by a digital exchange platform and is compatible with existing information architecture (44). It connects pregnant mothers, healthcare providers and payers (e.g., public health insurers, donors, regional governments) and enables payments, patient engagement, data collection and provides actionable feedback through dashboards. The platform is developed by PAF in the Amazon Web Services and is able to interact with other data sources, such as payment platforms and patient survey tools. The platform adheres to General Data Protection Regulation and local data protection laws to safeguard the privacy of pregnant mothers (44). To connect to the digital exchange platform, each clinic needs to have an internet connection and a desktop computer. As the Kenya National Hospital Insurance Fund (NHIF) uses an online billing process, most clinics are already equipped to work with digital processes.

Health wallet

As most Kenyans access financial services through their mobile phones, PAF offers enrolled women a "health wallet" on their cell phones to enable payments for health expenses at participating clinics (44). The MomCare "health wallet" operates

on the payment platform called M-Tiba, which is developed by CarePay (45). The "health wallet" can be funded by donors and (social) insurance schemes. The "health wallet" is used for two reasons; first it helps the mother establish that she is entitled to care, empowering her and improving both care-seeking behavior and experience. Second, opening the wallet is a digital confirmation that the mother was in the clinic at a specific time for her visit, ensuring that billing can only take place for visits that actually happened. Healthcare providers submit, through M-Tiba, their (claims) data, following the International Statistical Classification of Diseases and Health Related Problems, ICD-10 (46), and receive a bundled payment for a specified set of care activities on a per visit basis. Bonuses are paid based on each woman's adherence to the care pathway (based on a so-called "Journey Score") and outcome indicators. Data on claims and payments generated by M-Tiba is shared with the MomCare platform for further analysis and creation of performance dashboards.

Patient engagement and outcome measurements

The platform enables patient engagement throughout the various stages of the care pathway. At enrolment, pregnant women are asked questions on socio-economic status, demographics and obstetric history including pre-existing medical conditions, using a digital form. This allows for the care bundle to be aligned with the pregnant women's risk profile, e.g., a high risk pregnancy will require additional diagnostic and treatment, and maybe also referral for delivery. Along the pregnancy, SMS-based reminders are sent out to increase adherence to the care bundle and feedback is collected first by telephone calls and later by sending out short SMS-based questionnaires. The responses on these questionnaires are processed into patient-reported outcomes by the platform.

Provider feedback and improvement

The platform analyses collected data and provides participating clinics with dashboards showing data on health usage, costs, adherence and outcomes. See Figure 2 for an overview of key performance data collected by the platform. Dashboards are made in PowerBI but only shared as static graphs with the clinics during quarterly data disseminations. To follow each woman in her pregnancy journey, clinics are given access to the patient journey tracker app. This app can be accessed by local staff and login credentials are given and managed by PAF.

The dashboards enable clinics to compare their performance with peers and to identify issues in their service delivery. To support clinics in this process, PAF employs provider support teams lead by a program manager. These teams support clinics in interpreting the data and implementing (quality) improvement programs. Quality improvements are also supported by SafeCare. Each MomCare program manager is able to support about 10–15 health providers.

VBHC development approach

Since the VBHC approach has rarely been tested and implemented in LMICs, our approach was developed from beginning to end taking local settings and requirements into account. This section describes the three steps of this process: (i) Theory of Change (ToC) development, (ii) VBHC adaptation, and (iii) design of structured feedback loops.

Theory of change

As a first step, a Theory of Change (ToC) was developed to design the program, and monitor and evaluate the implementation process (47). The ToC describes how MomCare brings about long-term outcomes through a logical sequence of activities, outputs and intermediate outcomes (48). The ToC was developed through several iterative rounds in consultation with stakeholders on different levels, such as government officials of the Kenyan Ministry of Health and members of the Kenyan Obstetrical and Gynecological Society. Interviews and focus group discussions with the involved stakeholders were held to explore the context, challenges, problems, and solutions in providing high quality maternal care. These insights were combined with an extensive document analysis and literature review to design the final ToC version (Appendix 1).

VBHC adaptation

The VBHC framework consists of six components (49). As a second step of our development approach, the six components of the VBHC framework were adapted to the MNCH context in Kenya as listed in Appendix 2. Adaptation of the VBHC framework is necessary as health systems differ and effects of health system interventions depend on cultural, financial and social context. We specifically focus on outcome measurements and bundled payments as these components were seen as most impactful to patients and providers.

Defining outcomes that reflect the total cycle of care is key within any VBHC initiative. Outcomes should be disease (or in some cases subpopulation-) specific and multidimensional (29). However, designing a valid and reliable outcome set can be complex and time-consuming, especially regarding standardization, which is required to compare between providers and health systems around the world

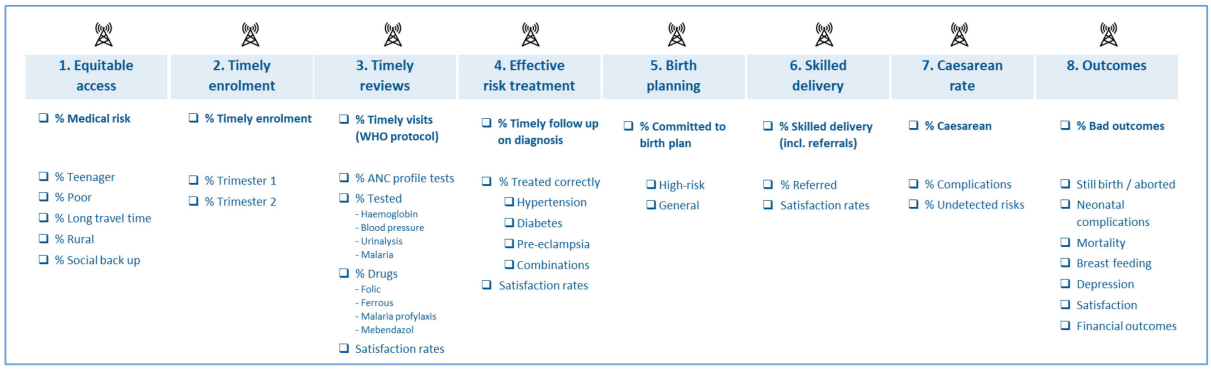

FIGURE 2
Key performance data collected by the platform.

(50). MomCare used an adapted version of the standard set Pregnancy and Childbirth as developed by the International Consortium for Health Outcome Measurements (ICHOM) (51). The ICHOM outcome set includes both clinician-reported outcome measures (CROMs) and patient-reported outcome measures (PROMs) and patient-reported experience measures (PREMs) such as maternal morbidity and birth experience. However, as countries differ in health systems, culture and language, exploring the applicability of outcome sets is required (52). In a previous study in a comparable group of mothers (53), the applicability of the ICHOM set was explored by a two-round feasibility assessment in which pre-selected outcomes were reviewed and finalized by local Kenyan providers and medical experts. In total 14 outcomes were selected as being appropriate in the Kenyan context of which five are patient-reported (53). MomCare used these selected outcomes, which were incrementally implemented along the unfolding of each of the cohorts and perfected over different learning cycles.

An important component of VBHC is reimbursement using bundled payments. Traditionally, providers in Kenya are reimbursed based on fee-for-service of single activities or capitation by the National Hospital Insurance Fund (NHIF) or out-of-pocket payments. A bundled payment is a one-off or periodic lump-sum payment for a range of services delivered by one or more providers based on standardized care pathways with an increasing emphasis on outcomes (54). Unlike fee-for-service, bundled payments transfer financial risk to providers as healthcare providers are expected to provide all necessary care within the bundle. As a result, providers are incentivized to coordinate care across settings, deliver appropriate care and reduce costs over the full care cycle (55). As Kenyan providers are inexperienced using other payment models than fee-for-service and capitation, the program chose an iterative approach by implementing sub-bundles that resemble each phase of the care pathway instead of one bundle that covers the whole pregnancy episode. In total 130 activities, that were separately billed before, were grouped into 32 sub-bundles. The bundled payment model also included a pay-for-performance scheme based on a journey score. The journey score is a standardized risk adjusted metric that quantifies the adherence to the maternity pathway and the care delivered in accordance with the guidelines (10). The score ranges from a minimum of 0 (no care received) to a maximum of 5 (well-attended and managed journey). In order to maintain provider involvement and maximize effects, bonus payments were made available based on the patient journey score and providers received actionable insights (risk stratification, appointment reminders) and clinical insights (data disseminations). MomCare does not apply any penalties when journey scores or outcomes decline.

Feedback loops

As a third step, we designed a system for structured learning based on data regarding outcomes, outputs and activities. This data, gathered through the platform is analyzed, enriched, and subsequently shared with the clinics through dashboards and clinic visits by PAF fieldworkers. Improvements to the program are implemented every time a new group of mothers (a cohort) was on boarded in the program. In this way, learnings from earlier cohorts can be used to adjust activities to improve outputs and outcomes for later cohorts. In this case study, we describe the roll-out of the MomCare program over seven cohorts, enrolled in the period from 2017 to 2020.

Uptake and roll-out

In the time-period of this study (2017–2020), MomCare enrolled 8,821 women. In Table 1, the uptake of and roll-out of MomCare is shown over time. Separated by 3 to 4-month intervals (except between cohorts 1 and 2, where there was a

TABLE 1 Uptake of and roll-out of MomCare.

	Cohort									
	Urban							Rural		
Indicator	1	2	3	4	5a	6a	7a	5b	6b	7b
Enrolled Mothers	217	172	517	481	282	901	1,240	824	1,978	2,209
# Hubs	0	1	1	1	1	1	1	-	-	-
# Spokes	2	1	2	3	3	4	6	-	-	-
# Combined hub and spoke	0	0	0	0	0	2	2	4	10	14

longer interval), cohorts of pregnant women were invited to enroll in MomCare at a contracted clinic. The total patient journey takes 45 weeks on average. At the start, admission was set at $\leq$ 16 weeks of gestation, but this was later widened. At enrolment, information about MomCare was given as well as mobile phone access to the "health wallet."

Table 1 also shows the number of participating clinics for each cohort. Clinics can have a hub, spoke, or combined hub and spoke status. Clinics having a hub status provide more complex health services when referred to, e.g., in case of a complicated delivery or C-section. Spoke clinics offer basic MNCH care services, including normal skilled deliveries. Clinics with a combined hub and spoke status offer both basic and more complex health services. From cohort 5 onwards, MomCare was expanded to the rural areas of Kakamega and Kisumu (cohorts 5b to 7b).

Cohort 1

The first cohort of MomCare started in Nairobi in November 2017 (Table 1) enrolling 217 women on the digital platform. As shown in Figure 3, three VBHC components were implemented in cohort 1. Two clinics were contracted and connected to the platform to act as an integrated practice unit (IPU) offering a bundle of basic MNCH care services, including four antenatal care (ANC) visits, skilled (normal) delivery service and two PNC visits (including immunizations). Clinics were reimbursed by bundled payments.

Cohort 2

Cohort 2 started in July 2018, enrolling 172 pregnant women in MomCare. This lower number was caused by a spoke clinic leaving MomCare and limited funding to enroll more women. To address the lack of complications coverage, a hub-and-spoke network (VBHC component 4) was created in cohort 2 to cover for C-sections and basic complications across clinics (see Figure 3). An additional clinic (hub) was connected and together with the spoke clinic a triage and referral process was defined. Secondly, the platform was made suitable to capture and share clinical outcomes and claims data. Finally, the inclusion criteria were widened from 16 to 18 weeks of pregnancy (WoP) to increase the enrolment of pregnant women.

Cohort 3

In cohort 3, starting in October 2018, a second spoke clinic was added to attract pregnant women and to strengthen the hub and spoke network. Also PROMs were added to the outcomes that were systematically collected from enrolled women and bonus payments based on the journey score were introduced. To help clinics learn and improve PAF support teams were formalized. The cut-off point to enroll in MomCare changed to a maximum of 26 weeks of gestation. With these wider inclusion criteria, 517 women enrolled in MomCare.

Cohort 4

Cohort 4 started in February 2019. As the referral process in cohort 3 did not result in a better patient flow, the hub and spoke network organized a series of workshops to optimize the referral process and synchronize their cooperation. Secondly, the content of the data workshops was better aligned with the needs of employees of participating clinics. In the data workshop more attention was paid to creating commitment at clinics to use data in their day-to-day operations. Thirdly, investments were put in strengthening the hub and spoke network by adding an extra spoke clinic to shorten travel time for enrolled women. In total 481 pregnant women enrolled in the program.

Cohort 5

In May 2019, MomCare implemented VBHC component 5 by expanding services to the rural areas of Kakamega and Kisumu. Now, all components of the VBHC framework were

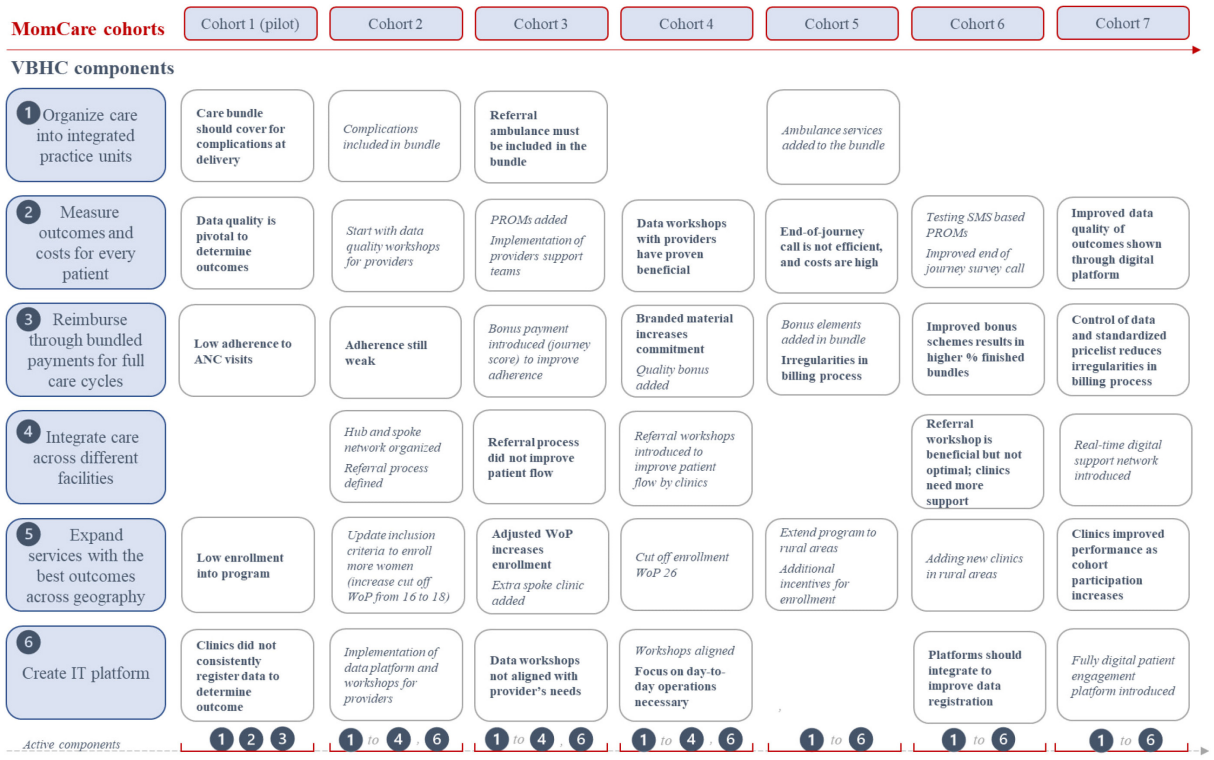

FIGURE 3
Implementation of VBHC components, learnings and adaptations (learnings are shown in bold, adaptations of components are shown in italic).

implemented. Other changes were the use of standardized pricelists, further improvement of the referral process, providing free maternity goods incentivizing women to enroll into MomCare, and integration of patient-reported outcome data collection tools (end-of-journey calls and SMS-based questionnaires) to simplify data capturing. From cohort 5 onwards, a distinction is made between the women enrolled in the urban area (cohorts "a") and women enrolled in rural areas (cohorts "b"). In cohort 5b, four clinics were contracted to offer the basic bundle including C-sections and treatment of complications. In total 824 women enrolled in cohort 5b.

Cohort 6

Cohort 6 started in September 2019. Based on the short-cycle learnings of cohort 5, several improvements were made. First, as transport costs can be a barrier to health care access (56, 57) ambulance services were added to MomCare. Secondly, access to data on outputs and outcomes was made easier and dashboards were improved to be used on a daily basis by clinics and monitoring staff. Thirdly, control of billing processes and provider engagement was tightened to prevent irregularities (such as double or false claims). Finally, the bonus payment was improved by adding adherence elements. In cohort 6, nine additional clinics were contracted, and 2,879 women enrolled in MomCare.

Cohort 7

In cohort 7, which started in January 2020 and coincided with COVID-19 lockdowns per March 2020, a fully digital patient engagement platform was introduced including digital enrolment, SMS-based reminders and outcome measurements. Second, a digital support network was introduced to help clinics improve their health services. The digital platform also enabled a patient journey tracker app, which can be used by clinics to follow each patient in their pregnancy journey. Six additional clinics were contracted and 3,449 women enrolled into the program, making this the largest cohort in the program. In cohort 7, SMS-based survey questions on mental health were introduced.

Progress over time

Over time, more clinics were added, more components of the VBHC framework were implemented, and more pregnant women were enrolled. Progress of the program was tracked

using various indicators. The overall impact of the program is reflected in the reach (number of enrolees), the Journey Score, and the variety of outcome measures tracked per enrolee. The reach of the program increased more than 15-fold, from 217 enrolees in cohort 1 to 3,449 enrolees in cohort 7a and 7b combined.

The Journey Score is a measure of adherence to the care pathway. Figure 4 shows the patient journey scores of individual clinics that participated in three or more cohorts. This data shows the effects of the short and long cycle learnings for each clinic. Clinics with lower baseline scores are clearly improving, and over time the differences between clinics become smaller. A less strong improvement is shown for the clinics operating in rural areas, but their baseline scores were already high.

Discussion

The objective of MomCare was to improve outcomes of MNCH care in LMICs through access to high quality care based on the VBHC framework. In HICs, volume-driven transitions aimed at high quality care have shown that unwanted cost increases can occur (54), something especially health systems in LMICs cannot afford. Therefore, in LMICs, value-driven health systems could be a game changer, as they are characterized by generating maximum value for patients by cost-effectively achieving the best possible outcomes. A volume-driven focus on access alone threatens health equity and the roll-out of universal health coverage (56, 58). This paper assesses the determinants of transitioning in LMICs from a volume-driven system toward a value-driven system, as per the VBHC framework (1, 9).

The VBHC literature does not provide an implementation methodology and experiences with VBHC framework implementation from HICs cannot be simply copied to the LMIC context. In LMICs, like Kenya, the healthcare landscape is fragmented, with a variety of funders (e.g., government, social insurance, donors) and relatively large differences in healthcare access between regions. This prompted MomCare to take an incremental cohort-based implementation approach of the VBHC framework, building on a scalable platform, and introducing VBHC components gradually. An advantage of the incremental cohort-based approach is that it increases accessibility of care across geographies, while simultaneously improving quality of care, in a relatively short time. This approach allows for co-creation, involving local stakeholders and it enables that services are continuously adapted to the health seeking behavior of the customers. Gradually, a VBHC ecosystem around MNCH was created and continuously improved: a referral system was implemented within a hub-and-spoke network of providers, a system was built to measure clinician and patient-reported outcome measurements, a digital platform was created to enable payments, data capturing and benchmarking, and bundled payments and outcome-based bonus payments were introduced.

In this cohort-based implementation approach, data-driven learning for PAF as well as for the healthcare providers took place at two different speeds: through short learning cycles vs. long learning cycles. Short learning cycles refer to improvements implemented from one cohort to the next and were typically related to care utilization and adherence to care. An example of a short learning cycle is that the model started with a very basic care pathway, but it was soon realized that there were women who needed care for more complicated pregnancies, hence the approach to expand the care pathway to include complicated services and include clinics in the provider network that provide those services. Long learning cycles refer to improvements based on data that is available only at the end of the full care cycle continuum that takes into account the antenatal, delivery and post-natal period of pregnancy estimated at a total of 45 weeks. Before the full care cycle of a cohort (cohort t) is completed, one or two new cohorts (cohorts t+1, t+2) have already started. While short learning cycles bring improvements from cohort t to cohort t+1, long learning cycles bring improvements from cohort t to cohort t+3. An example of long cycle learning is the additional training offered to providers around breastfeeding: train providers to inform women about the importance of breastfeeding and how to deal with challenges experienced by mothers. This improvement was based on outcomes that could only be measured at the end of a full care cycle. A prerequisite is that the implementing team and the providers must have a strong learning culture (59) that allows for course correction whenever necessary and is aided by the data driven approach that PAF takes.

During roll-out we identified several challenges, three of which still require further fine tuning today. First, it remains paramount to improve quality of data registries and consistency of data capturing by providers, especially data that is not captured automatically through billing processes such as mortality rates. Additional training of providers proved key to improve data collection and usage (60). Increased transparency of provider performance, benchmarking with other (competing) providers and financial rewarding through bonuses are all factors that impact the willingness of providers to collect and share data. Continued effort is needed to motivate and enable providers to reliably capture and report process and outcome data. Second, as the providers are used to being paid on a fee-for-service basis or *via* capitation, shifting financial risk from payer to provider by introducing full bundled payments was experienced as a bridge too far. It proved impossible (as yet) to shift financial risks to providers completely by introducing one bundled payment that covers the total patient journey. Therefore, the program grouped billable services into smaller bundles. Further investment is needed to train providers on how to manage financial risks related to bundled payments. A third challenge concerns the relatively limited validity of Western

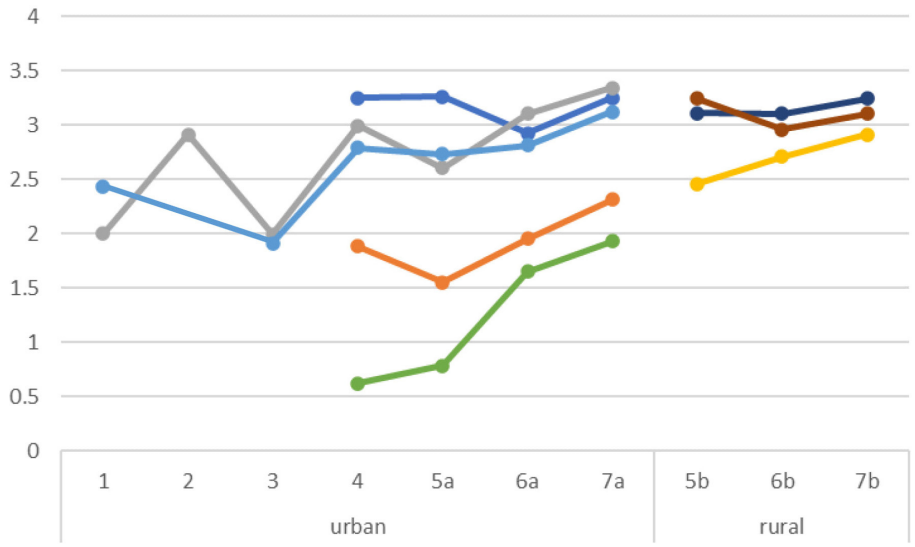

FIGURE 4
Journey Score per clinic. Each color represents a different clinic. Scores on a scale of 0–5.

patient-reported outcome measures. Outcome measures need to be adapted to what matters to pregnant women with different cultural backgrounds living in Kenyan urban and rural areas. Further research is needed to validate such adapted questionnaires to provide reliable PROMs for women's views of high quality MNCH care.

The success of implementing a VBHC based digital platform in LMIC settings, such as Kenya, depends on several enabling factors. These include having an IT infrastructure in place to enable digital communication and data collection, a high uptake of mobile phones in the community, the availability of mobile money, and management buy-in at clinic level to learn and to improve care. More specific enablers are the deployment of a provider support team to train and support clinics with VBHC interventions and digital skills (61). Another enabling factor relates to the position of a trusted third party like PAF to connect payers to providers and to create a high-trust environment in which clinics are willing to participate in a program.

Finally, the scalability of the program is key. The impact of MomCare on MNCH in Kenya depends on the ability to scale up the technology and bring the VBHC approach to MNCH to more women in more regions, both urban and rural. Various key elements of the MomCare program are easy to scale up. The technology is suitable for processing many new enrolments within a short period of time. The development of the digital platform requires a high investment and an incremental approach, but operational costs will decrease as more women enroll into MomCare. Since the start of MomCare, operational costs of the platform decreased from an estimated 4 USD for each enrolled woman to an estimated 1 USD. The supporting analysis tools of the digital platform, such as the dashboard and benchmarking tools, are easy to scale up. This also applies to outcome measurements along the care pathway. The data collection of both clinical and patient-reported outcomes is fully integrated into the digital platform.

Elements that are considered a greater challenge to scaling up MomCare are related to its provider network and the interactions with contracted clinics. MomCare aims to improve care processes and is highly data driven, but most staff members of clinics are not sufficiently trained in working with data and improving care processes. This requires intensive training and support by the MomCare provider support teams. But scaling up provider support teams is challenging because it requires specific knowledge about quality improvement processes, relationship management, data analytics and operational processes. We have learnt that significant support is needed for providers in the first 6–9 months of the program, to ensure an effective shift in mindset toward data driven care. Finally, as MomCare uses standardized care pathways and financially depends on payers such as donors and NHIF, it appears that MomCare is sensitive to unexpected system shocks, such as political instability, economic setbacks and unforeseen events, such as COVID-19. Adapting MomCare to these system shocks is challenging. Especially when it requires adaptations of the fundamentals such as the digital platform or care pathway.

Elements of MomCare that are difficult to scale up mainly relate to the acceptance of new payment models by clinics. Currently most MNCH clinics in Kenya are paid through fee-for-service (FFS), through out-of-pocket (OOP) or through the National Hospital Insurance Fund (NHIF). Implementing

alternative payment models such as bundled payments is difficult. Clinics have difficulty accepting alternative payment models, because financial incentives are not well-understood, and are seen as inappropriate. This is especially true for alternative payment models allocating more financial risks to providers. Scaling up is also difficult because a variety of payers is involved. Each payer has its own objectives and requirements for reporting and assessment, which increases transaction costs. Ideally funds are pooled to cover the operational expenses and health care costs of MomCare. But all-in-all, by using existing platforms for mobile money and SMS communications, the program managed to increase the sophistication of services provided while keeping transaction costs low (61).

Conclusion

This case study shows that implementation of the VBHC framework in an LMIC setting is possible with some adaptations to the local context. The digital platform with integrated mobile money and SMS-based communications was key to the success of the program. Participating clinics showed progress in improving MNCH outcomes. The first results are positive, but more research is needed to provide more clarity on its impact on costs and quality. The cohort-based approach created short cycle and long cycle feedback loops enabling gradual implementation of the six VBHC components in co-creation with stakeholders. We recommend that this cohort-based implementation approach as well as the integrated digital platform design as described in this case report is used for other conditions and patient groups, such as ischaemic heart diseases and diabetes mellitus type 2, in order to incrementally build and adapt a customized VBHC strategic framework for addressing multiple diseases and conditions with high disease burden in LMICs.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data that support the findings of this study are available from PharmAccess Foundation, but restrictions apply to the availability of these data, and thus are not publicly available. Data are available from the corresponding author upon reasonable request and with permission of PharmAccess Foundation. Requests to access these datasets should be directed to dohmen@eshpm.eur.nl.

Author contributions

PD, EW, and TD contributed to conception and design of the case report, collected, and organized the data for the case study. PD wrote the first draft of the manuscript. PD and EV finalized the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1040094/full#supplementary-material

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Key features of a trauma-informed public health emergency approach: A rapid review

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COVID-19 is a major threat to public safety, and emergency public health measures to protect lives (e.g., lockdown, social distancing) have caused widespread disruption. While these measures are necessary to prevent catastrophic trauma and grief, many people are experiencing heightened stress and fear. Public health measures, risks of COVID-19 and stress responses compound existing inequities in our community. First Nations communities are particularly at risk due to historical trauma, ongoing socio-economic deprivation, and lack of trust in government authorities as a result of colonization. The objective of this study was to review evidence for trauma-informed public health emergency responses to inform development of a culturally-responsive trauma-informed public health emergency framework for First Nations communities. We searched relevant databases from 1/1/2000 to 13/11/2020 inclusive, which identified 40 primary studies (and eight associated references) for inclusion in this review. Extracted data were subjected to framework and thematic synthesis. No studies reported evaluations of a trauma-informed public health emergency response. However, included studies highlighted key elements of a "trauma-informed lens," which may help to consider implications, reduce risks and foster a sense of security, wellbeing, self- and collective-efficacy, hope and resilience for First Nations communities during COVID-19. We identified key elements for minimizing the impact of compounding trauma on First Nations communities, including: a commitment to equity and human rights, cultural responsiveness, good communication, and positive leadership. The six principles guiding trauma-informed culturally-responsive public health emergency frameworks included: (i) safety, (ii) empowerment, (iii) holistic support, (iv) connectedness and collaboration, (v) compassion and caring, and (vi) trust and transparency in multi-level responses, well-functioning social

systems, and provision of basic services. These findings will be discussed with First Nations public health experts, together with data on the experiences of First Nations families and communities during COVID-19, to develop a trauma-integrated public health emergency response framework or "lens" to minimize compounding trauma for First Nations communities.

KEYWORDS

trauma-informed, public health emergency, COVID-19, complex trauma, CPTSD, Aboriginal and Torres Strait Islander peoples, First Nations

Introduction

Disasters can be natural (e.g., fires, floods, severe storms, infectious disease outbreaks and pandemics) or human-caused (e.g., mass violence and genocide), both of which result in widespread disruption to communities. Impacts can include loss of life, damage to property and economic loss (1). Disaster management is a core function of public health, and these responsibilities are outlined in international obligations such as the International Health Regulations (2005) and various national and jurisdictional regulations, to provide for the effective management of threats to public safety. Increased stress is a natural response to a disaster (2), therefore consideration of mental health consequences is integral to the public health response.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a novel virus first identified in late 2019, which causes an acute illness called coronavirus-19 (COVID-19). The spread of COVID-19 has evolved rapidly into one of the most significant public health disasters of the past century. Declared a pandemic on 11 March 2020, COVID-19 is estimated to have caused 3.72 million deaths by 7 June 2021. Global case numbers continue to peak at approximately 380,000 cases per day, as newly developed vaccines are administered in 2021. Previous pandemics were caused by influenza viruses, such as: the A(H1N1) pandemic in 2009–2020 (100,000–400,000 deaths); A(H3N2) in 1968 and A(H2N2) in 1957–1958 (1–4 million deaths each); and A(H1N1) in 1918 (20–50 million deaths) (3).

All populations have been affected by COVID-19, whether by serious illness, complicated grief (4), lockdowns (5), economic insecurity (6), disruption to normal life activities, "fear" of the virus, eroding trust in authorities (7), and stigmatization of people of Asian descent (8). Predictably, the COVID-19 pandemic is causing significant mental health impacts (9, 10), particularly for those directly infected or classified as "high risk" and required to quarantine, healthcare and other essential workers, as well as the general population (11), in addition to indirect effects such as reductions in help seeking for mental health conditions (12).

As with previous disasters that overwhelm our health, social and economic systems (11)—risks and poor outcomes from COVID-19 do not affect people equally. The COVID-19 pandemic has highlighted inequities and exposed the long-standing drivers of health inequalities within our society, with the potential for these inequities to be further compounded (13, 14). The Diderichsen model (15) provides a framework for understanding how social position and social determinants intersect. In the context of COVID-19, risk of transmission and social consequences of public health measures (e.g., lockdowns) are likely to intersect, and there is a need to identify when and where we can intervene to prevent the health divide widening (15). In addition, the mental health impacts of COVID-19 can reduce the effectiveness of public health emergency interventions and shape the spread of the disease (16). For example, psychological impacts can affect adherence with public health advice (including vaccinations) (17).

The World Health Organization (WHO) has highlighted that inequities experienced by Aboriginal and Torres Strait Islander (First Nations) communities in Australia, compared to other Australians, are the most significant inequities in the world (18). Despite national commitment by all Australian governments to "closing the gap" in life expectancy since 2007, annual reports to parliament have shown little progress (19). In July 2020, a new "National Partnership Agreement on Closing the Gap" (20), was signed—for the first time including First Nations representatives as parties. This agreement recognizes that fundamental structural changes to the way governments (including public health authorities) work with First Nations communities is critical to closing the gap. This is exemplified in the pandemic response in Australia. No community representatives had been included in developing the 2009 National Action Plan for Human Influenza Pandemics, and First Nations peoples were significantly more affected by the H1N1 influenza pandemic than other Australians (21). Evaluation research recommended that First Nations peoples be engaged and included in future pandemic preparedness and responses, and during the first wave of the pandemic in 2020 First Nations peoples had been significantly less affected by COVID-19, compared to other Australians (21).

The success has been attributed to First Nations leadership in community responses (22), which has informed legislative action, guideline development, health service planning and testing, health promotion, and advocacy (21). However, the outbreak spread to regional New South Wales and Victoria in August 2021 and has had a direct and devastating impact on First Nations people and communities.

An emerging area of science of particular relevance to public health and public health emergencies, such as pandemics, is the understanding of trauma. There have been many studies and formal recognition of "post-traumatic stress disorder" (PTSD) in trauma victims, war veterans and communities exposed to disasters for decades (23), and key symptom clusters of re-experiencing events (triggers), avoidance, and a sense of threat (24). Growing consensus has led to the recognition in 2018 of complex post-traumatic stress disorder (complex trauma) in the International Classification of Diseases 11th Revision (ICD-11) (25), caused by repeated inescapable traumatic experiences, often involving interpersonal violation (24). Key symptom clusters include emotional dysregulation, negative self-concept, and relational disturbances, in addition to the features of PTSD. Complex trauma is most commonly associated with childhood maltreatment, which affects up to 50% of children worldwide (26) and it is increasingly recognized as an international public health priority (27) and a major root cause of health inequities (28–30). These effects may outweigh the impact of socioeconomic conditions (29); with an English study estimating that child maltreatment can be attributed to the national prevalence of other adverse behaviors and events: 12% of binge drinking, 14% of poor diet, 23% of smoking, 52% of violence perpetration, and 38% of unintended teenage pregnancy prevalence (30). In addition to direct health effects, evidence suggests that public health interventions may be less effective for people who experience complex trauma (31, 32).

First Nations communities are also impacted by historical trauma (33), which in Australia includes state-sanctioned removal of First Nations children from their families, disruption of family networks and increased exposure to violence. While community cohesion, access to services and cultural continuity have been shown to have a protective effect for some trauma related outcomes among First Nations peoples (21), within the context of colonization, the socio-ecological risk factors experienced by many First Nations communities are likely to amplify rather than counteract the complex trauma effects originating from adverse childhood experiences (22, 23). The WHO European Review of the Social Determinants of Health and the Health Divide provides a framework for understanding how the intergenerational effects of complex trauma compound health inequities (34). These include: historical violence, leading to increased exposure to violence in early life, increased socio-ecological and socio-economic hardship, increased risks, and decreased effectiveness of public health interventions (31, 32); and intergenerational trauma transmission (35–37).

Enhancing our understanding of the physiology and epidemiology of trauma is particularly relevant for public health, especially within the context of the COVID-19 pandemic. Complex trauma occurs in response to prolonged exposure to severe threats where escape is not possible (24), which activates "fear" or survival responses from the amygdala, commonly referred to as "fight, flight, and freeze." Fear is one of the central emotional responses during the pandemic (38). Evolutionary behavioral science theorists propose that experiences of fear of infectious disease are unique to other fears, with both psychological and behavioral adaptions for avoiding infection (39). Negative emotions resulting from this fear can impact others (i.e., fear is contagious), and can make threats feel closer. People experiencing PTSD or complex trauma can be particularly affected, as existing "sense of threat" symptoms can be more readily activated. As events leading to complex trauma threats often occurred in early life, many people experience these responses as confusing and distressing, and may not link them to the initial "threat." Rates of severe mental distress have increased during COVID-19, particularly in areas where there are restrictive public health regulations in place to control the spread of disease (e.g., Melbourne) (40–43).

Understandings of trauma has important implications for public health emergency responses, including the need to address fear and stigma, social isolation and reduced connectedness (central to First Nations wellbeing). Many First Nations communities have experienced deep trauma as a result of previous state-sanctioned actions, ostensibly "for protection" of First Nations peoples, which may be reminiscent of state-sanctioned COVID-19 public health actions (44). These understandings have implications for public health more broadly, as "fear appeals" are a commonly used tool in a range of public health strategies, including COVID-19, tobacco control, road safety and immunization. A meta-analysis suggests that this can be effective if people feel capable of dealing with the threat (high degree of self-efficacy), but can be counter-productive and lead to defensive behaviors (flight, flight, or freeze) if people feel powerless to act (45). This is consistent with the parallel processing model (46), which is likely to be operant in these situations.

While there has been progress on developing trauma-informed responses in health and social services (36, 47), and trauma has been identified as a key priority for First Nations communities in Australia (48), there have been no reviews of trauma-informed public health emergency responses for First Nations communities.

Objectives

The aim of this rapid review is to identify and describe trauma-informed public health emergency approaches. Specifically, we address the following research questions:

1. What are the core conceptual features of trauma-informed public health emergency approaches?
2. What are the reported outcomes from application of trauma-informed public health emergency approaches?

The purpose of this rapid review is to inform a future stakeholder discussion to develop a culturally responsive trauma-informed public health framework for First Nations communities in Australia.

Methods

We referred to the Cochrane Guidance for refining methods for this rapid review (49) and have followed the PRISMA-E checklist (50) in reporting this review.

Eligibility criteria

Participants

General population only. We used a stepwise approach to study design inclusion, as per rapid review guidance (49), placing emphasis on higher quality study designs and relevance to the study question. We excluded strategies or approaches specifically designed for individuals (e.g., substance use programs, individual mental health support), healthcare workers, schools and other direct responders to an emergency, and people working in (war veterans) or impacted by war. These are covered in other reviews (11, 51–54) and the core conceptual issues for trauma-informed and trauma-specific support for these responder populations are likely to be different than approaches to support the general population in a natural disaster. However, we did include some studies where we identified relevant key concepts for a trauma-informed public health emergency response.

Interventions

We included any trauma-informed population-level public health emergency approaches targeted to respond to natural disasters (e.g., flood, fire, earthquake, cyclones, and epidemics/pandemics). Approaches that targeted communities affected by mass violence (e.g., war, terrorism, genocide) were excluded. However, relevant studies that addressed how previous experiences of mass violence intersected with responses to natural disasters were included.

Comparator/Study design

We included any peer-reviewed article published from 2000 onwards and written in English. We used a stepwise approach based on study quality, including intervention studies, descriptive/observational studies, qualitative studies, reviews, and expert opinion/commentaries.

Outcomes

We aimed to identify core conceptual features of trauma-informed public health emergency approaches. We also aimed to identify any reported outcomes from applying such an approach, including:

- Public health outcomes.
- Experiences and views of the population.
- Economic impacts.
- Theories that explain observed phenomena.

Searching

Data sources

We searched for potentially relevant studies from databases from 1/1/2000 to 13/11/2020. The following electronic databases were searched: Medline (OVID), PsycINFO (OVID), CINAHL (EBSCO), EMBASE (OVID) and two Web of Science databases (Social Sciences Citation Index, Book Citation Index (Social Sciences and Humanities).

Search strategy

The search strategy was designed around two core constructs:

1. Trauma or childhood maltreatment; AND
2. Public health or pandemic or communicable disease.

The search was developed in PsycINFO and translated into other databases. See File 1 in Supplementary material for sample search strategy.

Selection of studies

References were exported to bibliographic reference management software (EndNote) and then Covidence for screening. Using a standardized title and abstract screening form, the whole screening team jointly screened the same 50 abstracts to calibrate and build consensus on screening criteria. Titles and abstracts of all studies were then screened independently by two reviewers, with conflict resolution by a third reviewer.

Full-texts of all potentially included studies were retrieved and a pilot exercise was conducted with three reviewers to calibrate and test the full-text review criteria. Remaining full-texts were screened independently by two reviewers according to the inclusion criteria. Disagreements were resolved by a group discussion or if necessary, by a third reviewer.

It was evident in the preliminary screening that there were limited high quality study designs evaluating the impacts of trauma-informed public health emergency approaches. During full-text review, we used a stepwise approach, which erred

toward inclusivity and categorized the degree of relevance to the study question as:

- Relevant/high relevance: Population-level approaches considering trauma-informed public health domains, including explicit emergency responses.
- Partial/moderate relevance: Not explicitly an emergency approach but describes aspects of relevant trauma-informed public health domains in an emergency context.
- Low or unclear relevance: Not explicitly an emergency approach, may describe some relevant components in emergency or other contexts, but unclear if this adds any additional value.

Data extraction

We developed a data extraction tool using Microsoft Excel to systematically extract the following data (File 2 in Supplementary material):

1. Study details: First author, publication year, title, brief aim, study design (descriptive quantitative, descriptive qualitative, descriptive strategy/intervention, review, commentary, other), conflicts of interest.
2. Population details: Country, description, place of residence, race/ethnicity, language other than English, education status, socio-economic status, social capital, other vulnerabilities.
3. Public health emergency details: Type of public health emergency (Severe Acute Respiratory Syndrome (SARS), Coronavirus Disease 2019 (COVID-19), Middle East Respiratory Syndrome (MERS), other epidemic/pandemic, other public health emergency), description of emergency, year.
4. Trauma-informed response details: Trauma definition used, definition of trauma-informed response [if available], core concepts (safety, trustworthiness, peer support, collaboration, empowerment, cultural and gender considerations, holistic support, compassion, other).
5. Outcomes reported: public health outcomes, experiences and views, economic impacts, explanatory factors, other relevant phenomena.

Risk of bias appraisal

Given the variety of studies and stepwise approach to study inclusion, we drew on an adapted GRADE approach (55) (see File 3 in Supplementary material) to categorize the degree of confidence from high, moderate, low or very low in individual studies as follows:

1. Intervention studies, descriptive/observational studies, qualitative studies and reviews started with "high confidence" and were downgraded one category for serious concerns or two categories for very serious concerns about any of the following domains:
   a. Study limitations (concerns about whether methods appropriate; researcher relationship considered (qualitative studies); selection bias; incomplete outcome data inadequately addressed; inadequate accounting/adjustment for confounders).
   b. Adequacy of data (concerns about sampling, sample size, data analysis etc).
   c. Indirectness/relevance (concerns about outcome measures etc).
2. Expert opinions and commentaries were categorized as low confidence and downgraded to "very low" if there were concerns about the lack of supporting evidence and/or references, or there was no representative expert body identified [e.g., the Centers for Disease Control and Prevention (CDC), Substance Abuse Mental Health Services Administration (SAMHSA)].

Data synthesis

We used a "best fit" framework synthesis approach to data synthesis in this rapid review (56). This approach enables a relatively rapid, transparent, and pragmatic process, and incorporates inductive thematic analysis techniques only for data that that does not fit easily within the framework themes. This approach is particularly useful for "policy urgent" questions and findings can be shaped to be more directly applicable.

We reviewed existing trauma-informed public health emergency frameworks and used the principles from SAMHSA's Concept of Trauma and Guidance for a Trauma-Informed Approach (safety, trustworthiness and transparency, peer support, mutuality, empowerment, voice and choice, cultural, and gender considerations) (57), as well as a synthesis of trauma-informed frameworks used to develop a conceptual framework of core principles for co-designing perinatal strategies for Aboriginal and Torres Strait Islander parents experiencing complex trauma (safety, trustworthiness, empowerment, collaboration, culture, holistic, compassion) (35) to form the *a priori* framework. We also included an "Other" category for data that did not fit the framework, for subsequent thematic analysis. Data were synthesized in tabular and narrative form.

To avoid double-counting of studies, we grouped papers that came from the same overarching study or where the relevant content is an application or critique of an existing framework. We refer to these papers as "associated references."

Results

Study selection

The search yielded 9,922 articles after duplicates were removed, and a further 9,779 were excluded during title/abstract screening. We reviewed 148 full-text articles, and 48 articles were included in this review [40 "studies"—where 8 related articles (associated references) are grouped under the relevant primary "study" (of which there were 4)]. Reasons for exclusion at full-text review stage included a primary focus on mental health impacts, the wrong study designs, setting, or outcomes of interest, or not relevant to public health emergencies or trauma-informed approaches. See Figure 1 for a detailed flow chart.

Description of included studies

The 40 included studies (comprising 48 references of which eight were classified as associated references) were categorized fairly evenly across high, moderate, and low relevance to the study question. Eleven studies were categorized as high (58–68); 14 as moderate (69–82); and 15 as low (83–97).

There were nine primary studies [five quantitative (78, 81, 83, 90, 96), two qualitative (88, 97), one workshop intervention (91), one description of a community response (67)]. One book chapter (68) and eight reviews (61, 63, 73, 74, 79, 84, 94, 95) were included. Five commentaries (65, 71, 75, 89, 92) and 11 descriptive analytic/strategies (58, 60, 62, 64, 72, 77, 80, 82, 85, 87, 93) were included. Six "other" types of references were included: a descriptive overview (66), a letter to the editor (70), blog post/government information (59), editorials (69, 76, 87), and one thesis (86).

Most of the included studies were led by authors based in and writing about the United States [US 16 (58, 59, 64–67, 71–73, 80–82, 85, 86, 91, 95)] or were unclear, with a global/generic perspective [other 13 (60–63, 68, 69, 74, 79, 84, 89, 92–94)]. There were two studies each from Sierra Leone (76, 83) and China (70, 97), and one study each from Australia (87), Canada (88), Germany (96), Czech Republic (78), South Africa (75), Argentina (77), and South Korea (90). Two US studies were focused on minority population groups (African American, Latino and Native American Communities) (67, 71).

Half (21, 50%) of the included studies were specifically about public health emergencies: COVID-19 (17) (60, 62, 67, 69–71, 75, 77–79, 82, 89, 90, 92, 94, 96, 97), Ebola (2) (76, 83), other epidemic/pandemics (1) (72) and other public health emergencies (1) (59). Eleven studies addressed strategies/responses for a mix of emergency/disaster scenarios including pandemics, environmental disasters, mass violence (61, 63, 68, 73, 74, 80, 85, 87, 91, 93, 95). A further three focused solely on environmental disasters (65, 81, 88). Three studies were not related to an emergency response but were trauma-informed strategies more generally (58, 64, 66). Two other references were neither a trauma-informed approach specifically or an emergency response [one discussed the ethics of distressing social marketing campaigns (84), one a thesis, outlined a proposed community resilience model in addressing adverse childhood experiences (86)].

Six primary studies referred to "trauma-informed" approaches (58, 59, 62, 64, 66, 72), with five associated references (57, 98–101). One further study inferred a trauma-informed response (67) and two studies explored the impact of trauma on behavior in an infectious disease outbreak (76, 83).

Risk of bias within studies

Ten studies were graded as high confidence (60–62, 73, 74, 81, 83, 88, 90, 96). Fifteen (15) as moderate (58, 59, 63, 64, 68, 72, 77, 79, 80, 82, 84, 87, 93–95). Thirteen (13) as low (65–67, 69, 71, 76, 78, 85, 86, 89, 91, 92, 97). Two as very low (70, 75).

The complete table of characteristics of included studies and study confidence is presented below (Table 1).

Main findings

No studies were found which explicitly evaluated any outcomes following application of a trauma-informed public health emergency response.

We present here a brief overview of psychological impacts from an emergency, and how existing mental health conditions relate to the response, followed by reported public health outcomes, experiences and views, economic impacts and relevant theories. In the following section, we present the core components of a trauma-informed public health emergency response and relevant literature found.

Psychological response to an emergency

Included studies highlighted the psychological impacts of traumatic events. While the specific focus of this review is to examine trauma-informed approaches rather than impacts, we briefly outline some key aspects related to the capacity to respond to an emergency:

Most people will experience some fear in an emergency. In COVID-19 this includes being fearful about one's own illness and risk of dying from COVID-19, separation from loved ones and loss of livelihoods for self and others, and availability of healthcare and food (69, 78). These fear responses can influence behavior and may increase risk of contracting the virus. For example, during the Ebola outbreak people broke quarantine to access holy water as a cure, or ingested salt water (76). There were also economic impacts as people avoided businesses in

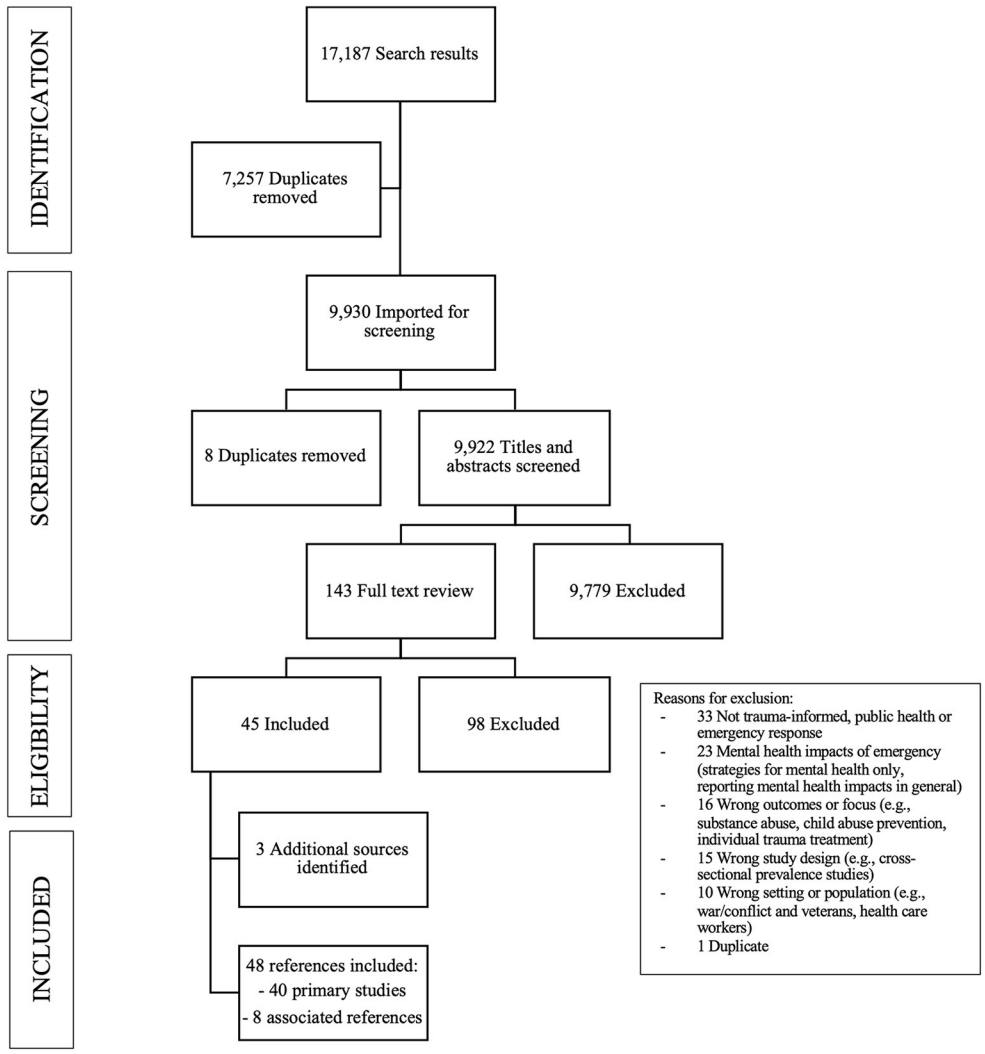

FIGURE 1
Flow chart of search results, studies screened for inclusion, and reasons for exclusion.

busy places (76). Fears may also result in stigma, reducing the likelihood that people will seek testing and treatment for fear of being rejected by their communities (69, 76). During the early stages of COVID-19, people of Chinese or Asian backgrounds experienced racism and stigma (70, 71).

Grief and loss are also common experiences during and after a public health emergency. People will be affected by illness and death among their family, friends and community leaders which will have flow on effects for mental health services (72). In a pandemic such as COVID-19, grieving processes, funerals and traditional rituals are disrupted with families unable to be with each other in final moments (69). People may also go on to experience "complicated grief," marked by greater distress over longer periods, following traumatic deaths such as from COVID-19 and low social support (68, 79). During/post disasters, people can also experience grief over the loss of possessions, as well as for the changes in the community, their sense of safety and their sense of contribution and value. "Grief leadership" is required (74).

There is an increased risk of negative mental health impacts, including depression, anxiety, post-traumatic stress disorder (PTSD), dissociative responses, acute stress disorder, panic disorders, demoralization, perceived stress, negative affect, physical health problems, and/or somatic concerns, poor sleep, increased substance use, and physiological indicators of stress (68, 74). The broader impacts of an emergency event (including unintended consequences of the emergency response), such as financial and food insecurity during and post the event, can contribute to poorer psychological outcomes (66, 74, 78). The evidence varies on the extent and severity of mental health

TABLE 1 Characteristics of included studies.

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
RELEVANT/HIGH RELEVANCE						
Bowen and Murshid (58) [Bowen and Irish (99) (low relevance)]	USA	Trauma-informed public health emergency generally (social policy)	To advocate for trauma-informed policy analysis to address social problems (e.g., opioid use).	More than half (55%) opioid-related bills aligned with at least one trauma-informed principle, such as safety (38/3%), choice, or empowerment. Greater attention to trauma needed.	Descriptive analytic (strategy/intervention)	Moderate
CDC (59) [Wolkin (98), SAMHSA (57), Griffin (100), Lynch et al. (101) (Low relevance)]	USA	Public health emergency (COVID-19) and trauma-informed principles	To describe training to increase CDC's Office of Public Health Preparedness and Response (OPHPR) responder awareness of the impact that trauma can have in the community.	Training for public health emergency preparedness and response through a trauma-informed lens centered on SAMSHA's six principles: safety; trustworthiness and transparency; peer support; mutuality and collaboration; empowerment voice and choice; cultural, historical, and gender issues.	Other (government information/blog)	Moderate
Glover et al. (60)	Other	PH emergency (COVID-19)	To outline "a framework for identifying and mitigating the equity harms of COVID-19 policy interventions"	COVID-19 lockdown policies particularly affect vulnerable populations, exacerbating pre-existing inequities and generating new ones. Construction and application of the framework demonstrated that each adverse effect, and each equity domain, can interact with, worsen, and be worsened by others. Policy responses have the ability to reduce the peak of the pandemic, or, if poorly designed or implemented, increase it. They also have the potential to increase or reduce inequities. Addressing the underlying social determinants of inequity in parallel is itself an essential intervention to mitigate the effects of this and future pandemics.	Descriptive analytic (strategy/intervention)	High
Hobfoll et al. (61), [Fairbank and Gerrity (102) Norris and Stevens (103)]	Other/USA	Disaster (mix)	To outline "five essential elements of immediate and mid-term mass trauma interventions," based on the Learned Optimism and Positive Psychology Model. The goals of this model are to identify, amplify, and concentrate on building strengths, enhancing hope and disputing catastrophic and exaggerated thinking in people at risk.	Five empirically supported intervention principles to guide and inform intervention and prevention efforts at the early to mid–term stages are promoting: (1) a sense of safety, (2) calming, (3) a sense of self- and community efficacy, (4) connectedness, and (5) hope. A criterion of wellness proposes that we must also attend to disaster victims' abundant problems in living that may interfere with their quality of life (103).	Review	High

(Continued)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Javakhishvili et al. (62)	Other (global)	PH emergency (COVID-19)	To outline the position of the European Society for Traumatic Stress Studies (ESTSS) regarding "trauma-informed responses in addressing public mental health consequences of the COVID-19 pandemic," and focuses on (1) trauma-informed policies, (2) capacity building, (3) collaborative research and (4) knowledge-exchange.	Studies on COVID-19 impact reveal a high level of distress and increased prevalence of mental health symptoms among the general populations of the affected countries, including anxiety, depression, adjustment disorder and PTSD, as well as hazardous and harmful alcohol use. To minimize these consequences, it is crucial to put in place trauma-informed policies, strategies, and interventions as well as to promote evidence-based methods of trauma-specific care, tailored to the new circumstances. The European Society for Traumatic Stress Studies outline a range of strategies and resources to aimed at contributing to this endeavor.	Descriptive analytic (strategy/intervention)	High
Kleber (63)	Other (global/unclear)	Disaster mix	To show the relevance of the discipline of traumatic stress studies to the field of public mental health by examining central concepts and findings concerning trauma and its aftermath and examining implications for public mental health. Attention is paid to the diagnosis of posttraumatic stress disorder (PTSD) and the construct of resilience as well as to specific areas of public mental health activities.	A public mental health perspective will help to develop preventive approaches to trauma and extend the impact of various forms of interventions. It will also make clear that trauma-informed care will have to consider the community and the society at large. Argues reconciliation can increase forgiveness of perpetrators and strengthen social capital. However, there were also negative psychological impacts and policy-makers should be careful with reconciliation processes.	Review	High
Loomis et al. (64)	USA	Trauma-Informed (health systems)	To describe the process through which the San Francisco Department of Public Health (SFDPH) developed and implemented their Trauma-Informed Systems (TIS) Initiative, an organizational model to address trauma at the systems level.	Six core principles underlie the work of the SFDPH's TIS Initiative: (1) Understanding Trauma & Stress, (2) Compassion & Dependability, (3) Safety & Stability, (4) Collaboration & Empowerment, (5) Cultural Humility & Responsiveness, (6) Resilience & Recovery. Initiative components focus on creating and sustaining trauma-informed knowledge and organizational practices. Trauma-informed systems represent an emergent organization-level intervention designed to address trauma.	Descriptive analytic (strategy/intervention)	Moderate

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Melton and Sianko (65)	USA	Environmental disaster (mix)	Commentary asking "How Can Government Protect Mental Health Amid a Disaster?"	Proposes the "congressionally mandated" National Disaster Recovery Framework be grounded in eight principles: individual and family empowerment, leadership and local primacy, preparation for recovery, partnerships and inclusiveness, communications, unity of effort, timeliness and flexibility, and resilience and sustainability.	Commentary	Low
Tebes et al. (66)	USA	Trauma-Informed health (population health systems/policies)	To describe a population health perspective for trauma-informed practice that complements the current clinical perspective, and then discuss implications of that perspective for programs, systems, and policies. Essential concepts about trauma over the life course and principles of population health science relevant to trauma-informed practice are summarized and implications discussed.	Advocates for a population health perspective that emphasizes a risk reduction and health promotion strategy that targets macrosocial determinants and rebalances the priorities for research and action about trauma exposure to complement the current clinical perspective. A population health perspective to trauma-informed practice will be essential to move the population health curve shaped by trauma exposure over the life course. Four priorities for trauma-informed practice from a population health perspective include: (a) adopting trauma-informed policies to prevent trauma exposure and to foster resilience in the aftermath of trauma; (b) infusing trauma-informed practice into everyday activities so it is a routine part of interpersonal transactions; (c) incorporating trauma-informed practices into existing service systems; and (d) adapting existing treatments to incorporate trauma-informed principles for population health impact.	Other (commentary/overview)	Low
Thompkins et al. (67)	USA (African-American Communities)	PH emergency (COVID-19)	To reflect on a series of 15-min videos produced to provide resources to pastors in African-American communities to aid them in conveying accurate public and mental health information about COVID-19. Video presenters included trusted experts in public and mental health and pastors with considerable experience responding to the needs of the African-American community during the COVID-19 pandemic.	Four culturally specific core themes identified to consider when providing care to African Americans at increased risk during the pandemic were: ritual disruption, negative reactions for not following public health guidelines, trauma, and culture and trust. Historical harm, health disparities, stigma, and distrust of medical institutions were highlighted. Participants noted congregants rely on their family and the church in times of crisis rather than medical experts.	Commentary	Low

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Watson et al. (68)	Other (global/unclear)	Disaster mix	Book chapter which aims to summarize empirical research and expert consensus, and make recommendations for furthering the field of disaster mental health intervention.	Need a public health approach that accounts for pre-existing individual and community resources, risk factors and disaster type, and categorizes subjects into appropriate exposure groups. Only some individuals require interventions, and some level of screening for predictors of continued distress is recommended. However, some have warned against simplifying a conceptual framework of risk factors in a way that might obscure the important nuances and complexities of a disaster's consequences.	Review	Moderate
PARTIAL/MODERATE RELEVANCE						
Adhanom Ghebreyesus (69)	Other (global/unclear)	PH emergency (COVID-19)	Editorial from Director-General of WHO to argue that "addressing mental health needs is an integral part of COVID-19 Response".	The WHO Department of Mental Health and Substance Use is developing public messages and promote the integration of mental health and psychosocial support into the COVID-19 response effort as part of risk communication and community engagement. The approach to mental health is comprehensive—not only focusing on responding to the current crisis and recovery after the crisis, but also on preparedness and getting services ready in countries before the next emergency through supporting countries in establishing community based mental health services for everyone everywhere.	Editorial	Low
Bao et al. (70)	China	PH emergency (COVID-19)	Letter arguing need to "address mental health care to empower society".	Many mental distress experiences as a result of COVID-19 pandemic. All 31 provincial-level regions in mainland China with confirmed 2019-nCoV cases activated so-called level 1 public health emergency responses. In addition to public health interventions, dealing with public psychological barriers and performing psychological crisis intervention is included in the level 1 response. Guidelines for authorities and a handbook for the public are described.	Correspondence	Very low (Downgraded for methodological concerns)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Fortuna et al. (71)	USA (Black, Latino and Native American Communities)	PH Emergency (COVID-19)	Commentary calling for "The Need for a Trauma-Informed Social Justice Response, to address Inequity and the Disproportionate Impact of COVID-19 on Communities of Color in the United States".	COVID-19 has had disproportionate contagion and fatality in Black, Latino, and Native American communities and among the poor in the United States. Toxic stress resulting from racial and social inequities have been magnified during the pandemic. The [USA] must focus and invest in addressing health inequities and work across sectors to build self-efficacy and long-term capacity within communities and systems of care serving the most disenfranchised and: 1. reduce silos between clinical care and social services and integrate; 2. Emphasize respectful, thoughtful, and consistent leadership to empower community; 3. Build capacity for telehealth partnerships; 4. Foster environments and relationships to help children develop and sustain self-regulation, relational, problem-solving skills, and positive activities; 5. Promote parenting competencies, positive peers, caring adults, positive community environments (including elimination of racist and xenophobic experiences), and economic opportunities for families.	Commentary	Low
Manderscheid (72)	USA	PH Emergency (other epidemic/pandemic—avian influenza)	Disasters can inflict severe trauma on a large number of people simultaneously. The purpose of this article is to explore the leadership needed to respond to such potentially catastrophic events.	Pandemics have widespread primary effects of increased morbidity and mortality, and the secondary effects of disrupting our economic, health, educational, and community institutions. Many new cases of mental illness are likely to develop, secondary to the epidemic of grief, depression, sleeplessness, and anxiety that will be associated with illness, the fear of illness, and death of loved ones. Effective trauma-informed leadership will require both excellent managerial skills and detailed substantive knowledge about the required response. Planning for a national response to pandemic influenza will require trauma-informed leadership and hence training of leaders is needed.	Descriptive analytic (strategy/intervention)	Moderate (Downgraded for methodological concerns)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Meredith et al. (73)	USA	Disaster mix	To describe two conceptual frameworks to guide hospitals and clinics in managing the psychological aspects of large-scale disasters that might involve a surge of psychological casualties	One framework illustrates the antecedents of psychological and behavioral consequences ("psychological triggers") of disasters. Another framework provides the foundation for the structures and processes needed to address the consequences of reactions to these psychological triggers. Structures include internal organizational structure and chain of command, resources and infrastructure, and knowledge and skills. Processes include coordination with external organizations, risk assessment and monitoring, psychological support, and communication and information sharing to support evidence-informed interventions. The frameworks informed the development of a training program for hospitals and clinics throughout Los Angeles County.	Review	High
Morganstein and Ursano (74)	Other (global/unclear)	Disaster mix	Review/expert paper to describe how disasters often have a predictable pattern of evolving over time and anticipated psychological and behavioral problems and community disruptions that create the most significant public health burden.	Various factors enhance transmission of adverse effects beyond the geographic location of an ecological disaster, with certain populations being particularly vulnerable to these effects. Understanding the range and pattern of these effects can aid in optimizing interventions. Interventions should be evidence-based, tailored to community needs, and serve to enhance the essential elements of safety, calming, self- and community-efficacy, social connectedness, and hope or optimism. Risk and crisis communication can shape community behaviors and influence perception of risk with trust and health-promoting behaviors being heavily influenced by thoughtful public health messaging. Effective leadership involves communication with community members, being present, honest, and trustworthy, modeling self-care, addressing community challenges such as grief and loss, and is essential for community recovery.	Review	High

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Naidu (75)	South Africa	PH emergency (COVID-19)	Commentary highlighting impact on COVID-19 on South Africans, who have experienced serial collective trauma.	The pandemic will exacerbate social and economic challenges and increase mental health risks. South African resilience will be tested again.	Commentary	Very low
O'Leary et al. (76)	Sierra Leone	PH emergency (Ebola)	Editorial which aimed to examine published research to provide contexts for better understanding of the mental health impact of Ebola. Outlines the unique role of fear-driven behaviors and the influence of culture on mental health outcomes, possible implications for future outbreak responses, and whether current measurement tools are sufficiently reliable and valid to assess mental health impact during large-scale epidemics.	Fear-related behaviors and stigmatization are common, and negatively affect access to care, quality of care and spread of the epidemic. This phenomenon should be addressed from the outset by public and mental health professionals aiming to educate the public *via* social and digital media, attempting to directly contain fear and panic, and improve access to modern care. Local cultures often play a key role in medical response, burial rituals and treatment-seeking for trauma-related disorders such as PTSD, anxiety and depression. Sensitive adaptation of modern psychiatric care to local practices should be an ongoing effort regardless of epidemic breaks, facilitated *via* partnerships with community and spiritual players. Culturally sensitive, trauma-focused interventions should be developed and tested before future outbreaks occur, to ensure appropriate and accessible mental health responses. Such intervention should integrate gold standard treatments, traditional cultural norms, habits, spiritual support, and community healing practices.	Editorial	Low
Polischuk and Fay (77)	Argentina	PH emergency (COVID-19)	A consequence of governmental "stay-at-home" protection orders is to confine potential perpetrators and victims of gender-based violence in close proximity thereby reducing the opportunity for survivors to report abuse and get assistance. In this essay, the authors describe the multilevel governmental response in Argentina to address gender-based violence during the first month of mandatory stay-at-home order amid the COVID-19 pandemic.	National and provincial governments enacted innovative and coordinated responses to gender-based violence that targeted systemic causes of gender-based violence, ensured continuity of existing services, and generated new communication strategies to allow non-verbal reporting during the pandemic. Governments should consider the gendered effects of responses to emergencies and respond through a multilevel and cross-sectoral response.	Descriptive analytic (strategy/intervention)	Moderate

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Trnka and Lorencova (78)	Czech Republic	PH emergency (COVID-19)	To provide information about distress and traumatic responses accompanying the first 7 weeks of the outbreak of the COVID-19 epidemic in the Czech Republic.	Fear, anger and hopelessness were the most frequent traumatic emotional responses during the first stage of the COVID-19 epidemic in the Czech Republic. The four most frequent categories of fear were: (a) fear of the negative impact on household finances, (b) fear of the negative impact on the household finances of significant others, (c) fear of the unavailability of health care, and (d) fear of an insufficient food supply. Pessimistic communications used by the Czech mass media contributed to intensifying traumatic feelings, fears, and psychological distress. Supportive activities included home delivery for older adults, special shopping hours for older adults in supermarkets, establishing help lines, and launching a new TV channel with an anti-stress broadcasts targeted to older viewers. At the same time, many civic activities were started, for example, an initiative called "Scientists Against Melancholy," in which Czech scientists posted short supportive messages to the general public on an online social network.	Descriptive (quantitative)	Low
Wasserman et al. (79)	Other (global/unclear)	PH emergency (COVID-19)	To systematically evaluate the influence of the COVID-19 pandemic on risk and protective factors for suicide at the societal, community, relationship, and individual levels.	The COVID-19 pandemic affects risk and protective factors for suicide at each level of the socio-ecological model. While there is evidence indicating that suicide rates decrease during times of crises, they are expected to increase once the immediate crisis has passed. Suicide should be prevented by strengthening universal strategies directed to the entire population, including mitigation of unemployment, poverty and inequalities; prioritization of access to mental health care; responsible media reporting with information about available support; prevention of increased alcohol intake; and restriction of access to lethal means of suicide. Selective interventions should continue to target known vulnerable groups who are socio-economically disadvantaged, but also	Review	Moderate

(Continued)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
				new ones such as first responders and health care staff, and the bereaved by COVID-19 who have been deprived of the final contact with loved ones and funerals. Indicated preventive strategies targeting individuals who display suicidal behavior should focus on available pharmacological and psychological treatments of mental disorders, ensuring proper follow-up and chain of care by increased use of telemedicine and other digital means.		
Wells et al. (80)	USA	Disaster mix	To describe community engagement and participatory research to improve mental health services, disaster recovery, and preparedness from a community resiliency perspective in Los Angeles County and the City of New Orleans.	Relationships, trust and engagement are core competencies for disaster preparedness and response/recovery. Diverse partnerships can organize around goals to improve community and individual outcomes. Time is required to form partnerships that can address sensitive issues (such as depression and trauma). For vulnerable populations, the level of trust development required, and "insider-outsider" dynamics following disasters, requires a responsive and long-term approach that values relationships and investments in mental health.	Descriptive analytic (strategy/intervention)	Moderate
West et al. (81)	USA	Environmental disaster (Hurricane Ike)	To examine the association between disaster exposure, community support, and mental health outcomes in urban and non-urban participants of Galveston and Chambers counties after Hurricane Ike.	Community support reduces distress across an entire community through the theorized constructs of community resilience and community coherence; and in reducing PTSD and depression symptoms associated with the interpersonal effects of a disaster in non-urban areas. Communities may play a more beneficial role in the recovery process in non-urban areas that have elevated levels of injury or death attributed to a disaster.	Descriptive (quantitative)	High
Wong et al. (82)	USA (Children in foster care or behavioral/ medical health needs)	PH emergency (COVID-19)	To highlight the health risks of the pandemic response measures to vulnerable pediatric subpopulations; and propose risk mitigation strategies that can be enacted by policy makers, health care providers and systems, and communities	Risk and mitigation strategies are needed for: (1) children with behavioral health needs, (2) children in foster care or at risk for maltreatment, and (3) children with medical complexity (CMC). Mitigation strategies delineated for these 3 at-risk populations are also likely beneficial for any child and family.	Descriptive analytic (strategy/intervention)	Moderate

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
				Importantly, children not already in these groups are at risk for facing new medical, behavioral, or social challenges that develop during the pandemic. In particular, children in households of low socioeconomic status are likely at the highest risk for new or worsening issues, underscoring the critical leadership role of Medicaid programs in these risk mitigation strategies.		
LOW OR UNCLEAR RELEVANCE						
Betancourt et al. (83)	Sierra Leone	PH emergency (Ebola)	To examine associations between war exposures, post-traumatic stress disorder (PTSD) symptoms, depression, anxiety, and personal Ebola Virus Disease (EVD) exposure and EVD-related health behaviors in the Western Rural and Western Urban districts of Sierra Leone at the height of the EVD epidemic (January–April 2015).	In post-conflict settings, past war trauma and mental health problems are associated with health behaviors related to combatting EVD. The associations between war trauma and both EVD risk behaviors and EVD prevention behaviors may be mediated through two key mental health variables: depression and PTSD symptoms. Individuals reporting greater intensity of depression symptoms and higher rates of PTSD symptoms also reported higher rates of behaviors that increase the risk of spreading EVD, while individuals reporting previous exposure to war or having a friend diagnosed with EVD reported lower rates of such behaviors. Considering mental health may help fight ongoing and future Ebola outbreaks in Sierra Leone.	Descriptive (quantitative)	High
Brown and Whiting (84)	Other (global/ unclear—UK based author)	Other (not emergency or TI—ethics of distressing social marketing)	To outline a framework to support assessment of the ethical acceptability of fear-arousing communications campaigns using the public health ethics literature as a guide.	Distressing health promotion advertising that uses messages that generate a negative emotional response aim to increase the likelihood that the audience will take the suggested action and adopt healthier behaviors. Potential harms include that viewers do not consent and cannot withdraw and that messages may increase stigmatization of population sub-groups. Distressing advertising has the potential to be effective but recommends a framework using public health ethics literature for advertisers to plan against to ensure such approaches are ethically defensible i.e., where the conditions of effectiveness, proportionality necessity, least infringement, and public accountability are satisfied, including pre-testing of messages with the target population.	Review	Moderate

(Continued)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Crepeau-Hobson and Drennen (85)	USA	Disaster mix	To analyse the Colorado Crisis Education and Response Network (CoCERN), a statewide asset based in community partnerships formed to deliver effective, efficient, and professional disaster behavioral health services to communities impacted by a disaster.	CoCERN protocols and guidelines address all core issues of disaster behavioral response, including command, communications, resource management and training and credentialling; with several key foundational elements: (1) it is not an entity—it is a partnership and agreement to work collaboratively and cooperatively in planning and response and provide an umbrella structure for guiding the behavioral response (2) It is only designed for immediate response period, as longer term recovery best left to local resources in affected communities, and (3) it is a community asset. The unified command aspect of CoCERN was crucial. Effective communication is a priority and a focus on social justice common to all elements.	Descriptive analytic (strategy/intervention)	Low
Ellis (86)	USA	Other (not emergency or TI—proposes as resilience model)	To develop a model of community resilience for application of systems thinking to public health planning.	The model aims to link wellness to the local community context and systems-level influences on community and population health outcomes. Cross-sector collaboration will address determinants of health and improve equity Using this model to assess community resilience, local health departments can convene multiple sectors at the local, state and federal level to manage and deliver assets and resources that contribute to a community's economic vitality, health, and wellbeing.	Thesis	Low
Forbes et al. (87)	Australia (global focus)	Disaster mix	To describe international consensus regarding the optimum disaster recovery programme and a methodology to trial its effectiveness. Currently, "psychological first aid" (or Level 1 intervention) is the universal prevention strategy of choice and is designed to enhance individual and community resilience and to foster cohesion and mutual support.	This program targets (1) populations exposed to a disaster of natural or human origin (2) primarily short-medium term, but provision for longer term, (3) goals to reduce distress and psychological symptoms (4) for delivery by primary health care and welfare practitioners at a local level, as well as by carefully selected and trained volunteers (5) will consist of a brief, highly structured and manualised intervention with brief training and supervision manuals.	Descriptive analytic (strategy/intervention)	Moderate (Downgraded for methodological concerns)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
			At the other end of the spectrum, evidence-based pharmacological and psychological interventions for diagnosable psychiatric conditions following disaster and trauma (Level 3). The middle level (Level 2) aims to assist the substantial number of people who develop ongoing disabling and distressing adjustment problems or sub-clinical psychiatric disorders.	The final protocol is simple to train and implement and key components are: (1) promoting healthy living, (2) arousal and affect management, (3) emotional processing, (4) value-based behavioral activation, (5) maintaining healthy relationships and (6) rumination and worry control.		
Genereux et al. (88)	Canada (with leaders from Canada, US, UK, Australia)	Environmental disasters (mix)	To critically assess the integration of Environmental Public Health (EPH) expertise and research into each phase of disaster management.	Six critical success factors: blending the best of traditional and modern approaches; fostering community engagement; cultivating relationships; investing in preparedness and recovery; putting knowledge into practice; and ensuring sufficient human and financial resources. Several promising knowledge-to-action strategies included mentorship programs, communities of practice, advisory groups, systematized learning, and comprehensive repositories of tools and resources. Good governance may be the single most important factor influencing the effectiveness of emergency preparedness, response and recovery. Beyond structures and plans, it is necessary to cultivate relationships and share responsibility for ensuring the safety, health, and wellbeing of affected communities, while respecting the local culture, capacity, and autonomy. Preparation for and management of EPH disaster risks requires effective long-term collaboration between science, policy, and EPH practitioners at all levels in order to facilitate coordinated and timely deployment of multi-sectoral/jurisdictional resources when and where they are most needed.	Descriptive (qualitative)	High
Johnson et al. (89)	Other (global/ unclear—Spain is a specific example)	PH Emergency (COVID-19)	To argue that, in the absence of a vaccine, governments need to introduce universal basic income as a means of mitigating this trauma.	The social and economic consequences of lockdowns and social distancing measures, such as unemployment, broken relationships, and homelessness, create potential for intergenerational trauma extending decades into the future.	Commentary	Low

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
				Without employment or adequate social security, individuals face both a "social" death in isolation from their communities and the removal of means of satisfying basic needs.		
Lee et al. (90)	South Korea	PH emergency (COVID-19)	To assess the prevalence of COVID-19 misinformation exposure and beliefs, associated factors including psychological distress with misinformation exposure, and the associations between COVID-19 knowledge and number of preventive behaviors.	COVID-19 misinformation exposure was associated with misinformation belief, while misinformation belief was associated with fewer preventive behaviors. Given the potential of misinformation to undermine global efforts in COVID-19 disease control, up-to-date public health strategies are required to counter the proliferation of misinformation.	Descriptive (quantitative)	High
McCabe et al. (91, 104)	USA	Disaster mix	To develop and evaluate a model of disaster mental health preparedness planning involving a partnership among three key stakeholders in the public health system. The curriculum and plan development involved establishing the parameters for a comprehensive but practical disaster planning template.	Within the span of a six-month period, stakeholders can effectively plan, implement, and evaluate an effective, practical, and durable model of capacity building for public mental health emergency planning for promoting disaster mental health preparedness and community resilience.	Descriptive (quantitative)	Low
Provenzi and Tronick (92)	Other (global/ unclear—specific examples from Italy/US)	PH Emergency (COVID-19)	To learn from infant research about the potential of psychological reparation for human trauma and disconnection, where the psychological burden related to the coronavirus disease 2019 pandemic is starting to be realized.	The coronavirus pandemic represents an unprecedented threat to human health worldwide. In the absence of a specific available cure for this disease, countries are adopting mitigation strategies that largely depend on physical distancing, with a dramatic restriction of social contacts. Reparation can be defined as the human ability to coregulate emotions and to resolve interactive mismatches and separations by reciprocally engaging in attuned interactive exchanges capable of expanding our capacities for resilience. Alongside economical and medical health solutions, investing in psychological, emotional, and affective reparatory acts is warranted to be a key component of the material and social support recovery strategies worldwide that citizens will need to achieve a new equilibrium and wellbeing.	Commentary	Low

(Continued)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
Purtscher (93)	European (global but with EU focus)	Disaster mix	To plan and train staff for psychosocial interventions, European and national guidelines have been developed.	European Policy Paper "Psychosocial support in situations of mass emergency" offers guidance for policy-makers concerning psychological support and social accompaniment for those involved in situations of mass emergencies Priorities to: rescue and maintain the vital functions, including basic and advanced life support, assistance to meet basic needs, such as shelter, drinking, eating, sleeping and hygiene, and providing information and social communication; provide psychosocial support to enable people to go on with their personal and family activities with regard to their privacy, dignity and liberty; maintain or regain physical, mental, emotional, and social wellbeing.	Descriptive analytic (strategy/intervention)	Moderate
Rajkumar (94)	Other (global/ unclear—author based in India)	PH emergency (COVID-19)	To discuss individual and community responses to COVID-19 from the point of view of attachment theory, a psychological theory which examines the formation and disruption of attachment bonds across the life-span from an evolutionary perspective. To provide a theoretical framework to understand the impact of COVID-19 on the psychological health of individuals and societies.	Attachment theory could help inform measures designed to promote adaptive behaviors and foster positive relationships among members of communities affected by COVID- 19, and to minimize stigmatization. In an indirect manner, attention to basic physical needs such as food and shelter could prevent excessive or inappropriate activation of the "attachment system". A similar effect could be obtained by regulating the alarming effects of media coverage. Services should especially be made accessible to those most vulnerable to the effects of disrupted interpersonal bonds, such as the elderly, the socially isolated, and those facing economic hardship related to the COVID-19 crisis.	Review	Moderate
Sandifer and Walker (95)	USA (some global references)	Disaster mix	To review key literature about disasters, resilience, and disaster-associated stress effects.	Recommend eight actions to improve resiliency through inclusion of stress alleviation in disaster planning: (1) Improve existing disaster behavioral and physical health programs to better address, leverage, and coordinate resources for stress reduction, relief, and treatment in disaster planning and response. (2) Emphasize pre- and post-disaster collection of relevant biomarker and other health-related data to provide a baseline of health status	Review	Moderate

(Continued)

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TABLE 1 (Continued)

References (Associated refs)	Country/ Population	Type of emergency	Aims and/or trauma-informed response details	Main conclusions	Study design	Confidence (High/Moderate/ Low/Very low)
				against which disaster impacts could be assessed, and continued monitoring of these indicators to evaluate recovery. (3) Enhance capacity of science and public health early-responders. (4) Use natural infrastructure to minimize disaster damage. (5) Expand the geography of disaster response and relief to better incorporate the displacement of affected people. (6) Utilize nature-based treatment to alleviate pre- and post-disaster stress effects on health. (7) Review disaster laws, policies, and regulations to identify opportunities to strengthen public health preparedness and responses including for stress-related impacts, better engage affected communities, and enhance provision of health services. (8) With community participation, develop and institute equitable processes pre-disaster for dealing with damage assessments, litigation, payments, and housing.		
Schäfer Sarah (96)	Germany (small sample from Austria, Switzerland, French-German border)	PH Emergency (COVID-19)	To assess the impact of the COVID-19 outbreak on mental health and to investigate the ability of pre-outbreak sense of coherence (SOC) levels to predict changes in psychopathological symptoms. This includes the resistance factor of SOC, which constitutes an important step toward developing interventions aimed at buffering the effects of global stressors.	Although mental health was stable in most respondents, a small group of respondents characterized by low levels of SOC experienced increased psychopathological symptoms from pre- to post-outbreak. Thus, SOC training might be a promising approach to enhance the resistance to stressors.	Descriptive (quantitative)	High
Sun et al. (97)	China	PH emergency (COVID-19)	To share observations on the psychosocial consequences of COVID-19 among people in China and articulate a population health perspective to understand and address identified issues.	Context-informed, evidence-based interventions are needed to effectively engage the public beyond a traditional mental health treatment approach, normalize people's experiences, and promote population health. As the population is experiencing increased vulnerability to psychological distress, this may be an opportunity to raise the public's awareness of psychological health and enhance strategies during and beyond quarantine to enhance population wellbeing.	Descriptive (qualitative)	Low

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impacts post-disaster, however it is thought that most of the effects are felt in the first year after the event and the severity is related to the degree of the exposure (personal injury, loss of property) (68). It is expected that COVID-19 too will result in these mental health impacts, similar to SARS, particularly among those who were required to quarantine, those working in healthcare settings, or those who contracted/had friends or family who contracted the disease (69).

In relation to acute mental health conditions, emergencies such as the COVID-19 pandemic can influence many risk and protective factors for suicide (including barriers to accessing healthcare and prioritization of other health conditions, social isolation and loneliness, financial insecurity, strained interpersonal relationships, increased access to and use of alcohol, and other substances) (79). While there is a recognized phenomenon that suicide risk may diminish in the early weeks/months after an emergency during the "honeymoon period" it can then increase again in the following months/years (74). Key strategies to prevent suicide include population level interventions to support employment, address inequality and increase access to mental health care; encourage responsible media reporting that drives people to support services; as well as interventions to prevent increased alcohol intake and restrict access to suicidal means (79).

In an emergency response, people with existing mental health conditions, psychiatric disorders and trauma histories may be less prepared than others, less able to adhere to directions (and therefore of greater exposure risk), and experience disruption in medication supply or treatment (74, 79, 83). Those taking psychotropic medications will be at particular risk during extreme weather events as these medications can impair heat regulation and fluid homeostasis (74). People with psychiatric disorders may also experience a greater prevalence of risk behaviors/factors that are identified as increasing susceptibility, such as smoking and COVID-19 (79). Previous experiences of trauma such as in post-conflict populations and related conditions of traumatic stress, PTSD and depression, have been shown to increase risk exposure behaviors and reduce the capacity to take preventive actions for Ebola and HIV (83). Although greater exposure to war events and anxiety were associated with more Ebola preventive behaviors (such as vigilant handwashing), perhaps indicating more risk averse people with greater survival skills (83).

The groups most at risk of, or factors associated with, ongoing psychological distress post-disaster include: women and those with children at home; ethnic minorities; socially disadvantaged people particularly older vulnerable adults; people with few psychosocial resources; people with limited experience coping with disasters and/or cope by assigning blame or avoidance; and people with a psychiatric history (68).

While all will experience some psychological response to an emergency, and some will experience acute, longer-term impacts, it is important to normalize the emotional response to the traumatic event, understanding that people are having a natural reaction to an extreme threat and most people will recover well (61, 74, 103). Some will even experience an increased sense of efficacy or "post-traumatic growth" (74). This is similarly expected at the broader community level. Morganstein and Ursano proposes six phases of psychosocial recovery for communities: Pre-Disaster, Impact, Heroic (action for survival immediately after event), Honeymoon (peak post-event emotional highs and community cohesion, coincides with increased availability of support and resources for recovery), Disillusionment (following withdrawal of support services), Reconstruction (74). However, slow moving disasters may delay the honeymoon phase, or in the case of a pandemic prevent the community from coming together, which is key to recovery (74).

Trauma-informed approaches

While each individual will experience public health emergencies such as the COVID-19 pandemic in a different way, for some people, this emergency overwhelms their coping strategies and is therefore experienced as a traumatic event (62). Given the widespread exposure to the impacts of COVID-19, this has led to calls for a systems-level "trauma-informed" public health response (62).

Although the Substance Abuse and Mental Health Services Administration (SAMHSA) does not require a specific definition or approach to trauma-informed systems (57), the SAMHSA trauma-informed principles (safety; trustworthiness and transparency; peer support; collaboration and mutuality; empowerment, voice, choice; and intersectionality/cultural issues) have been used to identify core components of a trauma-informed public health emergency response. While not explicitly a trauma-informed approach, the Five Hobfoll Principles for Mass Trauma Interventions include several related and relevant concepts, that are to: promote safety, foster calming, enhance self and community efficacy, maintain connectedness, and instill hope (61). In line with this, FEMA (the US Government Federal Emergency Management Agency) and SAMHSA deliver a post-disaster crisis counseling program where local health professionals deliver 1–2 brief sessions primarily focused on practical information and supportive listening (103).

Additionally, during a disaster response a population may reach a "tipping point" (74). These are small events that have large downstream effects, which may result in reduced adherence to directives and consequently have an impact on the health system (74). Clear, consistent communication, equitable distribution of resources, and community engagement are key to avoiding tipping points (74). Fear-driven behaviors and stigma during an epidemic/pandemic should be addressed in public education through the media (76).

Outcomes of trauma-informed public health emergency approaches

While no studies explicitly evaluated any outcomes following implementation of a trauma-informed public health emergency approach, public health impacts, experiences and views, economic impacts of public health emergencies, and relevant theories identified within included studies that discuss trauma-informed approaches or relevant concepts are outlined below.

Public health impacts of emergency responses

Findings from our rapid review demonstrate that the public health impacts of the COVID-19 pandemic are inequitable. For example, one study highlighted the disproportionate COVID-19 infection and fatality rate among Black, Native American, Latino, and socially disadvantaged people in the United States, and that the pandemic was exacerbating stress from racial and social inequities (71). Further, the application of the Progress Plus Equity Framework (PROGRESS+) in an evaluation of multiple COVID-19 policies, demonstrated that there were consistently inequitable adverse impacts across different policies, populations and equity domains. It was concluded that these policies are most likely to impact the vulnerable and this exacerbates existing inequities or creates new ones (60). Importantly, the evaluation noted that the impacts across different equity domains interact and can have a multiplicative effect on people's work and living situations, including food security (e.g., factors related to age, socioeconomic status (SES), and ethnicity can increase physical risk of exposure but may also contribute to be disproportionate impacts for certain interventions) (60). As such, it found that worsening inequities from the pandemic response will in turn, counterproductively intensify the pandemic. Whereas, policies to address inequities can also work as a pandemic mitigation strategy by addressing the same social factors that increase risk of transmission (such as insecure work) (60). An illustrative example under the domain of SES was the impact of New Zealand's border closures, which aimed to reduce the risk of COVID-19 reaching the Maori community. This action had the potential to adversely impact social and economic activities (including tourism), and therefore the mental health of Maori and Pasifika people; financial and social interventions are therefore required to ensure the policy does not further exacerbate inequalities (60).

Specific examples of post-emergency mental health interventions included a crisis counseling program post-Hurricane Katrina, which was found to have successfully reached ethnic minorities. Through local efforts, the program was well-received and perceived as culturally sensitive, although it was not necessarily adequate for addressing more complex mental health outcomes (103). It can be useful to increase public awareness and recognition of trauma and its impacts on individuals (63), and note that experiences of trauma may lead to "unhealthy coping"' or risk behaviors for some (69, 73, 74).

The research evidence underscores the importance of responding to trauma both at an individual and community level (i.e., for community-wide trauma, and for individual trauma in the broader community context) (57). A whole community may respond to trauma in a way that reflects a large-scale version of typical individual trauma responses, becoming fearful, hypervigilant and re-traumatized by repeat/similar events (57). This shared community-level trauma may then be transmitted as historical or intergenerational trauma (57). Just as "meaning making" is a form of trauma processing for individuals (74), healing community trauma similarly requires that the community is supported to make sense of the event and tell their story (57). Reconciliation may be a further approach to healing in large-scale post-trauma care (63). One review highlighted that a truth and reconciliation RCT intervention among victims of war crimes in Sierra Leone found that reconciliation processes resulted in greater social capital, strengthened relationships and increased public contribution. However, reconciliation also increased poor mental health outcomes (i.e., depression, anxiety and PTSD) (63).

Experiences and views

Experiences developing and implementing emergency plans

Some studies reported the views and experiences of those involved in developing the referenced frameworks and emergency response plans and their implementation. The SAMHSA trauma-informed principles were developed with expert and public input with 2,000 respondents and 20,000 comments/endorsements. This process was to ensure that the principles integrated knowledge from clinical practice and the voices of trauma survivors (57).

Collaborative approaches were well-received and improved outcomes. One study and its associated reference reported positive feedback and increased engagement and motivation among those participating in community disaster preparedness planning (91, 104). The "Guided Preparedness Planning" intervention was a collaboration between health districts, academic partners, and faith-based organizations. Feedback was positive, with participants reporting a better understanding of disaster mental health and plan content and enhanced confidence and efficacy to enact disaster plans (91). Evaluation of Psychological First Aid (PFA) training found increased confidence in providing PFA, expressing empathy, differentiating between distress and dysfunction, and making referrals/advocating (104). The Colorado Crisis Education and Response Network (CoCERN) partnership approach to supporting disaster affected communities received positive feedback from Red Cross representatives for the effectiveness and efficiency of a disaster response, particularly in relation to

the inter-agency partnerships with community mental health and the Red Cross (85).

Individual experiences of COVID-19 and other outbreaks

A range of views and experiences of individuals were reported specific to the COVID-19 outbreak including experiences of fear, mistrust and confronting inequity. A study of COVID-19 related fears in the Czech Republic found that the four most common fears were: (1) negative impact on their own household finances, (2) or of others, (3) availability of health care, and (4) food security (78). Food insecurity was reported in many settings as an impact of lockdowns including in communities across Africa; quarantined refugees and insecure workers in Lebanon, and students in the US and elsewhere missing meals due to school closures (60, 75). In Sierra Leone, Ebola survivors reported fear and depression when they suspected they had Ebola and community stigmatization after being released from treatment centers (76).

A qualitative study of Chinese college students who experienced distress during COVID-19 quarantine reported excessive internet/smartphone usage to manage their anxiety, insomnia, social disconnection and mistrust of official sources, but that this behavior exacerbated the effects (97). Another study looked at the impact of exposure to COVID-19 misinformation. It found that misinformation exposure was associated with misinformation belief, which was associated with reduced COVID-19 knowledge and preventive behaviors—but exposure itself was not directly negatively associated with knowledge or behaviors (90).

A study where African American pastors worked with public health experts to communicate with their community members found that people were dependent on family and the church in times of crisis and did not trust medical experts due to ongoing and historical harms (67). Community members were also confronted by reported statistics confirming the inequitable impacts of the pandemic: "We always knew that there were health disparities in the community, but hearing out loud that we are dying at a higher rate was devastating" (67).

Economic impacts

There were no studies reporting the economic impacts of a trauma-informed emergency response in practice.

However, some studies described the social and health harms from the economic impact of the pandemic, noting that it can be a major source of distress and a barrier to seeking healthcare (97). One described the potential for increased risk to children in foster care as school closures may cause some to re-evaluate their capacity to care for a child and the importance of providing paid leave and economic assistance to carers (82). Similarly, former foster children living in college accommodation may experience homelessness as tertiary institutions close (82). School closures also impact a child's food security where they provide meals (60). Another study highlighted the economic downturn from the pandemic as a potential risk factor for suicide through unemployment, financial difficulties and worries about the future (79). While there may be a reduced specific focus on suicide prevention by governments due to economic impact of the pandemic, there may instead be a greater investment in health policies generally, short/long term welfare support, and a strengthened mental health system—all protective against suicide. The key to reducing suicide in an economic downturn is addressing unemployment, providing job search support and universal basic incomes (UBI) (79). The provision of a UBI was advocated for in another paper, noting that Spain had introduced one to buffer against the risks/effects of the pandemic (89).

Two studies touched on inequity in the context of economic impacts of COVID-19, noting that the already disenfranchised populations of the US are those most adversely impacted (71). The Progress Plus audit of COVID-19 policies found that a number of policies were related to addressing economic impacts: South Africa topping up child support grants for those living in shanty towns, experiencing economic hardship and unemployment through insecure work as street vendors; cash payments for workers in Kenya, Nigeria and Lebanon; food supplies and nutrition support for refugees in Lebanon and US families; and the previously highlighted concerns the New Zealand lockdown's impact on tourism will exacerbate the existing inequalities for Maori (60).

Several studies touched on the cost associated with public health emergency responses. Modeling demonstrates the need to resource disaster preparedness as the cost of psychological and behavioral interventions post-disaster can be equal to, or greater than, the reconstruction costs (74). Three discussed the need for cost-benefit analyses to demonstrate the greater efficiency of population level responses (over individual treatments) and the importance of addressing the upstream social determinants of trauma and mitigate suffering at the individual level (58, 61, 66). Although prevention approaches "pay for themselves" over time, adopting trauma-informed practice at the population level will require increased investment through new funds or reallocation of resources (for training, research, and data systems) (66).

Relevant theories

There were several specific models, theories, frameworks and broader concepts, ideas or approaches that were relevant to a trauma-informed emergency response. These included the Learned Optimism and Positive Psychology Model (61); Health Belief Model (90); the Conservation of Resources Model and related community resilience and coherence (81); Attachment Theory (94); Sense of Coherence (96); the Progress Plus Equity Framework (60) and inequity in social determinants, socio-political, racial and environmental stressors (71); the patriarchy

and gender-based violence (77); "Fearonomic effect" (76); fear or distress-based communications (84); Population health perspectives (66, 86, 97); Psychological First Aid/Mental Health First Aid (68, 73, 104). A summary of the key features of each of these is provided in File 4 in Supplementary material.

Core concepts of a trauma-informed public health emergency approach

Table 2 provides a summary of primary studies (and associated references) covering literature relevant to core components of a trauma-informed approach and contributing to the framework analysis, with a synthesis of data relevant to each concept reported in text below (note: we reference the primary study in-text in the first instance unless there is a specific point raised only in the associated reference not also covered in the primary study. Table 2 details the components identified in each of the primary studies and/or the associated references where appropriate). Three studies (59, 62, 72) [plus two associated references (98, 100)] described proposed features or concepts of a trauma-informed public health emergency response. A further four, while not explicit trauma-informed responses highlighted the need to take existing trauma into account when responding to public health emergencies (67, 75, 76, 83).

Synthesis of framework analysis concepts

We mapped findings from the 40 primary studies (58–97) [and the eight associated references (57, 98–104)] to the eight core concepts identified for the framework analysis (Figure 2).

Safety

Twenty-four primary studies contained information relevant to the concept of "safety" (58–61, 64–66, 68–70, 73, 74, 76–80, 82, 83, 85, 86, 93–95). This included physical safety (such as evacuation or protection from a threat) (61, 64, 65, 73, 93) and reassurance of the safety of others and loved ones (61); providing financial and food security (93); and access to healthcare (76, 79, 93). Feeling a sense of safety, including through effective leadership and communications was important; but may be reduced by the reoccurrence of trauma memories and limited ability to assess realistic threats or exposure to misinformation/traumatic media that can lead to fear-based behaviors and non-compliance (61, 68, 73, 74, 76). This "felt safety" is critical to trauma-informed settings such as health systems, schools, and the justice system (57, 66, 101). People may also be experiencing fear of stigma from contracting an infection (76, 79).

Social norms, social isolation, and social support are also important for safety and relate to sources of information, advice and support in the event of an evacuation as well as the behaviors related to attachment theory (94, 103). It is important for disaster responses to promote a "return to normal," working quickly to re-establish routines and community assets (65, 93).

Communications and information from governments and media can have a significant impact on people's safety/sense of safety. Leaders and governments can both increase and decrease a sense of safety, and may intentionally undermine safety for political reasons (61, 74). Communications about the actions to take and available supports in response to a threat should follow established Risk Communications principles, as poor communication erodes trust and reduces compliance (74, 80, 95).

The media may also have a commercial incentive for repeated broadcast of traumatic images, which erodes safety and impedes recovery; responsible reporting and supportive broadcasting should be encouraged (61, 74, 82, 103). While information seeking may be used as a coping mechanism to control anxiety, this information, including through the media, may increase anxiety, cause confusion and retraumatise people. Recommendations include reducing exposure and enhancing media literacy skills to identify propaganda/misinformation (61, 74, 83, 103).

At the service level, practices that can compound trauma include coercion, isolation/segregation, and restraints (57). There is a risk this may increase to restrict movement during an infectious disease outbreak. These services may also employ people with their own histories of trauma who, without support, are retraumatised at work, or may experience secondary or vicarious trauma (64).

An associated concept within safety was Human Rights (69). When designing policy/emergency responses it is important to consider whose safety is being prioritized, such as in drug policy (58, 99), or whether there are adverse, unintended or inequitable impacts for vulnerable sub-groups, such as increasing the risk of one threat to address another (e.g., domestic violence during stay-at-home orders) (60, 69, 74, 77, 79, 82, 103). In Argentina, 20 women were killed in the first month of COVID-19 stay-at-home orders and police responses to reports of gender-based violence and missing women were considered negligent (77). Children may also be at increased risk of violence due to stressors of the pandemic and school closures (82).

Trustworthiness and transparency

Eighteen studies included information relevant to the concept of trustworthiness and transparency (58, 59, 61, 65, 67, 70, 72–75, 78–80, 82, 84, 90, 95, 97). Good communications were frequently cited as a way to be transparent and generate trust, such as providing regular, clear, and consistent information. Suppression of information can lead to mistrust, whereas good communication increases compliance with directions and promotes confidence, recovery, resilience, and mitigates panic;

TABLE 2 Core conceptual characteristics.

Study	Safety	Trust	Peer support	Collaboration	Empowerment	Cultural	Holistic	Compassion	Other	Explanatory factors
Relevant/High relevance										
Bowen . . . (58)	+	+	+	+	+	+	x	x	x	x
Bowen . . . (99)	+	+	+	+	+	+	+	x	x	x
CDC (59)	+	+	+	+	+	+	x	x	x	x
Wolkin (98)	+	+	+	+	+	+	x	x	+	x
SAMHSA (57)	+	+	+	+	+	+	x	x	x	+
Griffin (100)	+	–	+	–	–	+	x	x	x	x
Lynch et al. (101)	+	+	+	+	+	+	–	–	x	x
Glover (60)	+	–	–	–	–	+	x	x	x	x
Hobfoll et al. (61)	+	+	+	+	+	+	+	+	+	+
Fairbank . . . (102)	+	–	+	–	+	–	x	+	x	x
Norris . . . (103)	+	+	+	+	+	x	x	x	x	+
Javakhishvili et al. (62)	–	x	x	x	x	+	x	x	x	+
Kleber (63)	x	x	+	–	+	x	–	+	x	+
Loomis et al. (64)	+	–	–	+	+	+	x	+	+	+
Melton . . . (65)	+	+	+	+	+	–	+	–	x	x
Tebes et al. (66)	+	x	x	+	+	x	+	x	x	+
Thompkins et al. (67)	x	+	+	+	x	+	+	+	x	x
Watson et al. (68)	+	x	x	+	+	+	+	x	x	+
Partial/Moderate relevance										
Adhanom Ghebreyesus (69)	+	x	x	x	+	x	+	–	+	+
Bao et al. (70)	+	+	+	x	x	x	x	x	x	+
Fortuna et al. (71)	–	x	+	+	+	+	+	–	+	+
Manderscheid (72)	–	+	–	+	+	+	+	+	+	+
Meredith et al. (73)	+	+	+	+	+	+	x	x	+	+
Morganstein . . . (74)	+	+	+	+	+	+	+	+	+	+
Naidu (75)	x	+	+	x	x	+	+	+	x	x

(Continued)

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TABLE 2 (Continued)

Study ID	Safety	Trust	Peer support	Collaboration	Empowerment	Cultural	Holistic	Compassion	Other	Explanatory factors
O'Leary et al. (76)	+	–	+	+	x	+	+	+	+	+
Polischuk . . . (77)	+	–	x	–	+	+	x	x	x	x
Trnka . . . (78)	+	+	+	x	x	x	x	+	+	+
Wasserman et al. (79)	+	+	+	x	+	+	+	+	+	+
Wells et al. (80)	+	+	–	+	+	+	–	–	x	x
West et al. (81)	–	x	+	+	+	x	x	x	x	x
Wong et al. (82)	+	+	+	x	x	x	–	x	x	+
Low or unclear relevance										
Betancourt et al. (83)	+	x	x	x	x	+	+	+	+	+
Brown . . . (84)	–	+	+	+	+	+	x	+	+	x
Crepeau–Hobson . . . (85)	+	–	–	+	+	–	x	x	x	x
Ellis (86)	+	x	+	+	+	+	+	+	x	x
Forbes et al. (87)	–	–	+	+	x	x	+	x	x	x
Genereux et al. (88)	x	x	+	+	+	+	x	x	+	x
Johnson et al. (89)	–	x	x	x	x	x	+	x	x	x
Lee et al. (89)	x	+	x	+	x	x	x	x	+	x
McCabe et al. (91)	x	x	x	+	–	+	x	x	x	x
McCabe et al. (104)	x	x	+	+	+	+	x	+	x	x
Provenzi . . . (92)	x	–	+	x	–	x	x	+	x	x
Purtscher (93)	+	x	x	x	–	x	+	+	x	x
Rajkumar (94)	+	–	+	x	x	+	+	–	x	x
Sandifer . . . (95)	+	+	+	+	+	+	+	+	+	x
Schäfer (96)	x	x	x	x	+	x	x	x	x	x
Sun et al. (97)	x	+	+	x	x	+	x	x	+	x

Indicator Key: **Primary studies (bold);** Associated references (italicized); + Study contains content related to concept; x No reference to concept; – Unclear.

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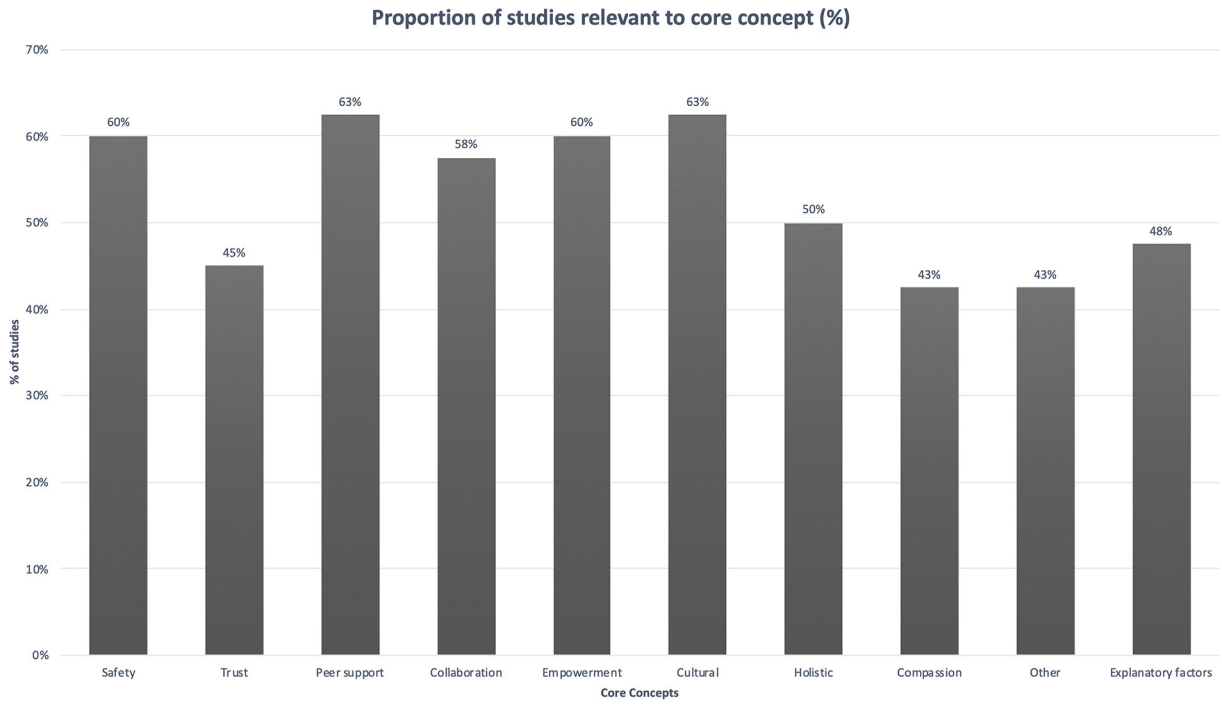

FIGURE 2
Proportion of studies with content related to each core concept of the framework analysis.

these communications must reach diverse communities and counter misinformation (65, 70, 72–74, 80, 95, 103).

Mistrust/distrust of authorities is a key concern and can have mental health impacts (65, 67, 74, 95, 97). Coupled with poor information/communication, it can also lead to non-compliance. Early and decisive action by governments builds trust and trust in the response is key to recovery and resilience, particularly when this belief is established pre-event through transparent planning (74, 75, 95). When there is a lack of transparency or poor communication, this can result in reduced awareness of protective behaviors or non-compliance because of distrust, and belief in conspiracy theories or misinformation. Consequently, communities may believe that the response is ineffective or perceive inequitable distribution of insufficient resources (65, 73, 74, 90, 95, 97). Policies such as quarantine may also contribute to mistrust and non-compliance (73).

Working collaboratively with the media to ensure the transparent dissemination of accurate information and no fear-based reporting is important; as is increasing media literacy because people may seek out alternative sources of information (through social media) to fill the gap when they begin to distrust traditional media (70, 74, 78, 79, 82, 90).

People will look to leaders and trusted groups in an emergency (including professional associations, faith-based organizations, and local groups) and these leaders should aim to be highly visible and avoid scapegoating others (61, 67, 74, 80). Developing trusted relationships at the community level pre-event is also important, to maximize transparency and accountability in communications (including through developing a shared language and understanding) and minimize insider/outsider dynamics (80, 84, 95).

In other settings, trust and transparency should be embedded within policies [such as drug policy (99)], service organizations [promoting belief in equitable treatment and access (58, 67, 95); trust in transparent decision making and provision of collaborative spaces (57)]; and in schools [promoting trust and transparency through consistency (101)].

Connectedness and collaboration

Expert consensus is that emergency responses should promote connectedness and collaboration (61, 68, 74, 103). This overarching grouping includes the two original standalone SAMHSA concepts of Peer Support and Collaboration.

Peer support or connectedness

Twenty-five studies included information related to the concept of "peer support" (58, 59, 61, 63, 65, 67, 70, 71, 73–76, 78, 79, 81, 82, 84, 86–88, 92, 94, 95, 97, 104).

Peer support is a facilitator of other key concepts and components of emergency responses including safety, hope,

trust, collaboration and recovery (57). A related concept, social capital, is also important for community resilience (86, 103, 104).

As such, public health emergency responses and policies must prioritize restoring social supports, systems, communications and rituals; and promote supportive relationships including creating opportunities for connection for isolated people (58, 61, 65, 67, 73, 76, 87, 94, 99, 101, 103). It may be possible to facilitate this through the use of media and technology, including supportive broadcasts, mobile phone use and social media, but for some may contribute to phone addiction (78, 97). Facilitating social support is important as it can moderate trauma and reduce stress, promotes individual and community efficacy and resilience, can encourage adaptive or preventive behaviors through sharing of practical information and experiences (shared trauma, storytelling and coping) (61, 63, 65, 75, 78, 81, 86, 92, 95, 101, 103, 104). For people and communities who have a strong connection and attachment to place, this in itself may be a form of support and can be part of recovery, including through eco-therapies (95, 103).

Lack of social support may have adverse impacts on mental health with isolation negatively impacting wellbeing, contributing to maladaptive behaviors, suicide risk, and domestic violence (61, 73, 76, 79, 81, 82, 92, 94, 97, 101). Some of this is explained by "attachment theory" whereby insecure attachment triggers these maladaptive behaviors, violence, and xenophobia (94). Emergencies and responses may result in reduced peer support and see increased conflict through the reignition of historical social/ethnic tensions; inequitable distribution of resources/competition; and communications that inadvertently stigmatize a target population group (61, 84, 95). Further, stigma may result in a community not welcoming an infectious disease survivor back (76).

Social support is important for both how people respond to an emergency and recover afterward. Those with strong social support are twice as likely to evacuate in an emergency than those with weak supports (103), and those with low levels of community support have greater likelihood of PTSD and depression symptoms post-event, with community support having a "buffering effect" on mental health outcomes (81). However, this effect was only observed in non-urban areas (81). Social support within the family is critical during an emergency as a resource more likely to be utilized than professional support; it contributes to individual and community resilience and is particularly important for young people (61, 65, 71, 86, 103). Community bonding is most likely to occur during the Honeymoon Phase (74), but this may dissipate overtime and individuals may experience relationship burnout (61).

Local community organizations have an important role in providing social support to their community members, including through Community Health Workers, particularly for those communities with historical trauma; but there is also an opportunity to provide professional peer support through interagency relationships across organizations/levels of Government (58, 65, 88). Similarly, leaders have a role to play in providing social support whether they are formal or informal leaders, including "grief leadership" where they help their communities process and understand their losses (74, 88). Leaders need their own peer supports and to practice self-care to be able to continue to provide this support to their communities (74, 88).

Collaboration and mutuality

Twenty-three studies covered information relevant to the concept of collaboration and mutuality (58, 59, 61, 64–68, 71–74, 76, 80, 81, 84–88, 90, 91, 95).

Many studies discussed the importance of strong relationships for cross-sector/cross-system/multi-jurisdictional collaboration to address broad determinants; minimizing insider-outsider dynamics through early establishment of ongoing relationships; using shared resources/staff to build consistency and communities of practice; with these collaborations likely leading to improved community resilience and better health outcomes (61, 65–67, 71, 73, 74, 80, 86–88, 91, 95, 101, 103, 104).

Participation from the target population (including disaster victims, eco-dependent communities, and clients), in the planning and response, including in the design of communications and messages and of policies is important for addressing power imbalances, utilizes local knowledges; increases efficiency of resources; promotes community efficacy, resilience and capacity building; and provides mental health benefits including increasing empowerment reducing helplessness (57, 58, 61, 66, 68, 71, 72, 74, 80, 81, 84, 85, 88, 91, 95, 99, 103, 104). This included the importance of local leadership and control (61, 65, 85, 103).

Interventions should maximize existing community strengths and resources by using local practitioners, healers, and ceremonies; adapting to the local context and traditions (particularly around rituals and burials); this may include using spiritual or religious leaders for mental health supports; as this adaptation will enhance credibility and increase service access (61, 67, 68, 71, 74, 76, 85, 87, 88, 91, 95, 104). Supporting individuals to build self-efficacy and through advocacy is another form of collaboration and is a role played by Community Health Workers (58, 61).

Another aspect of collaboration was to work with media companies to ensure accurate information is disseminated and misinformation on social media is countered (74).

Empowerment

Twenty-four studies included content relevant to empowerment (58, 59, 61, 63–66, 68, 69, 71–74, 77, 79–81, 84–86, 88, 95, 96, 104). This included individual, family, and community level empowerment (61, 65, 86, 95, 99, 103).

Key to empowerment was the sub-concept of efficacy. This related to both self-efficacy (including self-esteem and belief in the ability to manage the response) and community or collective efficacy (including self-governance, self-sufficiency, and "Community Competence"); with the two coming together through "social capital" (with group belonging leading to better outcomes and empowered communities promoting individual resilience) (61, 63, 66, 68, 71, 86, 101, 103, 104). This relates to peer support in that having community support gives individuals confidence to take action (61).

Resilience was a further related sub-concept. Resilience was defined as the "other side of trauma" and may be a quality, personality, process, outcome; there can be individual, community, national and socio-ecological resilience; it acts as a social buffer against adversity and can be promoted through interventions including Psychological First Aid; at the community level this resilience includes economic development, social capital, information/communication, community competence; resources; partnerships and networks; and engagement with vulnerable groups (61, 63, 68, 80, 81, 103, 104).

Being able to enact choice, voice, power, agency, self-advocacy and control (including as part of collaboration) promotes empowerment, resilience and wellbeing; this may include contributing to decision making, planning, message testing and community activities; helps to address the lack of diversity in decision making bodies and values local and Indigenous knowledges (58, 61, 63, 66, 72, 77, 80, 81, 84, 85, 88, 95, 103, 104). To facilitate this individual and community contribution capacity building is necessary. This includes teaching problem solving skills to individuals, enhancing the survival and technical skills of a community to build a sense of mastery and control; and supporting communities to deliver services directly to their members (61, 68, 69, 71, 88, 95, 101). Empowerment is only achievable with adequate resourcing. Where there is inequity in distribution of resources this erodes efficacy in already vulnerable communities and is critical for community resilience and collective efficacy (61, 103).

Another related sub-concept was hope or loss of hope/hopelessness. Traumatic events can result in feelings of loss of power/control, hopelessness, despair and futility when people have lost loved ones, employment, are experiencing uncertainty, and feel disconnected from decisions; people need hope to recover from trauma which may be facilitated through shared experiences, normalizing reactions, and enhancing agency through participating in community responses and working toward positive action-orientated future goals/outcomes (61, 66, 68, 79, 81, 95).

Coping was linked to hope, as people struggle to cope when they lose hope. Thus, may result in negative or maladaptive coping strategies; whereas positive emotions promote coping and increase functional capacity, likely facilitated by social supports (61, 68, 73, 74). The extent to which someone feels they can cope relates to whether they feel a sense of personal strength or that they are a victim and are feeling anger and resentment. However, through support and empowerment it is possible to help someone transition from "victim status" to "survivor status" (61, 74).

Also related to empowerment is the psychological construct of "Sense of Coherence" (SOC) and its role as a buffer against stressors (96). One study found that higher levels of SOC before the COVID-19 pandemic resulted in smaller changes in psychological symptoms and may be a universally beneficial buffer against mental health stressors for groups experiencing both high and low levels of stress (96).

Cultural safety, responsiveness, & intersectionality

Twenty-five studies were coded under cultural safety, responsiveness, and intersectionality; that is referred to cultural, historical or gender issues (58–62, 64, 67, 68, 71–77, 79, 80, 83, 84, 86, 88, 91, 94, 95, 97).

Four studies noted that how individuals respond to a public health emergency or traumatic event is influenced by their different cultural backgrounds, histories, and experiences and that those with previous trauma may be less able to adhere to public health directions (57, 58, 64, 67). Experiences of historical trauma was specifically mentioned by four studies (57, 58, 75, 80). These trauma histories along with socio-cultural factors mediate efficacy and the effectiveness of "self-help" strategies (61).

Many studies highlighted socio-cultural determinants and equity, noting that it is existing factors that determine who is most able to respond and most likely to be affected; the importance of addressing upstream drivers; how responses, such as in COVID-19, can exacerbate inequalities or create gendered impacts (including risk, labor, violence); but there are opportunities to maximize cultural strengths (such as through storytelling) (58, 60, 61, 67). The lack of diversity on many decision making bodies was thought to contribute to the disproportionate impact of emergency responses in some population groups, such as women (77). Relevant to this concept was also human rights (68).

The socio-cultural determinant of experiences of racism and discrimination may increase during an emergency particularly where inequitable distribution of resources inflames historical racial tensions/in-group out-group divisions; where one population group is blamed or stigmatized (such as anti-Asian sentiment during COVID-19); and may be activated by insecure attachment (61, 80, 84, 94, 95). Interventions must be culturally sensitive and adapt to the local context, needs and practices respecting local cultures and autonomy; this includes provision of services in-languages, tailoring messaging, engage the population in the development of an intervention (and building these relationships early); and finding safe ways to accommodate

cultural rituals and mourning practices (57, 58, 61, 68, 72–74). This may include offering eco-therapy for communities and cultures with a strong connection to place and experiencing loss of cultural identity (95). There may also be opportunities for responses to tap into support from cultural diasporas, drawing on the strengths of the wider ethnic community (95).

Considering cultural sensitivity and adaptation will increase service utilization. This might include: increasing engagement through local partnerships; offering free support services for minority groups; recruiting local/Indigenous people to deliver safe services; build on cultural strengths to promote healing; and address historical mistrust, biases, and discrimination (57, 58, 67, 68, 74, 76, 80, 104). In some countries, the response to an emergency at the national level may include resistance to any investigation of the original cause of an event or disaster (88).

Holistic support

Twenty studies were categorized as having content related to the concept of "holistic" including the need for responses that address a range of needs (61, 65–69, 71, 72, 74–76, 79, 83, 86, 87, 89, 93–95, 99). Many studies noted the importance of combined, comprehensive, and multifaceted or multidisciplinary approaches (67–69, 71, 72, 74–76, 86, 87, 95, 99). This included offering different interventions for changing needs over time that address all aspects from acute physical needs (safe shelter conducive to rest) to broader supports and resources that mitigate trauma, improve quality of life and social functioning (including healthy relationships); ensuring that public health integrates mental health and cultural/spiritual supports (as need to address distress and anxiety to be able to comply with public health directions); and using community-wide programs that address broader social determinants. Further needs included the provision of essential services or meeting essential needs (safe shelter, food security, healthcare, school and childcare; other physical needs); that providing these may mitigate maladaptive responses from anxious attachment; and that doing so must take into account privacy, dignity, and liberty (65, 74, 93, 94). A related sub-concept was about preventing resource loss (psychosocial, personal, material, structural (including jobs/organizations) resources) and making financial support available including through Universal Basic Incomes (61, 79, 89, 94).

Compassion

Seventeen studies were categorized as having content related to the concept of "compassion," kindness or caring and why this was important for the response and recovery (61, 63, 64, 67, 72, 74–76, 78, 79, 83, 84, 86, 92, 93, 95, 104).

Studies talked about the importance of compassion, dependability and empathy including through partnerships that practice "reflective listening and expressive empathy" as trusting relationships promotes wellbeing (64, 104). Some referred to solidarity and humanitarianism (75, 78) as well as providing social support programs for isolated and peer listening programs; noting that individual resilience relates to the buffering effect against adversity from community support (67, 86, 95).

Awareness and understanding of trauma was noted to be important including raising awareness and helping people to understand trauma behaviors and experiences to avoid re-traumatisation; ensuring communications do not re-traumatize people (63, 83). While equally the sub-concept of calming and normalizing stress reactions was also important (61).

Several studies emphasized the need for emergency responses to compassionately accommodate a range of needs which may include addressing mental health, panic disorders and substance use; provide supports specific to the elderly (dedicated shopping hours and home food delivery services, helplines, anti-stress broadcasts); and ensure privacy, dignity and liberty are maintained (72, 78, 93).

Compassion or lack of compassion around grief was also raised in three studies. This included that it was important for people to see a celebration of the deceased (such as televised eulogies so mourners know loved ones are missed); but notes that public indifference to deaths in the elderly can compound grief among families (67, 74, 79). The importance of leaders to practice "grief leadership" was also noted including recognizing the loss and trauma experienced, giving hope for recovery and the marking of the anniversary of the traumatic event as key to recovery (74).

Thematic analysis of "other" concepts identified

Two overarching and cross-cutting concepts/themes were identified through thematic analysis of relevant literature initially coded as "other" [from 17 studies (61, 64, 69, 71–74, 76, 78, 79, 83, 84, 88, 90, 95, 97, 98)]: leadership and communications.

Leadership (trauma-informed leaders)

Leadership was a cross-cutting concept that has been addressed in several previous sections including that leaders can both increase or decrease sense of safety (61, 74); that informal leaders may emerge spontaneously from communities (74); leaders must practice self-care and be aware of their own distress reactions as this can impact the community's ability to cope (74); the importance of "grief leadership" and marking disasters anniversaries as memorializing is an important aspect of the community recovery process and not acknowledging the anniversary can be damaging and demoralizing (74); that good governance is the most important factor in public health

response (88); that different leadership strategies are required for different types of events (e.g., a localized disaster vs. a national pandemic response (72); and finally that leaders must support trauma-informed responses through ongoing commitment, attention and organizational/cultural change (64, 98).

Communication and information

Similarly, issues around communications, information and the media have been raised under several of the preceding concepts.

Studies found the media can be traumatizing and increasing feelings of distress with a demonstrated dose-effect from repeated exposure to traumatic images through the media (61, 78). Despite the negative and traumatizing impact the media may have, people may feel they need to keep listening to stay informed, but this in turn may reduce the behavioral capacity of someone to respond and may even increase suicide risk (61, 71). Given the established relationship between existing mental health conditions and reduced capacity to take preventive action, it is critical that public health emergency communications take into account existing trauma and avoid re-traumatizing the population when communicating risk of death (83).

Communications have the power to shape beliefs and attitudes. On the one hand they can address fear and stigma; but on the other can also increase stigma when targeting one population group if framed as blameworthy (76, 84). Several studies touched on exposure to accurate information as well as misinformation or lack of information. This included the way that poor government communications or lack of information may cause distress and lead to mistrust of government and medical institutions, increase access to misinformation, increase low adherence, non-compliance, or maladaptive responses and susceptibility to conspiracy theories (73, 97).

While social media may have an important role to play in targeted, local information; the dissemination of misinformation is largely unregulated; and increased use of social media while social interactions are reduced (during a pandemic, for example) may further increase anxiety (74, 97). There is a need to ensure media companies follow existing regulations and codes (such as WHO reporting guidelines) and for governments to work with media companies and social media platforms on regulating misinformation and non-traumatizing broadcasts (78, 79).

Ultimately, studies recommended following established risk or crisis communication principles, as this will most likely result in desired behaviors. This approach includes ensuring communications are interactive, clear, consistent, credible; take into account population sub-group communication needs; and are continued throughout extended emergencies (as perception of risk leads to adaptive behaviors) (69, 73, 74, 95).

FIGURE 3
Visual summary of core concepts identified.

Visualization of core concepts identified from the international evidence to inform development of the trauma-informed framework

The originally identified core concepts from the *SAMSHA 6 Guiding Principles to a Trauma-Informed Approach* and the *Healing the Past by Nurturing the Future Trauma-Integrated Care Conceptual Framework*, have been combined with additional key factors identified in this review of the public health emergency literature, and are illustrated in Figure 3 above, including those from the *5 Hobfoll Principles for Mass Trauma Interventions*. These concepts will be workshopped with community members, experts and key stakeholders in the COVID-19 pandemic response, particularly with First Nations people, and used to develop a proposed trauma-informed public health framework.

Discussion

Public health emergencies, by definition, represent a significant threat to people's lives. Protective "stress" responses are natural but can be distressing and have significant effects on physical, social and emotional wellbeing, as well as people's behavior, which can impact the effectiveness of the overall public health response. Hence, we argue, *it is time for trauma-informed public health emergency responses* which explicitly recognize and attempt to mitigate stress responses, and consider equity and the populations most at risk. In this review, we found no studies that described or reported outcomes from a trauma-informed public health emergency approach. Thus, we propose a framework for

discussion, based on literature from included studies related to core concepts of trauma-informed approaches.

These interdependent concepts or principles include: (i) safety, (ii) trust and transparency, (iii) empowerment, (iv) holistic support, (v) connectedness and collaboration, and (vi) compassion and caring. Important supporting strategies include provision of basic needs and resources (such as food and safe shelter), ensuring well-functioning social systems, comprehensive multi-level responses, and human rights and justice. Key enablers of these principles are leadership, communication, cultural responsiveness, and a commitment to equity. Together, these components feed into the overarching goals to achieve: (1) a sense of security, (2) resilience, (3) wellbeing (4) self- and collective-efficacy and (5) hope.

The purpose of a trauma-informed public health emergency framework is not to describe essential public health emergency functions already outlined elsewhere, such as the key pillars under the *WHO COVID-19 Strategic Preparedness and Response Plan*: (1) coordination, planning, financing and monitoring; (2) risk communication, community engagement (RCCE) and infodemic management; (3) surveillance, epidemiological investigation, contact tracing and adjustment of public health and social measures; (4) points of entry, international travel and transport, and mass gatherings; (5) laboratories and diagnostics; (6) infection prevention and control, and protection of the health workforce; (7) case management, clinical operations, and therapeutics; 8) operational support and logistics, and supply chains; (9) maintaining essential health services and systems; 10) vaccination (105). Rather, such a framework offers a "trauma-informed lens" through which to consider proposed actions, and ways to mitigate effects of trauma and stress and ensure emergency response measures embed factors that promote resilience and recovery.

The core components we identified for the framework development as outlined above were informed by the *SAMHSA 6 Guiding Principles to a Trauma-Informed Approach*, the *Healing the Past by Nurturing the Future Trauma-Integrated Care Conceptual Framework*, and the key factors identified in the literature, including the *5 Hobfoll Principles for Mass Trauma Interventions*. Several of the supporting and enabling components are related to or explained by other relevant, existing frameworks. Demonstrating that just as this trauma-informed framework does not aim to explain public health emergency functions, nor does it seek to describe the mechanisms of good public health and health inequities.

In our review, equity, socioeconomic position, and the social determinants of health were frequently identified as key factors that increased risk of being affected by an emergency or exposed to a hazard, greater likelihood of poorer recovery and mostly likely to be adversely impacted by universal responses. Strategies that address these issues support the core concepts outlined above and are underpinned by the overarching enabler of a commitment to equity. The detail of how these issues intersect through structural determinants to influence health behaviors, enable choices and impact service utilization have been well-described in the *WHO Commission on Social Determinants of Health Conceptual Framework* (106), the *Health Equity Measurement Framework* (107), and *Health Equity in Australia: A policy framework based on action on the social determinants of obesity, alcohol and tobacco* (108).

Similarly, for First Nations people specifically, addressing broader social determinants as well as a focus on human rights, community control and culture/cultural determinants of health is critical, as outlined in the *Achieving Aboriginal and Torres Strait Islander health equality within a generation—A human rights based approach* report (109) and the *National Aboriginal and Torres Strait Islander Health Plan* (110). Taken together, these reflect the importance of another of our overarching enablers, Cultural Responsiveness; a fundamental aspect of a framework for First Nations people. This embeds a holistic view of health. Research with Stolen Generations survivors found that while early pandemic response measures were effective in protecting against the threat of COVID-19, these measures negatively impacted physical, mental health and wellbeing through disconnection from family, community, culture, and country (111). As such, these key determinants of Indigenous health must be central to any public health response.

Strengths and limitations of the rapid review

We undertook a rigorous and inclusive search with strict screening protocols. However, the search was not exhaustive and may have missed some relevant studies. Further, the quality of the included studies ranged from evidence reviews to commentaries. Many relevant articles (letters and commentaries) about COVID-19 were identified in the search and were not peer-reviewed, with no evaluations of trauma-informed public health emergency responses. Thus, we have not been able to determine the strength of evidence for such an approach. However, a key strength of this review is the systematic application of existing trauma-informed frameworks, namely the SAMHSA principles and that developed by First Nations people for the *Healing the Past by Nurturing the Future* project, to a comprehensive and extensive range of emergency literature and identify how already established core aspects of an emergency response align with trauma-informed concepts. This synthesis will provide the basis for further discussion and workshopping with First Nations communities and public health experts to develop a framework informed by the evidence that reflects an Indigenous worldview.

Implications for practice (services, communities)

Local leadership and control help to build trust in the broader response. Empowering and enabling community involvement is critical to the success of the response and can aid recovery. This engagement builds individual and community self-efficacy and reduces feelings of helplessness. Promoting caring and compassion is important for people to feel supported to take action and this aids in recovery. Fostering connectedness is also vital for wellbeing outcomes, and for receiving critical emergency information and support, and observing behavioral norms. While many people will experience increased connectedness in an emergency, it is important to recognize that this can diminish after the "honeymoon period." Services should work to facilitate connections for those who are isolated and where possible address threats to social cohesion, including behavior which may pose a threat to the safety of others and stigmatizing certain groups.

Implications for policy

Protecting public safety is the core responsibility of the public health emergency response, but some "safety" measures can be perceived/felt as "unsafe" by some, such as when coercive force is used to restrict movement. It is important for policy to consider adverse impacts and how these can reduce compliance and the effectiveness of the response. While reduced movement increases safety, it can negatively impact mental health and wellbeing. For some, staying safe and staying at home is not an available option. There must be a commitment to addressing equity in any policy response as there is potential to further increase inequities (and may have a multiplicative effect), whereas actively reducing inequity, such as through providing financial support and safe housing to allow people to comply with stay-at-home orders, will increase the effectiveness of the response. Good leadership and effective communication are vital for fostering trust in the response and the likelihood of compliance with policy measures. Transparently communicating key information is fundamental and this includes actively combatting misinformation, which may require dedicated regulation.

Implications and recommendations for future research

There is an urgent need for documentation and mixed-methods evaluation of trauma-informed approaches and outcomes. While there were several authors calling for a trauma-informed response to COVID-19 and other outbreaks, some relevant emergency response frameworks/strategies that contained related concepts, as well as indications the CDC have applied the SAMHSA principles to their public health responses, we found no evidence of the effectiveness of such a response. This is of particular importance for those communities at risk of heightened stress responses during a public health emergency, including those with existing trauma histories associated with government interventions, and those at risk of increased susceptibility due to structural inequalities (such as housing and insecure or frontline employment).

This rapid review sought to synthesize the public health emergency evidence through the prism of applying the principles of trauma-informed practice at a population level. The findings from this review will now be workshopped with experts and First Nations community members to inform the development of a trauma-informed public health emergency response framework for First Nations communities. We envisage that the resultant framework will be used to guide the current COVID-19 pandemic response and recovery, and in planning for future emergencies.

Conclusions

The effects of COVID-19 are highly inequitable for many in the community, including for Aboriginal and Torres Strait Islander communities impacted by historical and intergenerational trauma, racism and ongoing socio-economic deprivation associated with colonization. These experiences can affect a community's response and capacity to adhere to public health directions and demonstrates the need for culturally responsive trauma-informed approaches. Seeking to address inequities as part of the response will likely lead to greater effectiveness of the response overall.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

CH, MK, SG, CA, JM, CW, SB, and CC drafted the protocol. CH, MK, SG, CW, SB, and CC conducted screening. CH extracted and synthesized data. CC and CH drafted article. All authors provided input and approved the final draft.

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Conflict of interest

Author CA was employed by company We Al-li Pty Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1006513/full#supplementary-material

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Respectful maternity care and associated factors among mothers who gave birth in three hospitals of Southwest Ethiopia: A cross-sectional study

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Background: One of the primary barriers to reducing maternal morbidity and mortality is disrespect and abuse during childbirth in biomedical facilities. Despite the serious consequences of disrespect and abuse during childbirth, there is no evidence of the prevalence of respectful maternity care in Southwest Ethiopia. This study aimed to assess the prevalence of respectful maternity care and associated factors among mothers who gave birth in three hospitals in Southwest Ethiopia.

Methods: An institution-based cross-sectional study was conducted among 348 mothers who gave birth in three hospitals in Southwest Ethiopia. Bivariable and multivariable binary logistic regression were used to identify the factors of respectful maternity care.

Results: In this study, 348 mothers with their newborns were included, making a response rate of 100%. The overall prevalence of respectful maternity care was 81.2%. Maternal age [AOR = 2.54; 95% CI (1.01–6.43)]; maternal occupation [AOR = 5.23; 95% CI (1.15–23.72)]; antenatal care follows-up [AOR = 2.86; 95% CI (1.01–8.20)]; and discussions with the provider about the place of delivery during antenatal care follow up [AOR = 5.58; 95% CI: (2.12–14.70)] were found to be the most significant components of respectful maternity care.

Conclusion: The provision of respectful maternity care was high, but there are complaints of disrespect and abuse still present in three hospitals in Southwest Ethiopia. Maternal age, maternal occupation, antenatal follow up, and discussion with the provider about the place of delivery during antenatal follow-up were associated with respectful maternity care. Thus, improving antenatal care service utilization and discussions with health care providers about the place of delivery during antenatal care follow-up should be focused on.

KEYWORDS

abuse, disrespect, Mizan Tepi University, respectful maternity care, associated factors

Introduction

Pregnancy, labor, and delivery are crucial events in the lives of women and their families in all countries (1). The disrespect and abuse perpetrated on women in biomedical health facilities during childbirth is a global problem (2, 3). Respectful maternity care (RMC) is a person-centered strategy for maternity service that encourages procedures that reflect women's preferences and newborns' needs. It is based on ethical principles and respect for human rights (4, 5). We define disrespect and abuse (D&A) as any harsh care or thoughtless conduct directed toward a woman during childbirth (6).

Disrespectful maternity care has both direct and indirect impacts on women's birth outcomes, patient satisfaction, and future delivery plans (3, 7, 8).

The Ethiopian Minister of Health has launched a new compassionate, respectful maternity care (CRC) program based on WHO principles during childbirth and has given in-service training to all maternity care providers on CRC (9, 10). In addition, the establishment of maternal waiting rooms in biomedical health facilities, free labor and delivery service and transportation, pregnant women's conferences, and a media awareness campaign have all been attempted to promote SBA delivery (11). Despite these actions, 72% of Ethiopian women deliver their children at home, with a range of indicators depending on geography, economic status, and education levels (12). In addition, maternal and neonatal mortality rates remain at 412 per 100,000 and 29 per 1,000 live births, respectively (13). Furthermore, disrespectful maternity care at biomedical healthcare facilities is one of the key reasons for home delivery (14).

Despite RMC being the best and the key strategy to increase institutional delivery and reduce maternal and newborn mortality, there is no evidence of the prevalence and risk factors of RMC in the study area. Thus, this study aimed to assess the RMC and associated factors among women who gave birth in three public hospitals in Southwest Ethiopia.

Methods and materials

Study area

The study was conducted at Mizan-Tepi University Teaching Hospital (MTUTH), Gebretsadik-Shawe General Hospital (GSGH), and Tepi General Hospital (TGH) in Southwest Ethiopia. Those hospitals are the only hospitals in the Southwest Ethiopia regional state and are located in Benchi-Sheko Zone, Kefa Zone, and Sheka Zone, respectively. The hospitals provide emergency obstetric care, maternal and neonatal health infrastructures, and a full complement of skilled health professionals, including obstetricians, anesthesiologists, radiologists, neonatologists, nurses, and midwives.

Study design, and period

A facility-based cross-sectional study was conducted in these hospitals from 1 January to 30 February 2021.

Population

The study population included women who gave birth in three hospitals in Southwest Ethiopia, while the source population included mothers who gave birth in three hospitals in Southwest Ethiopia during the study period.

Eligibility criteria

Mothers in the postnatal care room during the study period were included in the study, whereas mothers who were critically ill and unable to communicate were excluded.

Sample size determination and sampling procedure

The sample size was calculated using the single population proportion formula based on the assumptions below. The 95% confidence interval (CI), (Z/2 = 1.96), marginal error (d) = 0.05, and proportion of RMC $p = 71\%$ are based on a study conducted in Jimma, Ethiopia. As a result, 348 mothers were included in the study after allowing for a 10% non-response rate (15).

The study was conducted simultaneously at MTUTH, GSGH, and TGH. A proportional sample allocation was applied to each hospital based on the number of deliveries performed in the 2 months before data collection. A total of 348 mothers (139, 113, and 96 from MTUTH, GSGH, and TPGH, respectively) participated in the study. For each hospital, the study participants were identified by systematic random sampling technique from the postnatal registration book. Participants were recruited within 12 h of delivery in the postnatal room.

Abbreviations: ANC, Antenatal Care; D&A, Disrespect and Abuse; AOR, Adjusted Odds Ratio; CI, Confidence Interval; COR, Crude Odds Ratio; GSGH, Gebretsadik-Shawe General Hospital; HWs, Health Workers; MTUTH, Mizan Tepi University Teaching Hospital; RMC, Respectful maternity care; SBA, Skilled Birth Attendant; TGH, Tepi General Hospital; WHO, World Health Organization.

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TABLE 1 The socioeconomic characteristics of mothers at three public hospitals in Southwest Ethiopia in 2021 ($n = 348$).

Variables	Categories	Number of respondents	Percentage
Age	20	66	19
	20–34	149	42.8
	> 35	133	38.2
Marital status	Single	27	7.7
	Married	257	73.8
	Divorced	25	7.2
	Widowed	39	11.3
Religion	Ethiopian orthodox	128	36.8
	Protestant	149	42.8
	Muslim	71	20.4
Ethnicity	Bench	133	38.2
	Shako	36	10.3
	Kaffa	82	23.6
	Oromo	37	10.6
	Amhara	60	17.3
Occupation	Housewife	201	57.7
	Merchant	70	20.1
	Private employee	34	9.8
	Government employee	43	12.4
Educational status	Non-educated	200	57.5
	Primary	100	28.7
	Secondary	36	10.4
	College and above	12	3.4
Family monthly income	<10 USD	96	27.6
	10–30 USD	112	32.2
	30–40 USD	76	21.8
	≥40 USD	64	18.4

Operational definitions

Skilled birth attendant

An accredited health professional such as a midwife, doctor, or nurse who has been educated and trained to proficiency in the skills needed to manage normal pregnancy, childbirth, and the immediate postnatal period, and in the identification, management, and referral of complications in women and newborns (16).

Measurements

The mothers were interviewed and their medical records were reviewed using an Amharic version interviewer-administered questionnaire and an English version checklist. Previous literature was used to construct the structured questionnaire and extraction checklist (17).

For the prevalence of RMC, 15 interviewer-administered questionnaires that contain dichotomous (yes/no) questions were used. It was determined that a mother was receiving RMC if she answered yes to all 15 questions. If a mother responded negatively (no) to at least one question, we have considered that she had disrespectful delivery care (17).

The data on maternal age, religion, marital status, occupation, educational level, residence, income, ethnicity, antenatal care (ANC) follow-up, the reason to deliver in the hospital, admission to the maternity waiting room before labor started, the duration of labor, the gender of the maternity care provider attending the birth, and a face-to-face interviewer-administered questionnaire in the postnatal room were used to collect information from providers on the place of birth during ANC. Healthcare providers attending labor and delivery, companion during labor, labor outcome, and labor started spontaneously/ induced were collected an extract checklist used when reviewing their medical records.

Data quality control

Technical training for data collectors was provided before the actual data collection, and a pretest on 5% of the total sample size outside the study area with similar characteristics to the study population was conducted to ensure the quality of the data. The adapted English questionnaire was translated into Amharic, the local language, and then back to English by a language expert for consistency checks. We used six trained and degreed midwives as data collectors and two physicians as supervisors to collect all the requisite sample sizes. Each completed questionnaire was double-checked for accuracy, consistency, and completeness by the supervisors every day.

Data processing and analysis

The data were double-checked, coded, and entered into Epi Data version 3.1 software packages before being exported to SPSS software for analysis. Frequency tables and percentages were also used to present the descriptive analysis. To explain the data, the mean and standard deviations were calculated and used for applicable variables. For the multivariable regression model, bivariable regression analysis with a $p < 0.25$ was used to select candidate variables. The AOR with their 95% confidence

TABLE 2 The obstetric characteristics of mothers in three public hospitals in Southwest Ethiopia in 2021 ($n = 348$).

Variables	Categories	Number of respondents	Percentage
ANC follow up	Yes	317	91.1
	No	31	8.9
Healthcare providers conducting labor and delivery	Nurse	25	7.2
	Midwife	266	76.4
	Doctor	57	16.4
Sex of health care provider conducting labor and delivery	Male	201	57.8
	Female	147	42.2
Companion during labor	Yes	72	20.7
	No	276	79.3
Labor outcome	Normal	293	84.2
	With complication	55	15.8
Reason to deliver in the hospital	Planned	182	52.3
	Referral	166	47.7
Admitted to maternity waiting home before labor started	Yes	281	80.7
	No	67	19.3
Duration of labor	<12 h	210	60.3
	>12 h	138	39.7
Labor started	Spontaneously	212	60.9
	Induced	136	39.1
Discussion with providers about the place of delivery	Yes	184	52.9
	No	164	47.1

CI was calculated after a multivariable logistic regression was fitted using the centering method. Finally, variables in the multivariable regression analysis with a $p < 0.05$ were considered significant.

Results

Sociodemographic characteristics

A total of 348 mothers with newborns were included in the study, making a response rate of 100%. 149 (42.8%) of respondents fall in the 20–24 years age group. Nearly one-third of the study participants, 133 (38.2%) were from the Bench ethnic group and 149 (42.8%) were followers of the Protestant religion. About two-thirds of the mothers, 257 (73.9%), were married. Around half of them, 201 (57.8%) were housewives, and one-third of them, 112 (32.2%), had a monthly family income of 10–30 US dollars (USD). Above half of the respondents, 200 (57.5%) were non-educated (Table 1).

Obstetric related characteristics

Of the total respondents, 317 (91.1%) had a history of ANC follow-up for recent childbirth; 266 (76.4%) of the mothers were attended by a midwife; 271 (77.9%) of mothers gave birth through spontaneous vaginal delivery, and more than half of 201 (57.8%) healthcare providers were males. The majority of mothers (281) (80.7%) were admitted to maternity waiting homes, which are designed to improve access to obstetric care for high-risk pregnant women or those who live very far away from health facilities before delivery. More than half, 184 (52.9%), mothers discussed delivery with a provider, and 276 (79.3%) did not have complications during delivery (Table 2).

Proportion of RMC

Of the proportion of RMC out of 348 mothers who gave birth in three public hospitals in Southwest Ethiopia, 283 (81.2%) mothers received RMC, but the remaining 65 (18.8) mothers were disrespected during labor and delivery (Figure 1). Out of the 348 respondents, 82.6%, 77.0%, 84.1% and 79.3%

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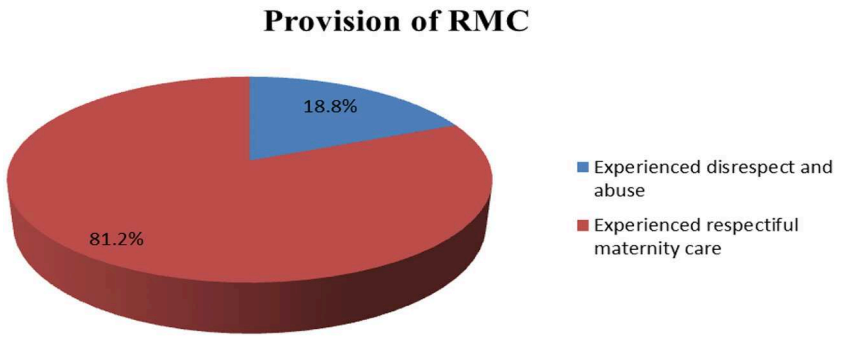

FIGURE 1
Provision of RMC during labor and delivery in three public hospitals of Southwest Ethiopia ($n = 348$).

TABLE 3 Provision of RMC during childbirth at three public hospitals in Southwest Ethiopia, 2021 ($n = 348$).

Category of RMC	Items of RMC	Experienced RMC			
		Yes	Percentage (%)	No	Percentage (%)
Friendly care	Care with a kind approach	299	85.9	49	14.1
	Care in a friendly manner	289	83.0	59	17.0
	Care with positive talk about pain and relief	293	84.2	55	15.8
	Care with showing empathy	286	82.2	62	17.8
	Care with respect to individual	302	86.8	46	13.2
	Care with understandable language	278	79.9	70	20.1
	Care by calling the laboring woman by the name	265	76.1	83	23.9
	Overall average	82.6%		17.4%	
Abuse-free care	The HWs responded to my needs, whether or not I asked.	254	73.0	94	27.0
	No one slapped me during delivery for different reasons.	293	84.2	55	15.8
	No one shouted at me because I haven't done what I was told to do.	257	73.9	91	26.1
	Overall average	77.0%		23.0%	
Timely Care	I didn't have to wait long before receiving service.	297	85.3	51	14.7
	Service provision was not delayed because of the health facility's internal problem	289	83.0	59	17.0
	Overall average	84.1%		15.9%	
Discrimination- free care	No one treats me disrespectfully due to some personal attributes	281	80.8	67	19.2
	No one insulated me due to personal attributes	289	83.0.0	59	16.1
	No one discriminated against me by economic status and language	285	81.9	63	18.1
	No one discriminated against me by race and ethnicity	276	79.3	72	20.7
	Overall average	81.2%		18.8%	

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TABLE 4 Bivariable and multivariable analyses showing crude and adjusted odds ratios for an association between RMC and risk factors among mothers who give birth in three public hospitals in Southwest Ethiopia, 2021 ($n = 348$).

Variable	Category	RMC		COR (95% CI)	AOR (95% CI)
		Yes	No		
Maternal age	<20	46	20	2.13 (1.14–4.67)	2.54 (1.01–6.43)*
	20–34	127	22	0.92 (0.48–1.17)	1.03 (0.46–2.33)
	≥35	112	21	1	
Maternal occupation	Housewife	165	36	1.65 (0.61–4.50)	1.62 (0.47–5.56)
	Merchant	59	11	1.41 (0.45–4.40)	1.43 (0.35–5.71)
	Private	23	11	3.63 (1.12–11.79)	5.23 (1.15–23.72)*
	Government employee	38	5	1	
ANC follow up	Yes	268	49	4.50 (2.08–9.72)	2.86 (1.00–8.20)*
	No	17	14	1	
A provider who conducts delivery	Nurse	39	27	8.07 (2.25–28.96)	2.74 (0.54–13.89)
	Midwife	211	33	1.82 (0.53–6.27)	1.13 (0.27–4.74)
	Doctor	35	3	1	
Companion during labor	Yes	42	30	5.26 (2.90–9.51)	1.43 (0.38–5.36)
	No	243	33	1	
Labor outcome	Normal	254	39	5.04 (2.68–9.47)	0.36 (0.68–1.90)
	With complication	31	24	1	
Reason to deliver in the hospital	Planned	164	18	3.36 (1.86–6.14)	0.63 (0.24–1.65)
	Referral	121	45	1	
Admitted to maternity waiting home before labor started	Yes	224	57	2.58 (1.06–6.28)	2.65 (0.81–8.62)
	No	61	6	1	
Duration spent on labor	<12 h	158	52	3.80 (1.90–7.58)	1.40 (0.38–5.13)
	> 12 h	127	11	1	
Labor started	Spontaneously	158	56	6.61 (2.91–15.01)	2.27 (0.62–8.26)
	Induced	129	7	1	
Discussion with providers about the place of delivery during ANC follow up	Yes	162	22	2.45 (1.39–4.33)	5.58 (2.12–14.70)*
	No	123	41	1	

1-Reference, *-Significant at <0.05. COR, Crude odd ratio; AOR, Adjusted odd ratio.

received friendly, abuse-free, timely, and discrimination-free care, respectively (Table 3).

Bivariable and multivariable logistic regression analysis

In the bivariable logistic regression model, maternal age, maternal occupation, ANC follow-up, the provider who attended the labor and delivery, companion during labor, labor outcome, a reason to deliver in the hospital, admission to maternity waiting home before labor started, duration of labor, how labor started (spontaneously vs. induced) and discussion about the place of delivery with a provider during ANC follow up were the main components of RMC. After adjusting for confounding variables in a multivariable logistic regression model, maternal age, maternal occupation, ANC follow up and discussion about the place of delivery with a provider during ANC follow-up were identified as the significant predicates of RMC.

Mothers who were <20 years old were 2.5 times more likely to receive respectful maternity care than those whose age was more than or equal to 35 years [AOR = 2.54; 95% CI (1.01–6.43)]. Mothers who had private work were 5.2 times more

likely to receive respectful maternity care than women who had governmental work [AOR = 5.23; 95% CI (1.15–23.72)]. Mothers who had at least one history of ANC follow-up in their current pregnancy were 2.8 times more likely to receive RMC as compared to their counterparts [AOR = 2.86; 95%CI (1.01–8.20)]. The odds of experiencing RMC were higher among mothers who discussed the place of delivery with healthcare providers during their current pregnancy as compared to their counterparts (AOR = 5.58; 95% CI: [2.12–14.70]) (Table 4).

Discussion

An important approach to minimizing maternal and neonatal morbidity and mortality is to increase pregnant women's access to skilled care during childbirth (5). The study aimed to assess the provision of RMC and related characteristics among birthgiving mothers in three public hospitals in Southwest Ethiopia.

The overall provision of RMC was 81.2%, according to the findings of this study. This result is higher than the studies found in Ethiopia (57%), and Kenya (80 %) (18, 19). However, the result is lower than a study conducted in Tanzania (20). This difference could be due to time differences associated with current accelerated reproductive health promotion activities, women-friendly programs, and various supportive types of training in some health institutions in the study area, as well as the small sample size of previous studies and different study areas.

In the current study, a variety of factors affected RMC. In this regard, the study found that mothers who were younger than 20 years old were more likely to have RMC than older mothers. This finding was supported by research conducted in Kenya (19). The reason for this association could be that women under the age of 20 are more educated than their counterparts; these mothers may have a greater understanding of healthcare facilities, as well as of their rights and privileges.

Mothers who had at least one history of ANC follow-up in their current pregnancies were more likely to receive RMC as compared to their counterparts. This finding is in line with findings from recent studies in Ethiopia's southern and eastern regions (21, 22). ANC follow-up enhances RMC provision. The pregnant women's adaptation to the services and close relationships with the healthcare staff are critical in creating trust in the facility's services.

Last but not least, RMC was part of a pregnant woman's discussion with healthcare providers about the place of birth. In this context, women who discussed a birthplace with maternity care providers during ANC were more likely to receive RMC than those who did not. This evidence supports research conducted in Oromia, Ethiopia, which found that mothers who had not received ANC visits were more likely to be disrespected and abused than those who had received ANC visits (23). This could be because women who had ANC and discussed a birthplace were more likely to know the healthcare professionals who would attend them during their labors and births.

The provision of RMC was high, but there are complaints of disrespect and abuse still present in three hospitals in Southwest Ethiopia. Maternal age, maternal occupation, antenatal follow up and discussion with the provider about the place of delivery during antenatal follow-up were associated with respectful maternity care. Thus, improving ANC service utilization and discussion with healthcare providers about the place of delivery during ANC follow-up should be focused on.

Study limitations

Our research might have the following limitations: Our research might have been subject to social desirability bias and fear of reporting abusive care, since the data were collected within the hospital setting. The other limitation is that meanwhile, the data were collected in the early postpartum period; thereby some women were too exhausted to respond to some questions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Mizan Tepi University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

AA developed the conception of the idea, wrote the proposal, and participated in the data collection and analysis. KK participated in data analysis, report writing, and prepared the manuscript. GA approved the proposal with some revisions and participated in manuscript development. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The bayesian approach of factors associated with preterm birth among mothers delivered at public hospitals in Southeast Ethiopia

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Background: Preterm birth remains the commonest cause of neonatal mortality, and morbidity represents one of the principal targets of neonatal healthcare. Ethiopia is one of the countries which accounts for the highest burden of preterm birth. Therefore, this study aimed to assess factors associated with preterm birth at public hospitals in Sidama regional state.

Methods: A facility-based cross-sectional study was conducted at public hospitals in Southeast Ethiopia from 1 June to 1 September 2020. To recruit the study participants, systematic random sampling techniques were used. Data were collected using pretested structured interviewer-administered questionnaire and a checklist *via* chart review. Data were entered using EpiData version 3.1 and exported to R software version 4.0 for analysis. Then, factors associated with preterm birth among mothers were assessed based on the Bayesian statistical approach.

Results: The study showed that the prevalence of preterm birth was 20.6%. Being a rural resident (AOR = 2; 95% CrI: 1.2–3.5), having no antenatal care service utilization (AOR = 2.3; 95% CrI: 1.1–4.8), hypertensive disorder of pregnancy (AOR = 3.5; 95% CrI: 1.8–6.9), birth space less than 2 years (AOR = 3.4; 95% CrI: 1.5–7.9), having premature rupture of membrane (AOR = 2.4; 95% CrI: 1.3–5.4), and physical intimate violence (AOR = 2.876; 95%CI: 1.534, 5.393) were risk factors of preterm birth. Whereas, women who had primary, secondary, and higher education levels (AOR = 0.2; 95% CrI: 0.1–0.4, AOR = 0.1; 95% CrI: 0.06–0.3, and AOR = 0.2; 95% CrI: 0.1–0.4), respectively, were preventive factors.

Conclusion: Most of the risk factors of preterm birth were found to be modifiable. Community mobilization on physical violence during pregnancy and antenatal care follow-up are the ground for the prevention of preterm birth because attentive and critical antenatal care screening practices could early identify risk factors. In addition, information communication education about preterm birth prevention was recommended.

KEYWORDS

preterm birth, public hospitals, Sidama region, Ethiopia, women

Introduction

According to the World Health Organization, preterm birth is defined as a delivery that occurs before 37 completed weeks of gestation (1, 2). Out of the 130 million babies born each year globally, approximately 15 million are born prematurely. Of these, 60–85% are found concentrated in Africa and South Asia where health systems are difficult to access and minimum utilization of health services (3). In Ethiopia, the prevalence of preterm birth ranges from 4.4 to 31.1% (4, 5).

Preterm birth is a major healthcare problem causing over 1 million deaths of neonates annually, and high rates of morbidity and disability among survivors (6). Preterm babies predominantly suffer not only from the immediate complication of prematurity but also long-term complications, such as cerebral palsy, intellectual impairment, chronic lung disease, and vision and hearing loss (6, 7). Family, society, and the country also suffer from the economic burden of preterm birth due to longer hospital stay, neonatal intensive care, and ongoing long-term complex health needs occasioned by the resultant disabilities (7).

Ethiopia is one of the top eight countries that account for the high prevalence of preterm birth in 2014 and the top six countries that contribute nearly two-thirds of all deaths from preterm birth complications worldwide in 2016 (8). In Ethiopia, 377,000 babies are born too prematurely each year and 23,100 children under 5 years died due to direct preterm complications (9). Even if Ethiopia had achieved the Millennium Development Goal-4 (MDG-4), 2 years before the targeted year, evidence showed that the pace cannot continue as per the plan, and then neonatal mortality increased (10).

Target 3.2 of Sustainable Development Goal (SDG) 3 is used to reduce global neonatal mortality to at least as low as 12 per 1,000 live births by 2030 (11). Also, the Ethiopian government aspires to decrease neonatal mortality to 10 per 1,000 live births by 2035 (12). However, in Ethiopia, the current neonatal mortality is 30, which is too far from the target set by SDG and FMoH (13). To achieve SDG and FMoH targets, better prevention and management of preterm birth and its complications are key strategies (3). Identification of risk factors is crucial to prevent and maintain the management of preterm birth. So, to prevent and control preterm birth, it is necessary to know the determinants of preterm birth using an appropriate statistical method of analysis. The Bayesian analysis approach is one of the data analysis approach independent of the classical analysis approach and the parameters are estimated from the posterior distribution, which is the combination of the prior information and the likelihood of the data (14). A prior distribution of a parameter is the probability distribution that represents our uncertainty about the parameter before the current data are examined and the likelihood function (often simply called the likelihood) expresses how probable a given set of observations is for different values of the statistical parameters (14). However, there is no evidence that shows studies conducted at the regional level to identify determinants of preterm birth by using the Bayesian statistical approach. Nevertheless, still there is a paucity of evidence regarding factors associated with preterm birth at the country level in general and in the study area, in particular, using an advanced statistical approach. Therefore, this study aims to determine the prevalence of preterm birth and its associated factors among mothers delivered at public hospitals in Sidama regional state using the Bayesian approach.

Abbreviations: ANC, Antenatal Care; AOR, Adjusted Odds Ratio; FMoH, Federal Minister of Health; HIV, Human Immunodeficiency Virus; LNMP, Last Normal Menstrual Period; SDG, Sustainable Development Goal; UTIs, Urinary Tract Infections.

Materials and methods

Study design, setting, period, and population

An institution-based cross-sectional study was conducted at public hospitals in the southeastern part of Ethiopia (Sidama regional state) from 1 June to 1 September 2020. Mothers who gave birth at public hospitals in Southeast Ethiopia (Sidama regional state) were the source population, and mothers who gave birth in the selected public hospitals during the study period were the study population. Mothers who gave live birth to singleton preterm neonate and their index neonates were included. But, mothers without a confirmed diagnosis of preterm birth due to did not remember their LNMP or have not had an early ultrasound record were excluded from the study. Similarly, medically induced preterm births are also excluded from this study.

Sample size determination and sampling technique

The sample size was determined using the single population proportion formula $n \geq \left[\frac{Z_{\frac{\alpha}{2}}^2}{\varepsilon^2}\right]^* P(1-p)$ (15) by considering the proportion of preterm birth ($P = 29.6\%$) (16), 95% confidence level ($Z = 1.96$), 5% of marginal error ($W = 0.05$), 10% non-response rate, and design effect of 2. After adding a 10% non-response rate, the required final sample was 704.

A multistage sampling technique was employed. Out of three general and 14 primary hospitals, one general and three primary hospitals, respectively, were randomly selected. In addition, there was only one comprehensive hospital located in the region and it was included in the study. The total sample size was proportionally distributed to each hospital based on an average

number of deliveries recorded in the most recent quarterly report of each health facility before the study period. Finally, the study participants were recruited using a systematic random sampling technique.

Operational definitions

Early ultrasound record: Ultrasound result is taken until 22 weeks of gestational age (17, 18).

Physical intimate violence: It is defined as any act of harm to women physically by the current or former intimate partner or husband (19).

Hypertensive disorders of pregnancy: It is defined as systolic blood pressure (SBP) of 140 mmHg or more or diastolic blood pressure (DBP) of 90 mmHg or more on 2 or more consecutive occasions during pregnancy (20).

Data collection tools, procedures, and techniques

Data were collected through face-to-face interviews using a standardized, structured, and pretested questionnaire and a chart review checklist. The questionnaire and checklist were adapted from other similar studies with some contextual modifications (19, 21). It contains sociodemographic characteristics, obstetric factors, preexisting medical factors, fetal factors, and physical intimate partner violence. A checklist was used to collect data from the medical record and actual measurements.

The gestational age was established based on a certain last menstrual period (LMP) date and/or early pregnancy ultrasound determined date (up to and including 22 completed weeks of gestation). When the LMP and U/S dates had not been correlated, U/S for gestational age assessment was taken in accordance with the recommendation of the American College of Obstetricians and Gynecologists (ACOG) (17, 18, 22). Those mothers with neither reliable LMP nor early pregnancy U/S date for GA estimation had been excluded. Data were collected by 10 trained BSc (Bachelor of Science) midwives who had been working in the delivery ward. Five BSc midwives were trained and supervised the data collection.

Data quality assurance

The questionnaire was prepared first in English and translated into the local language Amharic and Sidaamu Afoo, and finally, retranslated back to English by a language expert to increase accuracy. Before conducting the study, the questionnaire was pretested on 10% of the sample. Based on the pretest, an appropriate modification was made. The 1-day training was provided for data collectors and supervisors.

Data processing and analysis

The collected data were checked for completeness, entered into EpiData version 3.1, coded, cleaned, and exported to R software version 4.0 for further analysis. After the data were cleaned and coded, descriptive measures, such as frequency, percentage, graphs, and tables, were used to characterize the study population. The relationship between the dependent and independent variables was assessed using the binary logistic regression model based on the Bayesian statistical analysis approach. The dependent variable (preterm birth) is represented by $Y_i = \begin{cases} expriancing\ pre\ term\ birth \\ not\ expriancing\ pre\ term\ birth \end{cases}$, which is a categorical type of data. Thus, to estimate the parameters of the variable, binary logistic regression analysis based on the Bayesian approach was done using **Brms** R-package. Since we do not have prior information, we used vague prior distribution to determine the posterior distribution. To estimate regression coefficients, we used beta distribution (1, 1), and to estimate the variance, we used gamma distribution (0.001, 0.001). We also used chains = 2, initials (the starting values of the iterations) = 0, iteration = 10,000, cores (specifies the number of cores used for the algorithm) = 2, warmup (number of iterations that was discarded) = 1,000, and adapt delta (controls divergent transition) = 0.95 to estimate the estimates of the parameters from the posterior distribution.

Then, Hamiltonians Monte Carlo (HMC) method was performed to simulate direct draws from the complex posterior distribution. Therefore, since the iteration convergence is fast, we used No-U-Turn Sampler (NUTS). Finally, summary statistics were carried out from the posterior distribution after the model was converged, and the 95% credible interval was used for the test of significance. The empirical results obtained from a given HMC analysis are not reliable until the chain has reached its stationary distribution. Therefore, to monitor the convergence of the algorithm, we used the most popular assessment methods in which Rhat = 1, Bulk_ESS and Tail_ESS were greater than 1,000, density plots were smooth, and chains of the time series plots were mixed well.

Results

Frequency and percentage distribution of preterm birth

The prevalence of preterm birth among women delivered in the Sidama region of Southeast Ethiopia public hospitals was 20.4%.

TABLE 1 Frequency and percentage distribution of preterm birth by different variables among mothers who delivered at public hospitals in Sidama regional state, Southeast Ethiopia, 2020.

Variables	Categories	Preterm birth			
		No		Yes	
		Frequency	Percentage	Frequency	Percentage
Age	≤19	79	15.1%	28	21.2%
	20–34	214	40.9%	69	52.3%
	≥35	230	43.9%	35	26.5%
Marital status	Married	470	89%	111	82.2%
	Unmarried	58	11%	24	17.8%
Residence of respondent	Urban	391	74.1%	76	56.3%
	Rural	137	25.9%	59	43.7%
Educational status of women	No formal education	135	25.6%	71	52.6%
	Primary school	164	31.1%	34	25.2%
	Secondary school	118	22.3%	19	14.1%
	Diploma and above	111	21%	11	8.1%
ANC follow up	Yes	461	87.3%	94	69.6%
	No	67	12.7%	41	30.4%
Number of family member	<5	50	9.5%	18	13.3%
	≥5	478	90.5%	117	86.7%
Parity	<3	8	1.5%	9	6.7%
	≥3	520	88.5%	126	93.3%
Advised about danger sign of pregnancy	Yes	500	94.7%	115	85.2%
	No	28	5.3%	20	14.8%
hypertensive disorders of pregnancy	No	484	91.7%	96	71%
	Yes	44	8.3%	39	29%
Premature rupture of membrane	No	500	94.7%	106	78.5%
	Yes	28	5.3%	29	21.5%
Urinary tract infections	No	498	94.3%	91	67.4%
	Yes	30	5.7%	44	32.6%
Hgb of mother at booking	≤10	59	11.2%	25	18.5%
	≥11	469	88.8%	110	81.5%
HIV status of Mother	Non-reactive	509	96.4%	121	89.6%
	Reactive	19	3.6%	14	10.4%
Intimate partner violence	No	500	94.7%	94	69.6%
	Yes	28	5.3%	41	30.4%

A total of 47.6% of women who experienced hypertensive disorder during pregnancy had a preterm birth. In addition, 19.3% of women who had premature rupture of the membrane experienced preterm birth (see Table 1).

Binary logistic regression based on the Bayesian approach

As shown in Table 2, this model shows that the Rhat value is one and all effective sample sizes (both Bulk_ESS and

TABLE 2 Relationship analysis for preterm birth and predictors based on the Bayesian approach in Southeast Ethiopian women in 2020.

Variables	Characteristics	Estimates	SE	AOR	95%CrI of AOR		Rhat	Bulk_ ESS	Tail_ ESS
					L-CrI	U-CrI			
β0 intercept		−0.86	0.66	0.42	0.11	1.56	1	8,422	6,537
Age	≤19	0.83	0.38	1.28	0.98	2.4	1	6,432	7,231
	20–34 (ref)						1		
	≥35	0.61	0.33	0.92	0.53	1.66	1	6,648	5,882
Marital status	Unmarried	0.11	0.38	1.11	0.53	2.3	1	8,300	6,530
	Married (ref)								
Residence	Urban (ref)								
	Rural*	0.69	0.29	2	1.2	3.5	1	8,180	6,129
Educational status	Not formal (ref)								
	Primary*	−1.6	0.34	0.2	0.1	0.4	1	6,635	6,050
	Secondary*	−2	0.4	0.1	0.06	0.3	1	7,209	5,949
	Higher*	−1.83	0.47	0.2	0.1	0.4	1	7,271	6,767
Number of family member	<5 (ref)								
	≥5	0.06	0.49	1.1	0.4	2.8	1	7,918	6,312
Parity	≥3	−0.34	0.29	0.7	0.4	1.2	1	8,425	6,469
	<3 (ref)								
Birth interval in year*	<2 year	1.24	0.42	3.4	1.5	7.9	1	9,054	6,112
	≥2 year (ref)								
Antenatal care follow up*	No	0.85	0.37	2.3	1.1	4.8	1	7,368	6,258
	Yes (ref)								
Fist antenatal care started	<16 weeks (ref)								
	≥16 weeks	0.08	0.32	1	0.6	2	1	7,733	5,995
Danger sign of pregnancy advised	No	0.57	0.42	1.8	0.8	4	1	8,239	6,152
	Yes (ref)								
hypertensive disorders of pregnancy*	Yes	1.24	0.36	3.5	1.8	6.9	1	8,662	6,152
	No (ref)								
Premature rupture of membrane*	Yes	0.88	0.42	2.4	1.3	5.4	1	8,065	6,135
	No (ref)								
Hgb of mother at booking	<11	0.21	0.36	0.8	0.4	1.7	1	8,828	6,607
	≥11 (ref)								
Urinary tract infections	Yes	1.1	0.35	3	1.5	5.9	1	8,785	6,642

(Continued)

TABLE 2 (Continued)

Variables	Characteristics	Estimates	SE	AOR	95%CrI of AOR		Rhat	Bulk_ ESS	Tail_ ESS
					L-CrI	U-CrI			
	No (ref)								
HIV status of Mother	Positive	0.41	0.5	1.5	0.5	4	1	9,477	6,421
	Negative (ref)								
Sex of neonate	Male (ref)								
	Female	0.16	0.28	1.2	0.7	2	1	9,035	6,443
Intimate partner violence*	Yes	1.28	0.37	3.6	2	7	1	7,775	6,345
	No (ref)								

ref, reference category; *, significant at 95% CrI; SE, Standard Error; AOR, Adjusted Odd Ratio; CrI, Credible Interval; Hgb, Hemoglobin.

Tail_ESS) are greater than 300 times the number of chains. In addition to Rhat and effective sample size, the density plots were smooth and also chains of the trace plots were mixed well. Therefore, the model converged well. Since the model is converged, all estimates obtained from this model are reliable. Thus, all interpretations and inferences were made based on this model.

Discussion

Even though there have been advancements in perinatal medicine and feto maternal units, preterm birth remains the leading cause of neonatal mortality and morbidity, leading to the first place for neonatal intensive care unit admission and longer hospital stay (23, 24). This study aimed to assess the factors of preterm birth among mothers who gave birth at public hospitals in Southeast Ethiopia.

The magnitude of preterm birth in this study was consistent with the previous findings conducted in Bangladesh at 22.3% (25), Nigeria at 16.9% (26), Kenya at 18.3% (27), and Jimma at 25.9% (28). However, the finding of this study was higher than a study conducted in Brazil at 12.5%(29), Northwest Ethiopia at 12.8% (30), and northern Ethiopia at 13.3% (31). The discrepancy might be due to sociodemographic and economic variations of the study participants. Most of the participants in the current study were rural dwellers compared with the previous study that claimed an increased risk of preterm birth.

Of all the factors included in the model, being a rural resident, educational status of the mother, birth interval, ANC follow-up, hypertensive disorders of pregnancy, the premature rupture of membrane, and physical intimate violence were significantly associated with preterm birth in southern Ethiopia (Sidama regional state). The odds of delivering preterm babies among mothers who lived in rural areas were more likely than among urban residents. This finding is similar to the study conducted in the Amhara region (19), and Axum and Adwa town public hospitals (31). This might be explained by women who reside in rural areas are more likely to be exposed to hard physical work such as farming, which, in turn, increases the risk of preterm delivery. Also, in rural areas, there is no access to healthcare facilities, transportation, and improved water sources (32). Therefore, they travel a long distance to access them. This might lead them to experience preterm birth. The odds of having preterm birth among mothers who did not attend formal education were more likely than educated women. This result is supported by a cohort study conducted in Europe (33). The study revealed that mothers who did not utilize antenatal care during their current pregnancy were more likely to deliver preterm babies as compared to mothers who utilized ANC. This result is consistent with the study conducted in Dodola town hospitals, Southeast Ethiopia (34), Kampala, Uganda (35), and a systematic review in East Africa (36). This might be because women who had no ANC follow-up could miss information that is important to prevent, identify, refer, and treat preterm birth promptly in health facilities.

This study depicts that the odds of preterm delivery among mothers who experienced hypertensive disorders of pregnancy were more likely than mothers who have not experienced hypertensive disorders of pregnancy. This finding is in line with a study conducted in Tigray (37), Jimma (21), and Kenyatta national hospitals (38). This might be because hypertension decreases the uteroplacental blood and nutrients transfer, which leads to intrauterine growth restriction and/or early placenta dysfunction that cause preterm delivery (39).

The odds of preterm delivery among mothers who experienced birth spacing <2 years were more likely as compared to those who spaced more than 2 years. This finding is in line with a study conducted in Jimma (21), Northern Ethiopia (40), Axum and Adwa town (31), and

Amhara regions (19). This might be due to mothers having short inter-pregnancy intervals cannot recover from the biological stress imposed by the preceding pregnancy resulting in the reduction of macronutrients supplementation in the maternal body, folate depletion, cervical insufficiency, vertical transmission of infections, incomplete healing of uterine scar and abnormal remodeling of endometrial blood vessels, anemia, and maximizing the risk of certain other factors achieving pregnancy outcomes (41, 42).

The odds of mothers who experienced physical intimate violence during pregnancy were more likely to deliver preterm babies than mothers who did not experience physical intimate violence. This finding is in agreement with a study conducted in Iran (43), Vietnam (44), and Tanzania (45). This might be due to physical violence during pregnancy affecting premature delivery because of physical trauma upon the abdomen, uterus, and post-trauma-induced stress, which leads to premature onset of labor related to either direct effect or due to corticotrophin-releasing hormone (CRH) (46, 47). This finding has not been supported by a study conducted in Canada (48) and the Amhara region (19). This difference could be explained by a difference in the methods used for data analysis, the discrepancy in the measurement of physical intimate violence, and the difference in the sociodemographic characteristics of respondents.

Strengths and limitations of the study

This study identified several factors associated with preterm birth using an appropriate method of statistical analysis. But, there were some limitations to this study. The study participants might not remember (recall bias) their exact LNMP. So, to solve this problem, we used ultrasound records. The other limitation of the study was the prevalence of preterm birth in the Sidama regional state might be biased by referrals from the neighboring southwest Arusi and Oromia regional state hospitals. Thus, to alleviate this problem, we excluded women who have referral papers in their chart from the study.

Conclusion

Preterm birth had been a major public health problem in the study area for perinatal care, and thus deserves priority attention. There were many factors interwoven to affect the occurrence of preterm birth. Preterm birth is more likely to occur in women living in rural areas, with no ANC follow-up, narrow birth spacing, and suffering from physical violence during pregnancy. Whereas, women who attend primary education and above were preventive factors. Thus, efforts should be intensified to alleviate the identified risk factors to minimize the burden of preterm birth in the study setting, Southeast Ethiopia. Community mobilization on physical violence during pregnancy and ANC follow-up are the ground for the prevention of preterm birth because attentive and critical ANC screening practices could early identify the risk factors. Further community-based longitudinal (cohort) studies might explore additional determinants of preterm birth.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical clearance was obtained from the Institutional Review Board (IRB/202/12) at the College of Medicine and Health Sciences of Hawassa University. An official letter of cooperation was obtained from the Department of Midwifery to respective hospital administrators. Informed written permission was obtained from each hospital administrator. After the purpose and objective of the study have been explained, written consent was obtained from each study participant. Participants were informed that participation was on a voluntary basis and can withdraw from the study at any time if they were not comfortable with the questionnaire. In order to keep confidentiality, information was maintained throughout by excluding names or personal identifiers in the questionnaire.

Author contributions

YN conceived the study, analyzed the data, and wrote the first draft of the manuscript. GA supervised the study, methods, and proofread the manuscript. All the authors read and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The impact of COVID-19 on a South African pediatric cardiac service: implications and insights into service capacity

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Background and Objectives: The Western Cape public pediatric cardiac service is under-resourced. COVID-19 regulations are likely to have long-term effects on patient care but may provide insight into service capacity requirements. As such, we aimed to quantify the impact of COVID-19 regulations on this service.

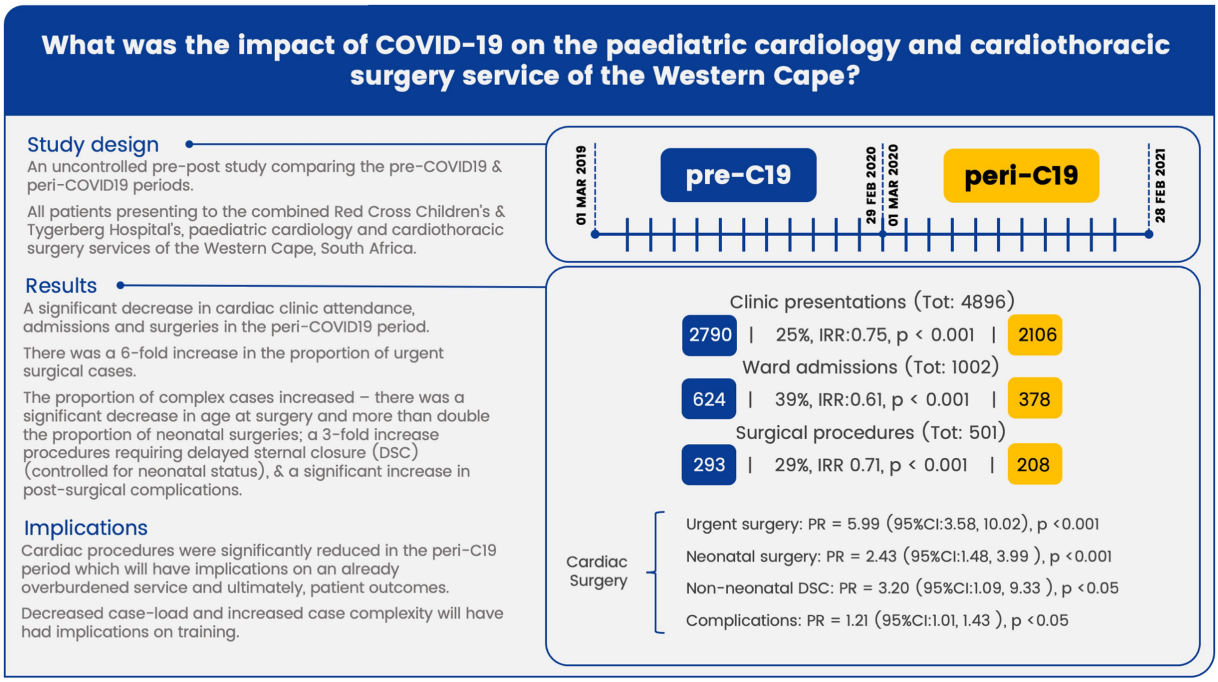
Methods: An uncontrolled retrospective pre-post study of all presenting patients over two, one-year periods; the pre-COVID-19 period (01/03/2019–29/02/2020) and the peri-COVID-19 period (01/03/2020–28/02/2021).

Results: Admissions decreased by 39% (624 to 378) and cardiac surgeries decreased by 29% (293 to 208) in the peri-COVID-19 period, with an increase in urgent cases (PR:5.99, 95%CI:3.58–10.02, $p<0.001$). Age at surgery was lower in the peri-COVID-19 period, 7.2 (2.4–20.4) vs. 10.8 (4.8–49.2) months ($p<0.05$), likewise, age at surgery for transposition of the great arteries (TGA) was lower peri-COVID-19, 15 (IQR:11.2–25.5) vs. 46 (IQR:11–62.5) days ($p<0.05$). Length of stay 6 (IQR:2–14) vs. 3days (IQR:1–9) ($p<0.001$), complications (PR:1.21, 95%CI:1.01–1.43, $p<0.05$), and age-adjusted delayed-sternal-closure rates (PR:3.20, 95%CI:1.09–9.33, $p<0.05$) increased peri-COVID-19.

Conclusion: Cardiac procedures were significantly reduced in the peri-COVID-19 period which will have implications on an overburdened service and ultimately, patient outcomes. COVID-19 restrictions on elective procedures freed capacity for urgent cases, demonstrated by the absolute increase in urgent cases and significant decrease in age at TGA-surgery. This facilitated intervention at the point of physiological need, albeit at the expense of elective procedures, and also revealed insights into capacity requirements of the Western Cape. These data emphasize the need for an informed strategy to increase capacity and reduce backlog whilst ensuring minimal morbidity and mortality.

KEYWORDS

COVID-19, pediatric cardiology, cardiothoracic surgery, cardiac surgery, congenital heart disease, service capacity



Graphical Abstract

1. Introduction

The South African pediatric cardiology and cardiothoracic surgery service is in general under-resourced. Although better resourced than most South African provinces, the Western Cape service, by international standards, is still considered to be under-resourced and any interruption to this service may have long term effects. We aimed to quantify the impact of COVID-19 regulations on the Pediatric Cardiology service of the Western Cape and the pediatric division of the Christian Barnard Division of Cardiothoracic Surgery.

1.1. Background

In response to the growing pandemic and the identification of COVID-19 cases in South Africa, on the 18 March 2020, the South African government restricted domestic and international travel, gatherings of more than 50 people and closed schools (1–3). This was followed by a 21-day level-5 lockdown on the 27 March 2020. Level-5 lockdown entailed restrictions on the movement of persons and goods, the prohibition of public transport, and the closure to the public of places and premises not essential to the provision of essential services or goods (4). Level 5 lockdown was extended for a further 14 days before the implementation of a staged de-escalation to lockdown level 1 almost 1 year later, on the 1st of March 2021. Although the health care sector was exempt from level 5 regulations (4, 5), most provincial health departments and private hospital groups elected to suspend the provision of elective and non-urgent interventions and surgery (6, 7).

The Red Cross War Memorial Children's hospital and Tygerberg Hospital serve as the combined pediatric cardiology and cardiothoracic surgery referral center for the population of the Western Cape, parts of the Eastern and Northern Cape and, serves a population of approximately nine million people (8). Annually this service typically performs around 120 interventional cardiac catheterisations, 300 cardiac surgeries and has a surgical waiting list of more than 200 patients (8). Although essential, many of these procedures are performed electively and as such would have been curtailed by the regulations described above.

Local and international studies show that COVID-19 restrictions have negatively impacted health services and lead to significant reductions in in-patient procedures (6, 9). In the Western Cape province of South Africa, general surgical procedures decreased by 44% in the peri-COVID-19 period (10). Internationally, an Italian multi-center study showed a 53% reduction in adult cardiac surgery for the 2020 peri-COVID-19 period when compared with the 2019 pre-COVID-19 period (11). Similarly, at the Seattle Children's Hospital there was a 26% reduction in pediatric cardiac surgery and a 44% reduction in non-surgical pediatric cardiac interventions during the peri-COVID-19 period (12).

The South African public pediatric cardiology and cardiothoracic surgery service is in general considered to be under-resourced with insufficient nurses, allied staff, pediatric cardiologists and cardiothoracic surgeons to meet the needs of the population (8, 13–15). Although better resourced than most South African provinces, the Western Cape service,

Abbreviations: CHD, Congenital heart disease; DSC, Delayed sternal closure; IQIC, International Quality Improvement Collaborative for Congenital Heart Disease; OPD, Out-patient department; Peri-COVID-19, The research period during the COVID-19 pandemic (01/03/2020–28/02/2021); Pre-COVID-19, The research period prior to the COVID-19 pandemic (01/03/2019–29/02/2020); RACHS-1, Risk Adjustment for Congenital Heart Surgery 1 score; 95%CI, 95% confidence interval; IQR, Interquartile range; IRR, Incidence rate ratio; PR, Prevalence ratio.

by international standards (16), is still considered to be under-resourced, with less than half the recommended 18 pediatric cardiologists for the population of 9 million and insufficient cardiothoracic surgeons to meet the needs of the estimated >550 Western Cape patients requiring open heart surgery annually (this number excludes patients from the Eastern and Northern Cape seen in the Western Cape service) (15–18). As such, any COVID-19-related backlog cannot be cleared by returning to pre-COVID-19 capacity (19). Additional capacity must be leveraged and evidence based strategies implemented to minimize complications and deaths in patients awaiting treatment. In addition, the COVID-19-related restrictions to the provision of non-urgent cardiac procedures, may reveal insights into Western Cape public pediatric cardiac service capacity. As such, this paper aims to quantify the impact of COVID-19 regulations on the public pediatric cardiology and cardiothoracic surgery service of the Western Cape, and to inform future studies and interventions to address the resultant backlog.

2. Materials and methods

We conducted an uncontrolled pre-post study of pediatric cardiology and cardiothoracic surgery patients presenting to the Department of Health, Pediatric Cardiology service of the Western Cape and the Chris Barnard Division of Cardiothoracic Surgery over two, one-year periods. The pre-COVID-19 period (01/03/2019–29/02/2020) and the peri-COVID-19 period (01/03/2020–28/02/2021).

Data were collected retrospectively from: the Chris Barnard Division of Cardiothoracic Surgery, pediatric cardiac surgery patient management and auditing system, the Pediatric Cardiology service of the Western Cape Red Cross Children's Hospital cardiology patient database and associated preoperative waiting list, the International Quality Improvement Collaborative for Congenital Heart Disease (IQIC) Red Cross Children's Hospital database, the Red Cross Children's Hospital Pediatric Intensive and Critical Care Unit Clinical Database and the Western Cape Department of Health Clinicom™ administration system. Institutional review board approval for this study was obtained from the University of Cape Town, Human Research Ethics Committee (HREC). A waiver of informed consent was granted as the study is a *post hoc* analysis of existing HREC approved registries and databases.

The primary objectives were to quantify changes in the number of cardiac out-patient department (OPD) visits, ward admissions, surgical procedures and cardiac catheterisations. Additionally, we compared changes in age, the distribution of diagnoses, OPD appointment attendance rates, ward admission duration and level of care, surgical procedure type, urgency of surgical care, surgical risk or complexity, using the Risk Adjustment for Congenital Heart Surgery 1(RACHS-1) score (20), surgical complication and mortality rates, and the number of cardiac catheterisation interventions and complications.

Poisson regression models were fitted to determine the incidence rates and incidence rate ratios (IRRs) for the dichotomized data: total OPD presentation, total ward admissions, total surgical procedures, and total cardiac catheterisations, modelled independently as the response variable, and the explanatory variable constituting the date, which was factorized into two levels, the pre-COVID-19 period or the peri-COVID-19 period, described above. Wilcoxon rank sum tests were used to compare differences in median age between periods. For categorical data, prevalence ratios between periods were calculated for each category individually, 95% confidence intervals were calculated, and *p*-values were generated using Chi-square and Fisher's exact tests where appropriate. Statistical analysis was carried out in R (version 4.2.0, R Foundation) (21).

3. Results

Combined surgical and medical cardiac admissions (Table 1; Figure 1) decreased by 39% from 624 in the pre-COVID-19 period to 378 in the peri-COVID-19 period. Median age at admission was similar between periods, 2.7 years (Interquartile Range [IQR]: 0.8–6.8) pre-COVID-19 and 1.81 years (IQR: 0.5–6.2) peri-COVID-19. With a significant decrease in patients aged 5 to 12 years (PR: 0.78, 95%CI: 0.63–0.98, $p < 0.05$) and a significant increase in children aged 12 to 19 years (PR: 1.85, 95%CI: 1.09–3.12, $p < 0.05$). The distribution of diagnoses was similar for both periods; structural CHD predominated, with 535 (64.8%) cases pre-COVID-19 and 328 (67.5%) cases peri-COVID-19, followed by myocardial or pericardial disease, with 71 (8.6%) cases pre-COVID-19 and 30 (6.2%) cases peri-COVID-19. Admission-duration was significantly longer ($p < 0.001$), 3 days (IQR: 1–9) in the pre-COVID-19 period versus 6 (IQR: 2–14) peri-COVID-19. ICU admissions decreased from 239 to 167, with a non-significant relative increase in ICU admissions (PR: 1.14; 95% CI: 0.98–1.33, $p = 0.085$) during the peri-COVID-19 period. Length of ICU admission was similar for both periods; 3 days (IQR: 2–6.5) for the pre-COVID-19 period and 4 days (IQR: 2–7.5) for the peri-COVID-19 period.

Out-patient visits (Table 1) decreased by 25% from 2,790 pre-COVID-19 to 2,106 in the peri-COVID-19 period. Median age at presentation was significantly lower in the peri-COVID-19 period ($p < 0.05$). Median age was 4.4 years (IQR: 1.3–8.6) pre-COVID-19 and 4.1 years (IQR: 1.0–8.75) peri-COVID-19, with a significant increase in the infant age group (PR: 1.17, 95%CI: 1.05–1.30, $p < 0.05$). The proportions of diagnosis categories were similar between periods except for a significant decrease in the proportion of myocardial & pericardial disease seen as out-patients (PR: 0.61, 95% CI: 0.50–0.75, $p < 0.001$).

Cardiac surgeries decreased by 29% from 293 to 208 (Table 2, Figure 2), with significant changes in the proportion of urgent (PR: 5.99; 95% CI: 3.58–10.02, $p < 0.001$) and elective cases (PR: 0.73, 95% CI: 0.66–0.82, $p < 0.001$). Median age at surgery was significantly lower, 7.2 months (2.4–20.4) peri-COVID-19 versus 10.8 (4.8–49.2) months pre-COVID-19 ($p = 0.001$), related to a significant increase in neonatal procedures (PR: 2.43, 95% CI: 1.48–3.99, $p < 0.001$) and decrease in patients aged 5 to 12 (PR: 0.55, 95% CI: 0.34–0.88, $p < 0.05$). Procedure type was similar across periods with septal defects (pre-COVID-19:116/293, 40% vs. peri-COVID-19: 79/208, 38%), right heart lesions (pre-COVID-19: 44/293, 15% vs. peri-COVID-19: 33/208, 16%), thoracic arteries and veins (pre-COVID-19: 37/293, 13% vs. peri-COVID-19: 36/208, 17%), and left heart lesions (pre-COVID-19: 22/293, 8% vs. peri-COVID-19: 15/208, 7%) procedures predominating (Table 2). Sub-analysis of surgery for transposition of the great arteries (TGA) revealed similar rates between periods (pre-COVID-19: 19/293, 6% vs. peri-COVID-19: 22/208, 11%), however, median age at TGA surgery was significantly lower in the peri-C19 period, 15 (11.2–25.5) vs. 46 (11–65.5) days ($p = 0.047$).

TABLE 1 Admission and OPD presentation data.

Period	Admissions					OPD presentations				
	Pre-COVID-19		Peri-COVID-19		% Reduction, *p* value	Pre-COVID-19		Peri-COVID-19		% Reduction, *p* value
Total	624		378		39%, $p < 0.001$	2,790		2,106		25%, $p < 0.001$
Age	**Median**	**IQR**	**Median**	**IQR**	***p* value**	**Median**	**IQR**	**Median**	**IQR**	***p* value**
Age, years (median [IQR])	2.7	(0.8–6.8)	1.8	(0.5–6.2)	$p = 0.19$	4.4	(1.3–8.6)	4.1	(1–8.75)	$p < 0.05$
Age, categorical	**Count**	**(%)**	**Count**	**(%)**	**RR &95% CI, *p* value**	**Count**	**(%)**	**Count**	**(%)**	**RR &95% CI, *p* value**
Neonate (0,27d]	28	5	26	7	1.53 (0.91, 2.57), $p = 0.10$	4	0.1	4	0.2	1.32 (0.33, 5.29), $p = 0.97$
Infant [28d,12 m)	179	29	121	32	1.12 (0.92, 1.35), $p = 0.27$	578	21	510	24	1.17 (1.05, 1.30), $p < 0.05$
Toddler [1,2y)	77	12	49	13	1.05 (0.75, 1.47), $p = 0.77$	324	12	236	11	0.96 (0.82, 1.13), $p = 0.66$
Early childhood [2,5y)	132	21	67	18	0.84 (0.64, 1.09), $p = 0.19$	586	21	419	20	0.95 (0.85, 1.06), $p = 0.34$
Middle childhood [5,12y)	183	29	87	23	0.78 (0.63, 0.98), $p < 0.05$	970	35	694	33	0.95 (0.88, 1.03), $p = 0.19$
Early adolescence [12,19y)	25	4	28	7	1.85 (1.09, 3.12), $p < 0.05$	322	12	242	11	1.00 (0.85, 1.16), $p = 0.96$
Late adolescence [19,21y)	1	0	0	0	na	2	0.1	0	0	na
Diagnosis	**Count**	**(%)**	**Count**	**(%)**	**RR &95%CI, *p* value**	**Count**	**(%)**	**Count**	**(%)**	**RR &95%CI, *p* value**
Structural CHD	535	65	328	68	1.04 (0.96, 1.13), $p = 0.33$	2,359	67	1776	65	0.97 (0.93, 1.00), $p = 0.08$
Myocardial & pericardial disease	71	8.6	30	6.2	0.72 (0.48, 1.08), $p = 0.11$	276	7.8	131	4.8	0.61 (0.50, 0.75), $p < 0.001$
Acquired heart disease	35	4.2	20	4.1	0.97 (0.57, 1.66), $p = 0.91$	103	2.9	88	3.2	1.10 (0.83, 1.45), $p = 0.51$
Associated syndromes	21	2.5	10	2.1	0.81 (0.38, 1.70), $p = 0.57$	87	2.5	86	3.1	1.27 (0.95, 1.70), $p = 0.11$
Cardiac arrhythmias	16	1.9	4	0.8	0.42 (0.14, 1.26), $p = 0.11$	58	1.6	42	1.5	0.93 (0.63, 1.38), $p = 0.72$
Normal heart	11	1.3	7	1.4	1.08 (0.42, 2.77), $p = 0.87$	56	1.6	53	1.9	1.22 (0.84, 1.77), $p = 0.30$
Other	136	17	87	18	1.09 (0.85, 1.39), $p = 0.51$	591	17	570	21	1.24(1.12, 1.38), $p < 0.001$
Total diagnoses[a]	825		486			3,530		2,746		
Ward - Length of stay	**Median**	**IQR**	**Median**	**IQR**	**95% CI, *p* value**					
Ward length of stay (d)	3	(1-9)	6	(2-14)	$p < 0.001$	–		–		–
ICU	**Count**	**(%)**	**Count**	**(%)**	**95% CI, *p* value**					
ICU admissions	239	38	167	44	1.15 (0.99, 1.34), $p = 0.07$	–		–		–
ICU deaths	6	2.5	7	4.2	1.67 (0.57, 4.88), $p = 0.34$	–		–		–
ICU	**Median**	**IQR**	**Median**	**IQR**	**95% CI, *p* value**					
ICU length of stay (d)	3	(2–6.5)	4	(2–7.5)	$p = 0.34$	–		–		–

na = not applicable.[a]Multiple diagnoses permitted per patient, but only 1 of each diagnosis category. Associations highlighted in green are statistically significant.

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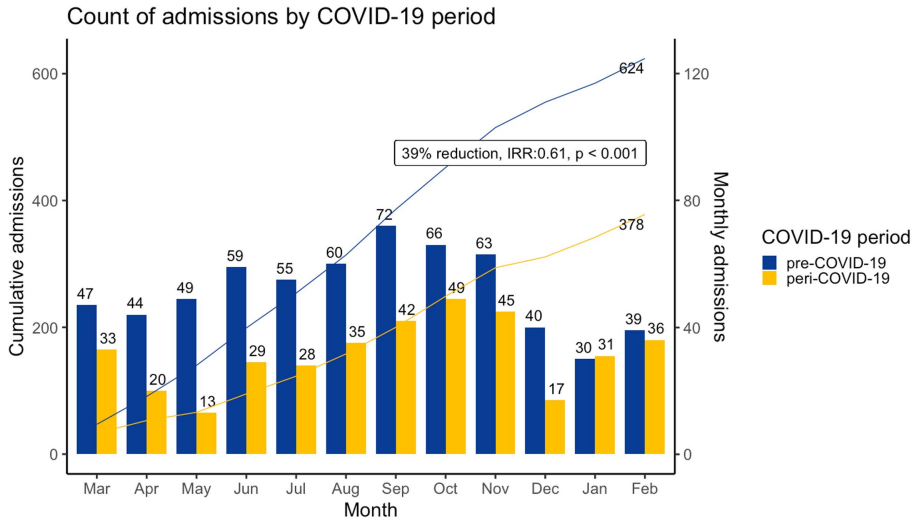

FIGURE 1
Count of cardiac admissions by COVID-19 period, cardiac admissions were significantly lower (IRR: 0.61, 95%CI: 0.48–0.62 $p<0.001$) in the peri-COVID-19 period.

Surgical risk scores, complication rates and mortality rates were available for the IQIC database and thus CHD procedures only (Table 3). RACHS-1 severity scores ranged from level 1–4 across both periods with no level 5 or 6 procedures performed. RACHS-1 levels 1–4 accounted for 13, 47, 34 and 6% of procedures in the pre-COVID-19 period and 15, 46, 32 and 8% of procedures in the peri-COVID-19 period, respectively. There was no significant change in RACHS-1 level proportions between periods. Delayed Sternal Closure (DSC) rates however were significantly higher in the peri-COVID-19 period (PR: 2.55, 95%CI: 1.13–5.74, $p=0.020$). Stratification by neonatal status indicated that this association was not a result of confounding due to the increased incidence of neonatal procedures in this period (non-neonatal DSC PR: 3.20, 95%CI: 1.09–9.33, $p<0.05$ vs. neonatal DSC PR: 1.10 95%CI: 0.34–3.59, $p=1.000$).

The combined surgical complication rate was significantly higher in the peri-COVID-19 period, with 62% of procedures having complications compared with 51% in the pre-COVID-19 period (PR: 1.21, 95%CI: 1.01–1.43, $p<0.05$). For complication categories multiple complications were possible per procedure; bacterial sepsis rates were high for both periods, 46% (116/252) in the pre-COVID-19 period and 56% (86/154) in the peri-COVID-19 period, however rates were similar between periods (PR: 1.21, 95%CI: 1.00–1.47, $p=0.055$). Similarly, surgical site infection rates were similar between periods 8% (19/252) pre-COVID-19 and 5% (8/154) peri-COVID-19 (PR: 0.69, 95% CI: 0.31–1.54, $p=0.358$), as where Cardiopulmonary bypass events, 0.4% (1/252) pre-COVID-19 and 0.6% (1/154) peri-COVID-19 (PR: 1.64, 95% CI: 0.10–25.97, $p=1.0$). There was, however, a significant increase in "other complications" a heterogenous group of complications not related to bacterial sepsis, surgical site infection or cardiopulmonary bypass events. The other complication rate increased from 22% (56/252) in the pre-COVID-19 period to 33% (51/154) in the peri-COVID-19 period (PR: 1.49 95%CI: 1.08–2.06, $p<0.05$).

There was no significant difference in in-hospital mortality, PR 0.38 (95% CI: 0.11–1.30, $p=0.107$) or 30-day mortality, PR 2.18 (95% CI: 0.50–9.61, $p=0.506$), however, loss-to-follow up rates at 6-weeks post-surgery were significantly higher in the peri-COVID-19 period than in the pre-COVID-19 period (PR: 2.95, 95%CI: 1.01–8.63, $p=0.039$).

Unfortunately, the catheterisation laboratory was closed for renovations for 3 months in the pre-COVID-19 period and 5 months in the peri-COVID-19 period, as such, the following results are likely exaggerated. Cardiac catheterisations decreased by 42% (175 to 102) with no significant change in median age (3.3 years, IQR:0.9–7.6 pre-COVID-19 vs. 4.4 years, IQR:1.2–9 peri-COVID-19, $p=0.17$), age category, or distribution of diagnoses. Similarly, there was no significant difference in the proportion of interventional procedures with 90 (51%) interventional cardiac catheterisations performed in the pre-COVID-19 period vs. 55 (54%) in peri-COVID-19 period (PR: 0.95, 95%CI: 0.76–1.20, $p=0.689$). The complication rate was also similar between periods (12%, 21/175, pre-COVID-19 and 16%, 16/102, peri-COVID-19, PR: 1.31, 95%CI: 07.2–2.39, $p=0.384$).

4. Discussion

Absolute clinic presentation, ward admission, and surgical and cardiac catheterisation procedure rates were all significantly reduced in the peri-COVID-19 period, when compared with the pre-COVID-19 period.

The 29% reduction (IRR 0.71, $p<0.001$) in cardiac surgery is especially concerning when one considers that the South African pediatric cardiology and cardiothoracic surgery service are in general insufficient to meet the needs of the population. A 2006 audit of South African pediatric cardiac services demonstrated an overall pediatric cardiologist to population ratio of 1:4.5million people, well below the suggested ideal ratio of 1:500,000 (16), and that cardiothoracic surgical capacity was insufficient, able to meet the needs of <40% of children with CHD (8). Accordingly the

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TABLE 2 Surgical data.

Period	Pre-COVID-19		Peri-COVID-19		% Change
Surgeries (total)	293		208		29%, IRR 0.71, $p < 0.001$
Age	**Median**	**IQR**	**Median**	**IQR**	**RR & 95%CI, *p* value**
Age, months (median [IQR])	10.8	(4.8–49.2)	7.2	(2.04–20.4)	$p = 0.001$
Age, categorical	**Count**	**(%)**	**Count**	**(%)**	**RR & 95%CI, *p* value**
Neonate (0,27d]	22	7	38	18	2.43 (1.48, 3.99), $p < 0.001$
Infant [28d, 12 m)	138	47	94	45	0.96 (0.79, 1.16), $p = 0.673$
Toddler [1, 2)	25	8	28	13	1.58 (0.95, 2.63), $p = 0.077$
Early childhood [2, 5)	45	15	22	10	0.69 (0.43, 1.11), $p = 0.121$
Middle childhood [5, 12)	54	18	21	10	0.55 (0.34, 0.88), $p = 0.010$
Early adolescence [12, 19)	9	3	5	2	0.78 (0.27, 2.30), $p = 0.655$
Procedure Kingdom	**Count**	**(%)**	**Count**	**(%)**	
Septal defects	116	40	79	38	0.96 (0.77, 1.20), $p = 0.716$
Right heart lesions	44	15	33	16	1.06 (0.70, 1.60), $p = 0.795$
Thoracic arteries and veins	37	13	36	17	1.37 (0.90, 2.09), $p = 0.143$
Left heart lesions	22	8	15	7	0.96 (0.51, 1.81), $p = 0.900$
Transposition of the great arteries	19	6	22	11	1.63 (0.91, 2.94), $p = 0.100$
Palliative procedures	20	7	8	4	0.56 (0.25, 1.25), $p = 0.100$
Pacemaker procedures	15	5	5	2	0.47 (0.17, 1.27), $p = 0.126$
Pulmonary venous anomalies	10	3	5	2	0.70 (0.24, 2.03), $p = 0.514$
Single ventricle	5	2	2	1	0.56 (0.11, 2.88), $p = 0.754$
Miscellaneous procedures	3	1	1	0	0.47 (0.05, 4.48), $p = 0.870$
Conduit operations	1	0	1	0	1.41 (0.09, 22.39), $p = 1.000$
Cor Triatriatum	0	0	1	0	na
DORV	1	0	0	0	na
Urgency	**Count**	**(%)**	**Count**	**(%)**	**RR & 95%CI, *p* value**
Elective	258	88	134	64	0.73 (0.66, 0.82), $p < 0.001$
Emergent	8	3	6	3	1.06 (0.37, 3.00), $p = 0.918$
Urgent	16	5	68	33	5.99 (3.58, 10.02), $p < 0.001$
Transposition of the great arteries	**Count**	**(%)**	**Count**	**(%)**	**RR & 95%CI, *p* value**
Number of operations	19	6	22	11	1.63 (0.91, 2.94), $p = 0.100$
	Median	**IQR**	**Median**	**IQR**	***p* value**
Age at surgery, days	46	(11–62.5)	15	(11.2–25.5)	$p = 0.047$

na = not applicable. Associations highlighted in green are statistically significant.

COVID-19-related backlog cannot be cleared by returning to pre-COVID-19 capacity, additional capacity must be leveraged and evidence based strategies implemented to minimize complications and deaths in patients awaiting treatment.

For example, a recent United Kingdom study (19) of COVID-19 related backlog in adult-onset severe aortic stenosis patients showed that COVID-19 related restrictions had resulted in a significant backlog of patients. In this case service capacity was based on the pre-COVID-19 aortic stenosis incidence rate, thus it would not be possible to clear this backlog by returning to pre-COVID-19 capacity, instead extra capacity would need to be introduced. Mathematical modelling showed that a 20% increase in capacity would require 535 (434–666) days to clear the backlog with an associated mortality of 1,172 (466–1859) during this period. The model showed that if this capacity increase was supplemented by converting 40% of surgical cases to transcatheter aortic valve implantation, the backlog could be cleared within a year or 343 (281–410) days with fewer (784 [292–1,324]) deaths whilst awaiting treatment. This data-driven approach enabled researchers to optimize increases in capacity and minimize patient morbidity and mortality.

The 325% increase in urgent cases during the peri-COVID-19 period, 68 (33%) versus 16 (5%) in the pre-COVID-19 period, (PR: 5.99, 95%CI: 3.58–10.02, $p < 0.001$) indicates under-capacity of the Western Cape pediatric cardiology and cardiothoracic surgery service. By curtailing elective but necessary procedures, COVID-19 restrictions artificially lowered demand for cardiothoracic services, increasing the capacity of the system to deal with urgent cases. Thus, the higher absolute number of urgent cases treated in the

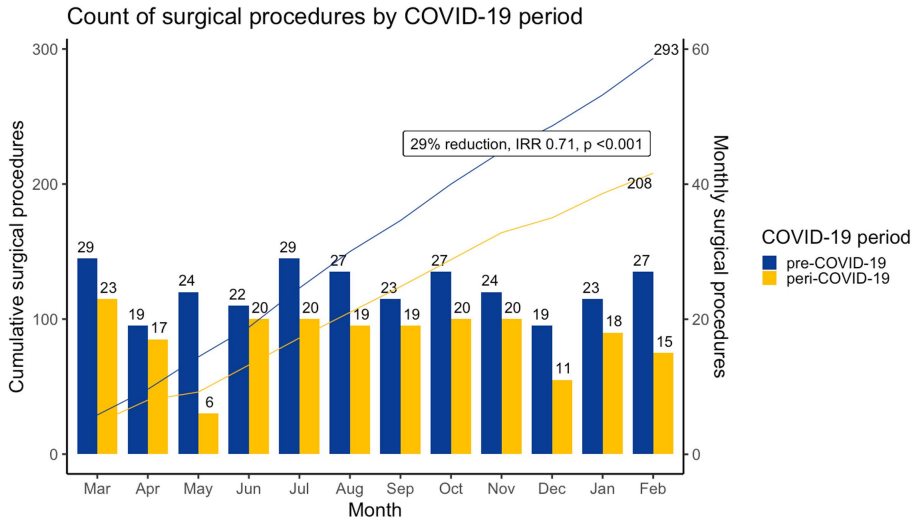

FIGURE 2
Count of cardiac surgeries by COVID-19 period, cardiac surgeries were significantly lower (IRR: 0.71, 95%CI: 0.53–0.89, p<0.001) in the peri-COVID-19 period.

peri-COVID-19 period better represents the true requirements of the Western Cape population. In fact, one could argue that the unique circumstances of the COVID-19 pandemic enabled the cardiac service to better treat patients at the point of physiological need, albeit at the expense of patients requiring elective procedures. This premise is corroborated by the sub-analysis of TGA-surgery. As expected, the absolute number of TGA-surgeries was similar between periods, however median age at surgery was significantly lower in the peri-COVID-19 period, 15 (11.2–25.5) days versus 46 (11–62.5) days ($p < 0.05$). In TGA early intervention is associated with improved outcomes (22) and many clinicians recommend that surgery be performed within 2–4 days of delivery (23). Unburdened by elective procedures the Western Cape paediatric cardiac service was able to intervene more timeously and significantly closer to the point of physiological need.

These data support previous studies which indicate the Western Cape cardiac service is running below capacity and as such the 29% reduction in surgical cases over the peri-COVID-19 period cannot be resolved by returning to pre-COVID-19 capacity. These data highlight the need for a detailed analysis of the composition of the Western Cape surgical backlog, surgical waiting times, and backlog morbidity and mortality rates. Additionally, they emphasize the need for the development of a fully informed and mathematically modelled strategy to increase capacity and reduce backlog whilst ensuring minimal rates of morbidity and mortality.

Direct measures of surgical complexity showed no significant change between periods, with no significant change in the proportion of procedure-type or RACHS-1 risk categories performed between periods. RACHS-1 risk categories 2 and 3 account for 81 and 78% of all procedures for the pre-COVID-19 and peri-COVID-19 periods, respectively. The predominance of risk category 2 and 3 procedures may mask subtle changes in surgical complexity between periods. Additionally, some indirect measures of surgical complexity showed significant differences.

Median age at surgery was significantly lower, 7.2 months (2.04–20.4) peri-COVID-19 versus 10.8 months (4.8–49.2) pre-COVID-19 ($p = 0.001$), related to a significant increase in neonatal procedures (PR: 2.48, 95% CI: 1.48–3.99, $p < 0.001$) and a decrease in patients aged 5 to 12 (PR: 0.57, 95% CI: 0.34–0.88, $p < 0.05$). Neonatal cardiac surgery is technically challenging and lesions requiring neonatal intervention are typically more severe (24). Despite this, internationally there is an increase in the number of neonatal procedures (25) Similarly, over the three year period prior to the COVID-19 pandemic, there was a non-significant increase in neonatal procedures in the Western Cape pediatric cardiothoracic service (PR: 1.17, 95% CI: 0.70–1.96, $p = 0.5$) (26). A major limitation of uncontrolled pre-post studies is that the exposure-group is not compared with a contemporaneous control-group, as such associations may be confounded by non-contemporaneous control bias. It is possible that this general increase in neonatal procedures is confounding this association, however, we believe that this trend alone could not be responsible for the more than two-fold increase in the proportion of neonatal procedures over the period. Instead, we believe this is another indicator of the prioritization of urgent neonatal cases in a system typically operating below capacity to meet the needs of the population. During the peri-COVID-19 period artificially lowered numbers of elective procedures increased capacity for urgent neonatal procedures on patients that otherwise may have died or would have been operated on in infancy but at higher risk.

Delayed sternal closure (DSC) may be indicated after pediatric cardiac surgery, typically in the setting of severely impaired cardiac function, is often used after neonatal cardiac procedures (27) and is a good indicator of surgical complexity. Indications and applications of the technique vary from center to center (27) in the Western Cape pediatric cardiothoracic service the decision to delay sternal closure is handled on a case by case basis, however neonates accounted for 42% of all cases of DSC reported over the study period. The proportion of cases requiring DSC in the peri-COVID-19 period was more than double that reported

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TABLE 3 Congenital heart disease surgery – complexity and outcomes.

Period	Pre-COVID-19		Peri-COVID-19		% Change
CHD surgeries (total)	252		154		39%, IRR 0.61, $p < 0.001$
Complexity (CHD only)	**Count**	**(%)**	**Count**	**(%)**	**RR & 95%CI, *p* value**
RACHS-1 – Level 1	32	13	22	15	1.10 (0.66, 1.82), $p = 0.716$
RACHS-1 – Level 2	116	47	69	46	0.95 (0.76, 1.18), $p = 0.647$
RACHS-1 – Level 3	84	34	48	32	0.91 (0.68, 1.22), $p = 0.538$
RACHS-1 – Level 4	14	6	12	8	1.37 (0.65, 2.88), $p = 0.407$
Delayed sternal closure (DSC)	9	4	14	9	2.55 (1.13, 5.74), $p = 0.020$
Neonatal DSC	4/22	18	5/25	20	1.10 (0.34, 3.59), $p = 1.000$
Non-neonatal DSC	5/229	2.2	9/129	7.0	3.20 (1.09, 9.33), $p = 0.025$
Complications	**Count**	**(%)**	**Count**	**(%)**	**95% CI, *p* value**
Suspected bacterial sepsis	116	46	86	56	1.21 (1.00, 1.47), $p = 0.055$
Confirmed bacterial sepsis[b]	35	14	17	11	0.79 (0.46, 1.37), $p = 0.404$
Surgical site infection	19	8	8	5	0.69 (0.31, 1.54), $p = 0.358$
Cardiopulmonary bypass event	1	0.4	1	0.6	1.64 (0.10, 25.97), $p = 1.000$
Other	56	22	51	33	1.49 (1.08, 2.06), $p = 0.016$
Combined[a]	129	51	95	62	1.21 (1.01, 1.43), $p = 0.039$
Mortality	**Count**	**(%)**	**Count**	**(%)**	**95% CI, *p* value**
In hospital death	13	5	3	2	0.38 (0.11, 1.30), $p = 0.107$
RACHS-1 – Level 1	1/31	3.1	0/24	0.0	na
RACHS-1 – Level 2	7/110	6.0	1/68	1.4	0.24 (0.03, 1.93), $p = 0.272$
RACHS-1 – Level 3	3/81	3.6	1/47	2.1	0.58 (0.06, 5.45), $p = 1.0$
RACHS-1 – Level 4	2/12	14.3	1/11	8.3	0.58 (0.06, 5.66), $p = 1.0$
30-day mortality	15	6	7	5	2.18 (0.49, 9.62), $p = 0.507$
RACHS-1 – Level 1	1/31	3.1	0/23	0.0	na
RACHS-1 – Level 2	8/108	6.9	2/67	2.9	0.42 (0.09, 1.92), $p = 0.408$
RACHS-1 – Level 3	3/81	3.6	4/41	8.9	2.49 (0.58, 10.64), $p = 0.388$
RACHS-1 – Level 4	3/11	21.4	1/11	8.3	0.39 (0.05, 3.27), $p = 0.706$
Loss to follow up	5	2	9	6	2.95 (1.01, 8.63), $p = 0.039$

[a]Multiple complication categories permitted per procedure, but only 1 combined complication per procedure.
[b]Confirmed bacteremia on sterile blood culture.
na = not applicable. Associations highlighted in green are statistically significant.

in the pre-COVID-19 period (PR: 2.55, 95%CI: 1.13–5.74, $p = 0.020$), indicating an increased proportion of severe cases in this period. In addition, when controlled for neonatal status through stratification the strength of this association increased (PR: 3.20, 95%CI: 1.09–9.33, $p < 0.05$) indicating that this finding was not a result of the increased proportion of neonatal procedures in the peri-COVID-19 period and is a result of the increased proportion of urgent and complicated cases.

There was no significant change in the number or length of ICU admissions, however, total length of stay (combined ward and ICU) was significantly longer in the peri-COVID-19 period, 6 (IQR: 2–14) days versus 3 (IQR: 1–9) days in the pre-COVID-19 period ($p < 0.001$). Complication rates were higher in the peri-COVID-19 period (PR: 1.21, 95%CI: 1.01–1.43, $p < 0.05$). Bacterial sepsis rates were high for both periods with a non-significant increase in the peri-COVID-19 period. The definition of bacterial sepsis, however, was broad and based on the IQIC definition of: "presumed or confirmed bacterial sepsis with fever or hypothermia, tachycardia, hypotension, tachypnoea, leukocytosis or leukopenia." Positive blood cultures were not a requirement and bacterial sepsis, secondary to other infections such as pneumonia, catheter associated bloodstream infections, or surgical site infections were also included. Culture-confirmed bacterial sepsis rates were lower overall with a non-significant decrease in the peri-COVID-19 period. Surgical site infection rates and cardio-pulmonary bypass event rates were similar between periods. There was, however, a significant increase in complications not related to bacterial sepsis, surgical site infection or cardiopulmonary bypass events (PR: 1.49 95%CI: 1.08–2.06, $p < 0.05$) in the peri-COVID-19 period, this association was not directly related to an increase in viral illness or COVID-19 cases during the peri-COVID-19 period, however, may have been a result of pandemic related stressors or increased complexity of cases in this period.

Interestingly, despite the increase in the complexity and the proportion of urgent cases, both in-hospital and 30-day mortality

rates remained stable across periods and compare favorably with international benchmarks (20). It is possible that systemic changes in peri-operative care implemented during the peri-COVID-19 period were protective. For example, non-essential procedures and visits were cancelled and personnel who worked in these areas redeployed to critical areas (7). This combined with reduced-surgical caseloads likely resulted in an improved ratio of health care practitioners to patients in critical care areas. Additionally, stricter bedside hygiene practices including the use of personal protective equipment, rigorous hand washing protocols and isolation precautions were likely protective. Moreover, paediatric admissions accounted for only 2.9% of all South African COVID-19 admissions (28) thus these changes may have been in excess of actual requirements. Also, it is possible that these findings indicate the benefits of earlier surgical intervention.

COVID-19 restrictions have had negative impacts on both undergraduate and post-graduate medical training. Effects on post-graduate training were primarily related to reduced caseload and exposure, diversion of staff to COVID-19 related activities, cancelled academic conferences and professional fora, and suspension of international training (29). For example, anesthetic trainees across 6 continents, reported that reduced caseload, sub-specialty experience, and supervised procedures impaired learning (30). Additionally, in the United States, reduced patient volumes resulted in reduced procedural learning opportunities, leading some residency programs to waive minimum procedure requirements for graduating residents (29). The 30% reduction in surgical procedures and 40% reduction in cardiology admissions during the peri-COVID-19 period clearly indicate reduced caseloads for Western Cape pediatric cardiology and cardiothoracic surgery residents. Additionally, despite RACHS-1 scores being similar for both periods, the higher proportion of urgent cases, neonatal procedures, and increased admission-duration in the peri-COVID-19 period indicates an increase in severe or complicated cases. These cases would likely necessitate increased senior responsibility, further impacting cardiothoracic surgery training. Accordingly, the higher proportion of complex and technically challenging cases together with the significant reduction in caseload may have implications on cardiothoracic surgical training and both qualitative and quantitative studies of cardiothoracic surgical training during the peri-COVID-19 period should be considered.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Data are available upon reasonable request from TA. Requests to access these datasets should be directed to thomas.aldersley@uct.ac.za.

Ethics statement

The studies involving human participants were reviewed and approved by Human Research Ethics Committee, University of Cape Town. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

LZ, JL, and TA: conceptualization. LZ, JL, AB, and LS: supervision. TA, PH, and SS: data curation. TA: formal analysis and writing – original draft. TA, AB, PH, JL, GC, RD, BF, RM, HP, SS, LS, and LZ: writing – critical review and editing. LZ: funding acquisition. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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From research to a political commitment to strengthen access to surgical, obstetric, and anesthesia care in Africa by 2030

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Objective: This study aimed to engage African leaders and key stakeholders to commit themselves toward the strengthening of surgical, obstetric, and anesthesia care systems by 2030 in Africa.

Methods: From research to a political commitment, a baseline assessment was performed to foster the identification of the gaps in surgical care as a first step of an inclusive process. The preliminary findings were discussed during the International Symposium on Surgical, Obstetric, and Anesthesia Systems Strengthening by 2030 in Africa. The conclusions served to draft the Dakar Declaration and its Regional Action Plan 2022–2030 to improve access to surgical care by 2030 in Africa, endorsed by Heads of State.

Results: The International Symposium was composed of two meetings that gathered (i) 85 scientific experts and (ii) 28 ministers of health or representatives from 28 sub-Saharan African countries. The 28 African countries represent (i) 51% of the continent's total population, (ii) 68% of the 47 African countries of the WHO Africa Region, (iii) 58% of all African Union countries, and (vi) 79% (3,371) of the WHO Africa Region's total (4,271) health districts. The International Symposium and the Heads of State Summit successfully produced the Dakar Declaration on access to equitable, affordable, and quality Surgical, Obstetric, and Anesthesia Care by 2030 in Africa and its Regional Actions Plan 2022–2030 which prioritizes 12 urgent actions needed to be implemented, six strategic priorities, 16 key indicators, and an annual dashboard to monitor progress.

Conclusion: The Dakar Declaration and its Regional Action Plan 2022–2030 are a commitment to establish quality and sustainable surgical, obstetric, and anesthesia care in each African country within the ambitious framework of "*The Africa we want*" Agenda 2063.

KEYWORDS

Africa surgical initiative, safe surgery, safe anesthesia, Dakar Declaration, Regional Action Plan

Background

Over the past three decades, the African continent has made steady progress in improving public health, despite disparities between regions, countries, and within countries. Africa's exponential economic growth and development, and the additional significant contribution of global health initiatives, have facilitated this progress.

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Some of the advancements in health include a 37% decline in mortality rates between 2000 and 2015 (1). Life expectancy has also grown by nearly 10 (46–56) years from 2009 to 2019 (2). However, Africa's overall performance still lags in other health indicators. These fragile gains, however, have not been matched with similar progress in health system strengthening, service integration, or hospital care, nor have they been equitably distributed among individuals of all socio-economic levels (3), mainly in the area of surgical, obstetric, and anesthesia (SOA) care.

TABLE 1 Baseline assessment in 601 district hospitals.

Serial no.	Countries	No. of health districts	20% of district hospitals assessed
1.	Benin	77	16
2.	Burkina Faso	70	14
3.	Burundi	47	9
4.	Botswana	24	3
5.	Cameroun	190	38
6.	CAR	35	7
7.	Congo	52	10
8.	Comoros	17	3
9.	Côte d'Ivoire	113	22
10.	DR Congo	480	32*
11.	Eritrea	58	12
12.	Eswatini	4	1
13.	Ethiopia	123	25
14.	Gambia	7	1
15.	Ghana	260	50
16.	Guinea	38	8
17.	Guinea-Bissau	11	3
18.	Liberia	15	5
19.	Madagascar	114	19*
20.	Malawi	28	6
21.	Mali	75	15
22.	Mauritania	57	7
23.	Niger	72	14
24.	Nigeria	774	157
25.	Rwanda	30	7
26.	Senegal	79	15
27.	Sierra Leone	16	3
28.	South Sudan	80	16
29.	Chad	129	26
30.	Togo	44	9
31.	Uganda	136	26
32.	Zambia	116	22
Total		**3,371**	**601**

*In these countries, the number of district hospitals surveyed did not reach 20%.

Despite the efforts made by some Africa Union Member States with tangible achievements, the continent does not yet appear to be on track to achieve Sustainable Development Goal 3: "Health for all and promotion of wellbeing for all at all ages."

Africa alone bears 25% of the global burden of disease and one-third of the world's clinical conditions requiring emergency care and essential surgical, obstetric, and anesthetic services (EESOACSs). Despite having 17% of the world's population, the continent has only 2% of the world's doctors and 0.7 surgical specialists per 100,000 people (4).

Every year, 16.9 million people worldwide die due to lack of access to surgical care, and 93% of sub-Saharan Africa still lacks access (5). Surgery has been a neglected component of health care for people on the African continent. Equitable integration of surgical and anesthetic care remains one of the key challenges to strengthening health systems and achieving universal health coverage in Africa.

Over the years, the focus was mainly on infectious diseases, resulting in a significant reduction in morbidity and mortality from these conditions in some African countries (6).

On the occasion of the celebration of 30 years of Mercy Ships in Africa (1990/91–2021/22), Mercy Ships seized this opportunity to consolidate and strengthen its partnership with African countries and all national and international partners involved in strengthening surgical care and to mobilize policymakers and leaders to work together to integrate and scale up surgical care in national health development strategies.

Evidence has shown that investing in and strengthening surgical care within the existing healthcare system would lead to the overall strengthening and improvement of the entire healthcare system (7, 8).

As additional efforts were needed to strengthen the provision of safe, timely, and affordable emergency and essential surgical care and anesthesia, the World Health Assembly resolution 68.15 was made (9). Mercy Ships and the government of the Republic of Senegal launched a process to engage key stakeholders to commit themselves toward strengthening surgical, obstetric, and anesthesia care systems by 2030 in Africa.

Methods

From research to political commitment, the WHO baseline assessment, which uses two simplified tools (*country general information and district-hospital survey*), is the first step in an inclusive process. Data were collected and analyzed using the Survey Monkey® platform. This was followed by a strategic analysis and guidance involving African experts and Ministers of Health gathered in an International Symposium. Six Heads of state then endorsed the Dakar Declaration and its Regional Action Plan to improve access to surgical care in Africa by 2030.

(i) The baseline assessment aimed to foster the identification of the gaps in surgical care. The assessment was conducted in 6 months (January–July 2022) in 601 district hospitals (Table 1) in 32 sub-Saharan African countries (Figure 1) and performed by more than 600 national investigators and coordinators from the

FIGURE 1
Thirty-two sub-Saharan African countries involved in the baseline assessment.

FIGURE 2
Dakar Declaration: steps from research to political commitment.

TABLE 2 Nine key commitments of the Dakar Declaration.

	Dakar Declaration commitments
1	**WE CALL UPON** all Nations of the Africa Region, key national and international partners, and stakeholders in surgical safety to commit the implementation of the 12 urgent actions needed as per the annex 1 of this declaration.
2	**WE COMMIT** to involve Governments, Legislatures, Ministries of Health, Ministries of Finance, and supported by key stakeholders including educators, trainers, and mentors of surgical, obstetric and anesthesia workforce, professional health associations and societies, academic institutions, local and international partners, health professions regulating bodies, civil society, and patient advocacy groups.
3	**WE COMMIT OURSELVES** for the scaling up and investment in the Strengthening of Surgical, Obstetric and Anesthesia Care in Africa toward the implementation of the Regional Action Plan 2022–2030.
4	**WE RECOGNIZE** that surgery has been a neglected component of national health systems and that Nations share common challenges including infrastructure, human resources, financing, and strategic vision.
5	**WE COMMIT OURSELVES** toward meeting the target of the Abuja Declaration in allocating 15% of a national budget to health.
6	**WE COMMIT OURSELVES** to advocate for the creation of a regional fund (similar to the Global Fund for AIDS, Malaria and Tuberculosis) to boost resource mobilization to strengthen access to Surgical, Obstetric and Anesthesia Care.
7	**WE COMMIT** to implement the 2022–2030 roadmap with its strategic priorities, key indicators and dashboard as per the annex 2 of this declaration.
8	**WE ENDORSE** the conclusions of the 28 African Ministers of Health of the WHO Africa Region meeting in Dakar, Republic of Senegal, on May 6th, 2022 and the setting-up of an African Scientific Working Group to oversight the implementation of the Regional Action Plan.
9	**WE RESOLVE** to gather every 2 years between now and 2030 to assess progress, to exchange ideas and innovations, and to share experience between and among countries.

TABLE 3 Twelve (12) urgent actions needed to be implemented by 2030.

N°	Twelve urgent actions needed
1	Urgently expand core and support services workforce needed to provide safe surgical care and expand pre- and post-service trainings and professional development programs;
2	Urgently increase health infrastructure and equipment that enhances access to good quality and safe surgical care for our population especially the most vulnerable and deprived communities;
3	Improve the financial investment into expanded surgical services and that improves access and reduces financial barriers, and removes risk of financial impoverishment for vulnerable groups including children, women and the disabled;
4	Establish structures to improve governance, leadership, and management of surgical, obstetric, anesthetic, and related services as part of Universal Health Coverage;
5	Engage with communities to prevent the causes of morbidity and mortality related to surgical and related conditions and the promotion in our populations of healthy lifestyles;
6	Streamline actions to relieve our populations of the high disease burden posed by surgical, obstetric, and anesthetic deficiency;
7	Mobilize resources from domestic and external sources to expand necessary investments into surgical services and achieve financial risk protection from accessing surgical, obstetric and anesthesia services;
8	Build workforce capacity through training programs and mentoring, to increase essential surgical procedures and interventions in each country by 2030;
9	Improve health information systems to facilitate the use of surgical data for innovation and improvement of surgical services;
10	Create and expand regional, national, and international partnerships for both technical and resource mobilization;
11	Incorporate gender equity into National Surgical, Obstetric, Anesthesia Plans with clear indicators;
12	Integrate essential surgical, obstetric and anesthesia interventions, indicators, and budgets into national health sector policies, strategies, and plans.

Ministry of Health at the national level and investigators at the district-hospital level. As in similar studies or surveys, refereeing the AFRO guidelines, the sample size was set at 20% of the total number of health districts for each selected country (10). The health districts were selected from all the regions of the country to ensure representative geographical coverage with a convenient sample of 20% of district hospitals in each country. In three countries (D R Congo, Madagascar, and Botswana), the district hospitals surveyed did not reach 20% because of security issues and flooding as well as incomplete data.

Data were collected in the following areas: infrastructure, human resources, service delivery, information management, finance, impact of COVID-19 on surgery, governance, and leadership and children's surgery and uploaded into the survey monkey platform. The survey was pretested in two countries before final deployment. (ii) The International Symposium (IS)

TABLE 4 Regional action plan strategic priorities, key indicators, and annual dashboard.

N°	Strategic priorities (6)	Key indicators (16)	Annual dashboard
1	Governance and leadership	1.1 National Health Strategy, National Surgical, Obstetrics and Anesthesia Plan; 1.2 100% of countries should have launched NSOAP and commenced implementation; 1.3 Annual National Surgical meeting for countries to report and track progress; 1.4 Setting up of Africa Scientific Task Force for capacity building, support to implementation and monitoring and evaluation of progress.	National Surgical, Obstetric and Anesthesia Plan, Annual National Surgical Meeting
2	Human ressources	At least 50% should have surgical/obstetric and anesthesia provider 24/7.	24/7 availability of surgical, obstetric and anesthesia provider
3	Infrastructure	3.1 100% should have functional operating rooms; 3.2 100% of should have oxygen available 24/7; 3.3 100% availability of pulse oximetry in operating rooms.	(i) Functional operating rooms, permanent access to oxygen, pulse oximetry availability
4	Service delivery	4.1 At least 50% 2-h access to facility with surgical care; 4.2 100% 2 h access to safe blood supply; 4.3 100% use of safe surgery checklist; 4.4 At least 50% of hospitals should have IPC programmes: 4.5 100% tracking of perioperative mortality.	Access to care, blood delivery, use of the WHO surgical safety checklist, peri-operative mortality rate, infection control and prevention programme
5	Health information and research	5.1 100% should have reliable and durable health record system; 5.2 50% should have electronic health record system	Emergency and essential surgical care, pediatric surgeons,
6	Finance	6.1 50% financial risk protection for surgical care; 6.2 Funding provided for research in 100% of hospitals.	Financial risk protection

was organized by the Government of Senegal and Mercy Ships in close collaboration with the WHO Regional Office for Africa and in partnership with various international and regional organizations and African key actors of the health sector at all levels. The IS gathered participants from 28 African countries, namely, Benin, Burundi, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Comoros, Côte d'Ivoire, Ethiopia, Eswatini, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Malawi, Mauritania, Niger, Nigeria, Senegal, Seychelles, Sierra Leone, South Sudan, Uganda, and Togo (Figure 1), and Somaliland as an observer and was held in two phases: (a) The Experts Meeting identified and agreed on the key findings of the baseline assessment, formulated priority recommendations, proposed a roadmap 2022–2030 for scaling up and investing in the strengthening of surgical, obstetric, anesthesia, and nursing care in Africa, and developed a draft Declaration of commitment that was submitted to the Ministers of Health meeting. (b) The African Ministers of Health discussed and adopted a Declaration of commitment to access to equitable, affordable, and quality surgical, obstetric, and anesthesia care in Africa, as well as a draft Regional Action Plan 2022–2030, a roadmap for the scale-up and investment in the strengthening of surgical, obstetric, anesthesia, and nursing care in Africa by 2030, including a monitoring and evaluation plan. (iii) On 30 May 2022 in Dakar, Senegal, the Heads of State Summit of six countries (Cameroon, Congo, Comoros, Gambia, Guinea-Bissau, and Senegal) endorsed the Dakar Declaration on Access to Equitable, Affordable, and Quality Surgical, Obstetric, and Anesthesia Care in Africa by 2030, commonly referred to as "The Dakar Declaration," and its Regional Action Plan 2022–2030 (Figure 2). President of Senegal, Macky Sall, and current Chairperson of the African Union will submit the Dakar Declaration to the African Union Heads of States ordinary summit in February 2023.

Results

The preliminary findings of the baseline assessment show that the surgical care and national health systems in the majority of the countries assessed are disorganized, weak, and fragile. Few countries have created "National Surgical, Obstetric, Anesthesia and Nursing Plans (NSOAPs)" to guide and strengthen surgical care, and most of Africa remains underserved in terms of surgical care. The baseline assessment identified the ongoing challenges to universal health coverage from deficiencies in surgical, obstetric, anesthetic, and related care due to (1) workforce deficits in the core human resources needed for surgical services, (2) significant infrastructure and equipment deficits and disparity within countries, (3) lack of service delivery due to weaknesses in the core and support services required to deliver safe, surgical care, (4) challenges of financing surgical, obstetric, and anesthesia services as part of national health strategies, (5) lack of regulation and governance structures for surgical care at all levels, (6) information, (7) inadequate health promotion and prevention efforts on the causes of morbidity and mortality from surgical and related conditions, and (8) lack of leadership and management of surgical, obstetric, and anesthesia care. The Dakar Declaration contains nine key commitments (Table 2). The Regional Action Plan 2022–2030, the result of the political commitment, is an 8-year workplan for all African countries to upgrade their surgical care system by 2030. The Regional Action Plan prioritizes 12 urgent actions (Table 3), six strategic priorities, 16 key indicators, and an annual dashboard to monitor progress (Table 4).

Discussion

The current focus on health systems and service delivery is not aligned with an effective policy response in Africa (7, 11). Many priorities are still partner-driven, with limited policy or institutional buy-in. The verticalization of the efforts predominates, both for health services and health system strengthening initiatives, with limited linkages within and across the different areas. The main consequence being a fragmented service delivery without guarantee of the availability of essential services.

There is also a weak emphasis on an integrated approach to the system-strengthening efforts, which leads to duplications and, in some cases, underinvestment in critical elements needed for effective service provision.

In this context, effective leadership has paramount importance to manage new change initiatives and implement national reforms within the health sectors. Leaders have a key role to facilitate mechanisms for making policies, managing the sector, and producing as well as accounting for results from health interventions in the six building blocks of the health systems as defined by the WHO. In those conditions, the health governance area represents a scope of actions across all domains providing policies, standards, regulations, and guidance to control the use of resources and the functioning of health systems (12).

Taking forward the implementation of multiple commitments made at regional and international levels is challenging in Africa, as countries are complex and exhibit wide variations in their system focus, design, and performance. For example, the Abuja Declaration made in 2001 which aims to dedicate 15% of the national budget to the health sector is implemented only by a few African countries (13, 14). The main consequence being a fragmented service delivery without a guarantee of the availability of essential services. Therefore, the Abuja Declaration is still necessary for the successful implementation of the Dakar Declaration to upgrade and scale up all needed interventions to build strong and resilient national health systems.

The Dakar Declaration is a joint initiative bringing together the government of Senegal and Mercy Ships with the participation of key regional and international partners involved in the surgical, obstetric, and anesthesia care system strengthening in Africa.

Conclusion

To solve the current surgical care crisis, African leaders must commit to significant and focused efforts to improve the availability, quality, and affordability of surgery in the continent and then within their countries.

These efforts should be supervised by heads of state and implemented by the ministries of health in close collaboration with relevant stakeholders, including, but not limited to, the private sector, the non-governmental sector, professional organizations, and not-for-profit sectors. The culmination of the efforts needed has led to a Regional Action Plan (RAP) 2022–2030 and then to national surgical, obstetric, and anesthesia plan (NSOAP) as part of the National Health Plan (NHP). Both the Regional Action Plan and the NSOAPs will guide the integration at regional and national levels into the Africa Health Strategy 2016–2030 and into the national health policy, strategy, or plan, as there is now global and regional recognition that health systems planning is incomplete if the surgical system is left unaddressed. The Dakar Declaration and its Regional Action Plan, therefore, are a commitment as a clear pathway to building quality and sustainable surgical, obstetric, and anesthesia systems in Africa and in each country within the ambitious framework of "*The Africa we want*" Agenda 2063 (13). In the era of the Declaration of Astana on PHC for UHC and SDGs (October 2018), the surgical service should be an integral part of its first component, which is "integrated packages of quality services and considering essential public health functions" (15). The definition of essential service packages should also include surgical services so that the health system can respond easily to the needs of the communities. As a reminder, "The Africa we want" is a shared framework for inclusive growth and sustainable development for Africa to be realized in the next 50 years. It is a continuation of the Pan-African drive over centuries, for unity, self-determination, freedom, progress, and collective prosperity pursued under the African Renaissance.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The status of pediatric surgery in Malawi: a narrative mini-review

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Introduction: Pediatric surgery is essential to a well-functioning health system. Unmet surgical needs contribute to 6.7% of pediatric deaths in Malawi. Understanding the current state of pediatric surgical care in Malawi is necessary to recognize gaps and opportunities in service delivery and to develop evidence-based national planning and solutions.

Methods: This narrative mini review synthesized the literature on the state of pediatric surgery in Malawi through the pillars of the World Health Organization's Health System Building Blocks. A search of PubMed, Embase, and Scopus databases was executed to identify relevant studies and a thematic analysis was performed. Further, to ensure contextual accuracy, pediatric surgeons from Malawi were consulted and involved in this review.

Results: Twenty-six papers were identified. In Malawi's central hospitals, there are six specialist pediatric surgeons for a pediatric population of more than 8 million. There is limited pediatric surgical capacity at the district hospitals. There is little to no written evidence of the national governing and finance structures in place for pediatric surgical services.

Discussion: In countries like Malawi, where a significant portion of the population comprises children, it is crucial to recognize that pediatric services are currently inadequate and fall short of the required standards. It is crucial to prioritize the enhancement of services specifically designed for this age group. This review aims to shed light on the existing gaps within pediatric surgical services in Malawi, providing valuable insights that can inform the development of comprehensive national surgical planning strategies.

KEYWORDS

pediatric, surgery, Malawi, global surgery, NSOAP, sub-Saharan Africa

Introduction

Approximately 1.1 billion children and adolescents, predominantly from lower-middle income countries (LMIC), live without access to safe surgical care (1). The 2015 Lancet Commission on Global Surgery (LCoGS) report on the state of surgical care worldwide highlighted these critical inequalities in surgical delivery (1, 2). The report and subsequent calls to action from the LCoGS emphasized the need for a systematic National Surgical, Obstetric and Anesthesia Planning (NSOAP) approach to be globally adopted (2, 3). The LCoGS guidelines do not stipulate specific targets for pediatric surgery, despite recognizing the importance of improving access for this population. In response to this gap, the Global Initiative for Children's Surgery (GICS) advocated that understanding existing gaps in

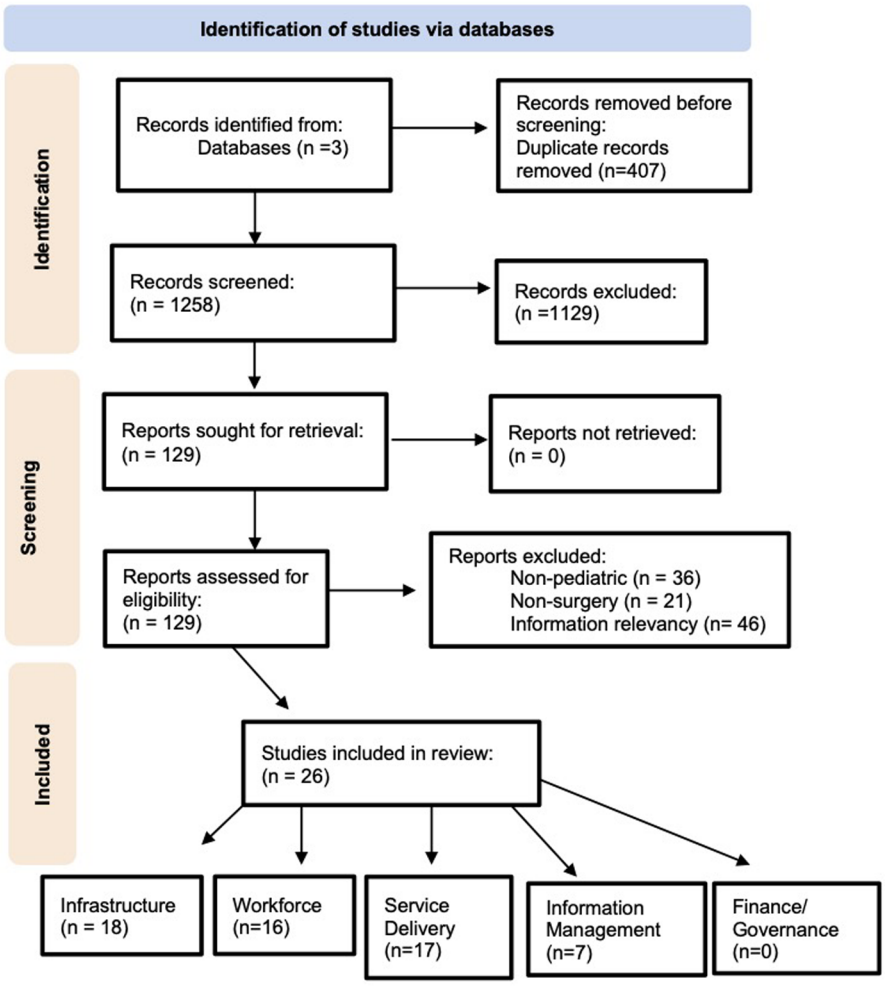
pediatric surgical services is imperative for ensuring that universal health coverage encompasses the healthcare needs of all (4). The GICS proposed a list of "Optimal Resources for Children's Surgery" that detail what surgical services should be required and provided at every level of healthcare (4).

Currently, six countries in sub-Saharan Africa (SSA) have fully developed NSOAPs, Zambia, Nigeria, Madagascar, Rwanda and Tanzania (5). Nigeria was the first of them to incorporate pediatric surgical care into its plan using the GICS recommendations and a pediatric modified WHO assessment tool (6). In 2019, the Southern African Development Community (SADC) committed to developing NSOAPs for all 14 of their member states (7). However only three member states: Zambia, Zimbabwe, and Tanzania, have accomplished this, none including pediatric specific targets (5).

Malawi, a SADC member state, has not yet developed a NSOAP, despite the commitment. Inclusion and investment in pediatric surgical care is imperative for the future of Malawi, as children under 14 years old' (around 8.24 million) account for nearly half of the nation's population (8). The risk of major economic impact from disability due to untreated surgical conditions is threatening (9). There are an estimated two million children in Malawi who may have an incapacitating, but surgically treatable condition needing management (9). A 2020 household study in Malawi, found untreated surgical conditions contributed to 6.7% of all pediatric deaths in the country (10). To address this need, evidence-based development of an NSOAP must be conducted. However, there is no current synthesis of this evidence. Therefore, the aim of this review is to take stock of the current state of pediatric surgery in Malawi, to provide such information for future surgical capacity development.

Methods

This narrative mini review on pediatric surgery in Malawi was conducted in accordance with a systematic review procedure described by Petticrew and Roberts (11) and is reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (12) (**Figure 1**). The search



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

FIGURE 1
The PRISMA flow diagram for the narrative review detailing the database searches, the number of abstracts screened, and the full texts retrieved.

strategy was developed in collaboration with a medical librarian at the Royal College of Surgeons in Ireland. An electronic search was conducted in PubMed National Library of Medicine, Embase, and Scopus databases. The search encompassed the following search string, ((("pediatric surgery" OR "paediatric surgery") AND Malawi) OR ((child* OR infant* OR neonate*) AND (surgery OR surgical)) AND Malawi), adjusted to each database. Papers in English from 2010 to March 2023 were included to ensure the most current publications were retrieved.

The initial search was conducted on December 6, 2022, and an updated search was conducted on June 1, 2023. Identified articles were downloaded, and titles and abstracts were screened by two authors (CFM, IH) using the online systematic review platform Rayyan (Rayyan Systems Inc., Cambridge, MA, USA). During this phase, the inclusion criteria were established to include studies encompassing any aspect of pediatric or child surgery, particularly focused on surgical care provision, studies discussing the availability or lack of surgical services for children in the country, and studies reporting on surgical outcomes and complications in children, this ensured the selection of all pertinent scientific articles. Furthermore, there were no restrictions imposed on the type of publication or research design. Conversely, studies conducted outside Malawi or not involving Malawian patients, along with articles that did not report on surgical care or conditions, were excluded. Any conflicts that arose were resolved by a third reviewer (CP). Subsequently, a full-text review of the selected articles was conducted. The included articles focused on surgical care provided to children, documented or discussed the availability or lack of surgical services for children in the country, or reported on surgical outcomes and complications in children.

Data was extracted from eligible studies using Microsoft Excel. This review utilized indicators from the NSOAP framework which track progress based on the World Health Organizations (WHO) Health Systems Building Blocks as a framework to synthesize the extracted data (2, 3). The NSOAP indicators operationalize the six pillars of infrastructure, workforce, service delivery, information management, finance, and governance (3) tailored to the specifics of surgical care.

To ensure the accuracy and relevance of the study, experts in pediatric surgical care from Malawi were involved at all stages of this review. These experienced professionals validated the findings from the literature and provided valuable insights into the current practices and challenges in pediatric surgery provision.

Results

The included screened articles consisted of quantitative studies, qualitative studies, mixed-method studies, and secondary reviews, which all aimed to assess or describe system elements of surgical care in Malawi (**Figure 1**). Twenty-six articles with information relevant to at least one NSOAP-defined building block were included in this review. Several papers included in this review contain information pertaining to more than one NSOAP building block. Consequently, these papers have been utilized in multiple sections of the analysis, to effectively capture the multidimensional nature of the literature. A summary of these findings can be seen in **Table 1**. This section reports only on what has been published in the literature included in this review.

Infrastructure

Eighteen articles included evidence of infrastructure, such as surgical facilities, supplies, and referral systems. Malawi's healthcare system has three tiers linked by a referral system, primary care centers, secondary district hospitals, and tertiary central hospitals (13). Surgical services are only available at the

TABLE 1 Summary of findings.

NSOAP pillar	Strengths	Gaps
Infrastructure	• Two public central referral hospitals with pediatric specialty care, with one pediatric specific surgical and intensive care unit. • One private specialty pediatric orthopedic hospital. • Established electronic consultation network between district hospitals and pediatric surgeons giving guidance on treatment and referral needs.	• Unnecessary referrals lead to overburden on central hospitals. • Frequent unavailability of pediatric sized supplies both surgical and anesthetic. • Lack of diagnostic imaging options leads to surgery as means of diagnostic.
Workforce	• Increase in available pediatric surgeons in recent years, from 1 surgeon in 2010 to 6 surgeons by 2022. • Future workforce improvements with COSECSA pediatric specialty trainees. • Task-shifting of minor surgeries to clinical officers at district level gives greater access.	• Number of surgeons does not meet WHO recommendations. • Hesitancy from doctors who do not specialize in pediatric care and clinical officers to perform operations on children, leading to higher rates of referrals.
Service Delivery	• District hospitals have capacity to treat burns, minor injuries, and some congenital anomalies. • Central hospitals treat more complex burns, congenital anomalies, cancers, neurological conditions, and ophthalmological conditions.	• High rates of non-operative treatment in facilities with non-pediatric specialty providers, either referring or sending home for non-operative care.
Information Management	• Central hospitals track pediatric surgical procedures when able to electronically or in logbooks. • District hospitals encouraged to keep track of procedures electronically or in logbooks.	• Governmental HMIS does not record all pediatric surgical procedures. • Issues with follow up and data accuracy. • District hospital surgical data are difficult to keep track of.
Financing	• No clear information found in literature regarding budget allocation or financing systems in place for pediatric surgical care.	
Governance	• No definite information found in literature regarding governance and governmental oversight in pediatric surgical care.	

secondary district and tertiary central hospital levels (9, 13). District hospitals, located in 25 of Malawi's districts have basic surgical capacity, and ability to provide regional, spinal, ketamine and general anesthesia for surgical procedures (13, 14). However, pediatric size supplies/equipment are commonly unavailable in district hospitals (15). A 2020 study found equipment such as pediatrIc oropharyngeal airway and endotracheal tubes, necessary for administering anesthesia, to be most frequently unavailable (15).

Malawi has four central referral hospitals: Kamuzu Central Hospital (KCH), Queen Elizabeth Central Hospital (QECH), Zomba Central Hospital, and Mzuzu Central Hospital. The literature indicates that KCH and QECH are the facilities serving as referral centers for pediatric cases. There is no data on what infrastructure Mzuzu and Zomba Hospitals have for pediatric surgical services. KCH, located in the capital Lilongwe serves the central region of Malawi (13, 16). The main operating theater at KCH has four fully functional operating rooms that can perform pediatric surgeries (16, 17). There is no separate pediatric intensive care unit at KCH for perioperative and postoperative services (18). The only pediatric intensive care unit in Malawi is the Mercy James Centre for Pediatric Surgery and Intensive Care (MJC), located within the grounds of QECH in Blantyre (19, 20). Opened in 2017, MJC has six pediatric ICU beds, three pediatric operating theaters, and a 60-bed pediatric surgical ward (20). QECH itself is equipped with seven theaters capable of conducting pediatric surgeries and has pediatric diagnostic imaging modalities including ultrasonography, CT, and x-ray (18, 21–23). Due to the specialty care capacity, MJC and QECH are the major referral centers within the country for pediatric cases needing advanced surgical treatments (19, 21). There are also private hospital facilities, located in central areas, that conduct specialized pediatric surgical services. The Beit CURE International Hospital in Blantyre, provides orthopedic, plastic, and reconstructive surgeries for pediatric patients (24, 25).

The referral system in Malawi allows for transfer of more complex surgical cases which cannot be managed locally from district hospitals to central hospitals (26). However, several studies reported that the inefficiency and inappropriateness of these referrals led to higher risk of over-triage and delays in surgical intervention for pediatric patients (27–29).

Workforce

Sixteen articles contained evidence regarding the surgical workforce, including allied health providers providing surgical treatments. In 2010, there was only one pediatric surgeon serving a population of 5.98 million pediatric patients (30). By 2022, there were four pediatric general surgeons (9, 24, 31) and two pediatric neurosurgeons (32).

There are no specialist surgeons in the district hospitals, which instead rely on means of task shifting so that surgical interventions are conducted by clinical officers and general medical officers (14, 33). While there is evidence that clinical officers in district hospitals surgically treat children, there is no data on the number who perform these surgeries and the volume at which they do so (33, 34). As suggested by Maine et al., the tendency for district hospitals to transfer pediatric cases highlights clinical officers' limited skills to care for children who may need surgical procedures, regardless of their complexity (27).

Task-shifting also occurs at central hospitals. The literature reports that when there are no pediatric surgeons, operations are conducted by general surgeons, medical doctors, or clinical officers, and are assisted by general anesthesiologists who do not specialize in pediatric care (17, 28, 35, 36). In these facilities, clinical officers perform minor burn surgeries, foreign body removals, and ventriculoperitoneal (VP) shunt placement (35). Further, general surgeries and urology cases are more often performed by medical doctors (29, 34, 35). However, these non-specialty providers have varying confidence levels operating on children (35). One study reported that among facilities where there was no surgeon available, there was a tendency to operate on less complicated, adult patients, while pediatric or more complex cases were referred to the central hospitals or may be sent home for non-operative care (28). A lack of pediatric care training, pediatric anesthesia providers, post-operative critical care, and follow-up abilities contribute to this reluctance (28, 29).

Service delivery

Seventeen articles comprised information regarding service delivery, including surgical volume at hospitals, system coordination, and safety. There is no comprehensive nationwide data on the number of surgeries performed on children in Malawi. In a review of records from 2011 to 2019 at KCH, 342 pediatric patients underwent burn operations including split-thickness skin graft, debridement, escharotomy, and amputation (13, 37). In a case review conducted between February 2012 and October 2015, KCH had 1680 pediatric surgical admissions and consultations of congenital colorectal disease (22). Of which, 82 pediatric patients were admitted with anorectal malformations, and 26 underwent surgical intervention (22). These operations included exploratory laparotomy, diverting colostomy, posterior sagittal anorectoplasty, and anal dilation (22). In patients with Hirschsprung's Disease, 41 operations performed, included exploratory laparotomy, rectal biopsy, and definitive pull-through (22). Review of MJC admissions from its opening in 2017 until 2019, showed 5,205 outpatient visits, 3,730 theater cases, 3,249 pediatric ward admissions and 579 PICU admissions (19, 20). Pediatric neurosurgeries and treatments of traumatic brain injuries are conducted at QECH and KCH (32, 38). A retrospective analysis report from the Beit CURE International Hospital (BCIH) found that from 2012 to 2013, a total of 1,154 pediatric orthopedic operations were conducted in all public and private facilities in Malawi (24). 53% of these cases ($n = 609$) were performed at BCIH (24); the most common pathologies treated were clubfoot, genu valgus, and burn contracture (24). Staff from BCIH are also periodically seconded to Mzuzu Central Hospital and operate on some 45–75 children per year at that facility (24, 25).

In central hospitals, the absence of perioperative imaging support contributes to the higher rates of non-specific admission diagnoses and misdiagnoses, leading to a reliance on operative intervention as a means of diagnosis (17). In pediatric operations

performed by clinical officers and other general surgeons, Reid et Al. reported concerns that a lack of training could lead to a risk of infection (18). This was further exemplified in a study from KCH in 2019, showing that clinical officers, not neurosurgeons, performed shunt operations for hydrocephalus treatment (18). However, in these cases of task-sharing, there is no distinct variability in mortality and complication rates between clinical officers and medical doctors (18, 34, 35).

Pediatric patients needing surgical treatment account for the majority of trauma operations performed at the district level (33). Evidence from district level hospitals show that among pediatric procedures, the most performed operations are hydroceles, hernia repairs, male circumcision, and clubfoot repairs (14, 33). Some of these facilities also reported to have the capacity to surgically treat cleft lip and imperforate anus (14). While some congenital anomalies can be treated at the district level, patients below the age of 15 account for most referrals from district hospitals and other central hospitals (21).

Information management

Seven articles contained data on information management. There is no evidence in the literature that the Malawian Ministry of Health's Health Management Information System (HMIS) tracks pediatric surgery information and there is no national mandate to ensure record and accuracy of this data (24). Individual hospitals are responsible for tracking pediatric surgical patient information (39). These data are meant to be sent from the facilities to an HMIS officer at the district office to be entered into the district health information system (39). However, multiple studies in this review reported issues with the health record systems, including incomplete data and information tracking for pediatric patients (16, 21, 35). District and central hospitals keep surgical logbooks to track procedures; some in electronic databases and some in handwritten paper clinical logbooks (39). Statistics regarding the number of admissions, number of operations and common diagnoses are provided upon request to the Central Monitoring and Evaluation Division at the Ministry of Health (MOH) (39). In central hospitals, there are surgical patient databases, which an HMIS clerk is meant to use to record final diagnosis, length of stay, treatment summaries, and indicate if a surgical procedure was performed (17, 22, 39). However, a 2014 study at KCH found that 50% of general and congenital pediatric surgery patients in each subspecialty had missing outcome data (35). Further, limitations with the inpatient registry caused records of many pediatric patients, particularly outpatient and short-stay cases, not to be captured in the system (35). An audit of pediatric deaths at KCH also found that some information of patients who died could not be traced in the facilities records and that discharged patient records were also frequently missing (16). Pittalis et al. noted that collection of referral data from district hospitals, which typically includes data on pediatric referrals, is unattainable due to the lack of standard recording systems differentiating surgical patients from medical cases (21).

Financing

There are no data in the relevant literature on budget allocation or governmental financing support for pediatric surgery in Malawi. Private facilities, namely the Beit CURE International Hospital, charge their adult patients for specialist plastic and orthopedic surgeries, and then utilize those funds to sustain free pediatric surgical services (24, 25).

Governance

No clear evidence of any governance structure for pediatric surgery exists in the available literature. Only one article mentioned the Malawi Ministry of Health Child Protection and Justice Act 2010, which takes responsibility for preventing premature deaths and disability in children (9).

Discussion

This review provides a comprehensive analysis of the available evidence regarding pediatric surgical care in Malawi. These findings contribute valuable insights to the existing literature in conjunction with validation from surgical experts. All findings related to each building block, with an exception to the information regarding workforce, were confirmed by the surgical expert team. The information found has direct implications for the improvement of surgical services for pediatric patients in Malawi and may serve as evidence for NSOAP development. Notably, a significant gap in the country's capacity to deliver services pertains to the lack of comprehensive national survey data on pediatric surgical activity. While demand for services is evident, exemplified by an estimated 2.2 million children living with surgically treatable conditions (9), the absence of precise procedure records inhibits the ability to gauge the extent to which this is being met. As a target benchmark, the Lancet Commission on Global Surgery recommends 5,000 surgical procedures per 100,000 population (2). An insufficient national data collection system is a major challenge, as there is no baseline information on how far from recommended targets Malawi may be, with no possibility of drawing meaningful population level conclusions.

The first and second iterations of Malawi's Health Sector Strategic Plan prioritize the provision of reliable, complete, accessible, timely, and consistent health information data to be used for evidence-based decision-making in the health system (40). The tracking of pediatric surgical data has not been included in this priority setting. While the importance of data is noted in the strategic plan the current routine health information system doesn't support the collection and use of pediatric surgical data. Although DHIS2 has been adopted as the national health information system paediatric surgical data is still collected via paper records and is not routinely entered into DHIS2 (39, 41). Therefore, the literature in this review relies on individual hospital reporting, particularly from two central hospitals, KCH and QECH, and the private not-for-profit facilities.

Further, the available evidence shows that with six pediatric surgeons, the demand for pediatric surgical care far exceeds the supply available (9). The current recommended need for a surgical workforce would be 41 pediatric surgeons for the population of 8.24 million children in Malawi (30). However, this reported number of pediatric surgeons from the literature is not the most current. According to the pediatric surgery experts from Malawi on this review team, the current number of pediatric surgeons is five. The fluctuation of these estimates reflects recent provider departures and the retention of newly graduated providers, but absence of a collective database renders this information difficult to find. As a constituent member of the College of Surgeons of East, Central and Southern Africa (COSECSA) Malawi has increased its pediatric surgical workforce and therefore widened access to specialty training in the last decade (14, 42). The availability of a designated pediatric surgical hospital (MJC) and strategic international partnerships for specialty training, has assisted in this success towards scaling up the workforce (19). Evidence from 2021 shows that pediatric surgical trainees assisted in 1,745 surgeries in Malawi (42). Comparatively, Tanzania, also a COSECSA member and a nation that has an NSOAP, has been able to grow its workforce to 12 pediatric surgeons (43). Collectively, the pediatric surgical workforce in the COSECSA region comprises only 52 specialists (44). However, priority for building this specialty workforce has proven to be successful in other regions of sub-Saharan Africa. A notable example is Nigeria, the first country to include pediatric surgery in its NSOAP. As a result, the pediatric surgery workforce in Nigeria has experienced significant growth, expanding from approximately 35 specialists in 2006 to over 130 by 2021 (45). This achievement highlights the positive impact of prioritizing pediatric surgery within the healthcare system and serves as an encouraging model for other countries in the region.

This review underscores the absence of comprehensive guidance regarding the financing and governance of pediatric surgery in Malawi. It is evident that national authorities across Sub-Saharan Africa (SSA) have accorded low priority to funding pediatric surgery, a fact supported by substantial corroborating research (31). Notably, surgical provisions are absent from national funding programs in Malawi, and the government has yet to allocate a dedicated budget for this essential domain (46). Despite incurring substantial costs, public central and district hospitals provide surgical services free of charge to both adults and children (46). Malawi's shortage of specialists creates a reliance on task-shifting of pediatric surgical delivery to clinical officers, mainly at the district level (34, 35). Clinical officer hesitancy due to lack of pediatric training, and financial burdens deter district hospitals from expanding their services and embracing task-shifting responsibilities (34, 35, 46). However, as evidenced in Uganda, the use of task shifting for pediatric care has been seen as a beneficial way of making services more accessible and relieving the burden of the unmet need (47). To mitigate concerns of safety and provider hesitancy, it is imperative that the Ministry of Health (MOH) prioritize financing pre-service and in-service specialty trainings of clinical officers, particularly in administering pediatric anesthesia. Additionally, the implementation of MOH governance of regulations for task shifting of pediatric services should be prioritized.

The findings of this review illustrate the critical nature of these resource deficiencies. The lack of comprehensive procedure records highlights a knowledge gap that necessitates immediate attention and further research to improve health outcomes for children in Malawi. Therefore, it is paramount for the government to actively engage and invest in the sector, ultimately ensuring that the planning and implementation of an NSOAP significantly enhances health outcomes for all segments of the population.

Author contributions

CM, CP, EB, IH, and JG contributed to conception and design of the review. CM and IH performed the search and screening. CM wrote the first draft of the manuscript. CM, CP, and JG wrote sections of the manuscript. CP, EBy, TC, EBo, BN, and JG reviewed the manuscript, provided edits, comments and feedback. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Implementation of World Health Organization behaviorally anchored rating scale and checklist utilization: promising results for LMICs

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Background: Operating teams can decrease the likelihood of patient risk by using the WHO Surgical Safety Checklist. To ascertain the impact of demographic factors on behaviorally anchored ratings and investigate operating room (OR) staff attitudes toward checklist administration, we set out to better understand how OR personnel use the checklist in a tertiary care hospital in Pakistan.

Materials and methods: A monocentric sequential mixed-methods study employing a quantitative approach of using World Health Organization Behaviorally Anchored Rating Scale (WHOBARS) assessments of surgical cases by OR personnel and two independent observers, who were certified surgeons having extensive experience in the rating of the WHOBARS scale for more than 1 year, followed by a qualitative approach of staff interviews were carried out in a tertiary care setting. In June and July 2022, over the period of 8 weeks, an intervention (training delivery) was implemented and evaluated. The information, skills, and behavior adjustments required to apply the checklist were taught in the course using lectures, videos, small group breakouts, participant feedback, and simulations.

Results: After the introduction of WHOBARS, 50.81% of respondents reported always using the checklist, with another 30.81% using it in part. Participants' years in practice, hospital size, or surgical volume did not predict checklist use. Checklist use was associated with always counting instruments (51.08%), patient identity (67.83%), difficult intubation risk (39.72%), the risk of blood loss (51.08%), prophylactic administration of an antibiotic (52.43%), and the use of pulse oximeter (46.75%). Interviewees felt that the checklist could promote teamwork and a safe culture, particularly enabling speaking up. Senior staff were of key importance in setting the appropriate tone.

Conclusion: The use of a multi-disciplinary course for checklist implementation resulted in 50.81% of participants always using the checklist and an increase in counting surgical instruments. Successful checklist implementation was not

predicted by the participant's length of medical service, hospital size, or surgical volume. If reproducible in other countries, widespread implementation in LMICs becomes a realistic possibility.

KEYWORDS

WHOBARS, surgical safety, LMIC, quality improvement, humans

Introduction

The occurrence of adverse events in a hospital context is currently estimated to be 10% globally (1), according to conclusive data. An estimated 234 million procedures are carried out worldwide per calendar year, according to reports. Of these, one million die, and there are thought to be seven million complications (2). Despite the possibility that inadequate hospital facilities and employees contributed to the increased mortality (3), up to 30% of contacts in the operating room (OR) suffer from communication breakdowns, which happen every 7–8 min on average (4). As a result, surgical care and the complications that come along with it carry a significant disease burden that requires the attention of the public health community on a global scale.

The WHO launched the Surgical Safety Checklist in 2008 as part of its second Global Patient Safety Challenge, Safe Surgery Saves Lives (5). The National Patient Safety Agency (NPSA) required the National Health Service (NHS) in England and Wales to use the checklist in January 2009 (6). The checklist's goal was to aid operating room (OR) teams in recalling crucial information that might be forgotten during an operation. Additionally, it was a tool for promoting communication and teamwork between OR staff members (5).

The World Health Organization Behaviorally Anchored Rating Scale (WHOBARS), a novel tool that evaluates behaviors related to the delivery of the checklist, was created to assess the level of engagement during the process (7). While using the checklist, health workers can be observed using the WHOBARS to evaluate their behavior. The effective participation of the entire OR team during the delivery of the WHO Surgical Safety Checklist (SSC) is necessary to realize its full potential to decrease perioperative damage. The overall structure of the checklist is left unchanged, but hospitals are invited to modify it to suit their needs. Studies proving the effectiveness of these modified checklists have persisted in demonstrating that using the SSC or a comparable checklist is generally advantageous (8).

One of the main justifications for checklists is that they may be used in varied contexts and significantly contribute to a reduction in morbidity and mortality related to surgery. The highest improvements are seen in low-income and middle-income countries (LMICs), where this checklist can cut mortality and morbidity after surgery by up to 50% (9). However, using the checklist incorrectly can have the opposite consequences (10). Although everyone demonstrates an understanding of the importance of this checklist, not everyone follows or uses it as intended (11). As a result, it is important to evaluate whether building an implementation strategy can help the checklist function sustainably.

This study was conducted in various healthcare facilities across Pakistan to assess the current utilization and effectiveness of the WHO surgical safety checklist. While the checklist is recommended in these settings, its implementation and adherence may vary. The study aimed to identify gaps, challenges, and potential areas for improvement in surgical safety practices by evaluating the utilization and effectiveness of the checklist. The findings will contribute to strategies and interventions aimed at enhancing the implementation of the WHO checklist in Pakistan, thereby improving patient safety outcomes. The rationale for this study was rooted in the recognition of the critical role that the checklist plays in improving patient safety during surgical procedures. Understanding the current situation in Pakistan and identifying barriers to checklist implementation provide valuable insights for developing targeted interventions and initiatives to enhance surgical safety practices and reduce preventable errors in the country. Ultimately, the goal was to promote the widespread adoption of the WHO checklist and foster a culture of patient safety in Pakistani healthcare settings.

Methodology

This sequential exploratory mixed methods study with a sequential exploratory design where quantitative data were initially collected followed by qualitative data collection in the form of in-depth interviews was conducted over the course of 8 weeks starting from June to the last day of July 2022. The researchers obtained qualitative data from interviews and quantitative data using results from the WHOBARS rating as follows:

OR staff and two independent observers who were certified surgeons having extensive experience in rating the WHOBARS scale for more than 1 year used WHOBARS for the quantitative part of the study to rate the quality of checklist administration during surgical cases, answering questions 1 to 3. Descriptive statistics were used to analyze WHOBARS scores for secondary outcomes, and multivariate linear regression was used to identify which factors were significantly associated with checklist utilization. The use of checklists as measured by questionnaire was the primary outcome of interest in the quantitative statistical analysis. Covariates were included in the analysis for more accurate results. Multivariate linear regression was used for ranking questionnaire answers. The significance level for the analyzed data was set at 0.05, and the analysis was done using IBM Corp., released in 2013, IBM SPSS Statistics for Windows, version 22.0. Armonk, NY: IBM Corp.

Researchers conducted in-depth interviews lasting at least 1 h with more than 5 representative respondents from the OR staff who voluntarily presented themselves for the interview and who had completed the WHOBARS self-rating exercise for the qualitative part of the study to learn more about their thoughts and feelings regarding the checklist (research question 4) and its use in the OR. Interviews were conducted in Urdu and then translated into english and analyzed and categorized into overarching themes based on the six essential safety procedures for evaluating the effects of interventions. Both researchers were involved in the process of categorization and analysis.

Our study is fully compliant with the COREQ guidelines (12). A complete COREQ checklist has been provided as a Supplementary file. UIN research registry 8486 (13) identifies our study in Research Registry. Our research adheres to the principles outlined in the Helsinki Declaration.

All operating room staff was provided with pre-study presentations and information sheets, and their written consent was collected. Three operating rooms (ORs) were used, two for adults and one for children. To get a verbal agreement from patients (and/or their legal guardians), we provided them with information about the planned observations. If they did not want research staff to be present during their (or their child's) surgery, they were given the choice to opt out of the study.

Public and patient participation

No members of the public or study participants were involved in any way. The research was performed in a tertiary care facility in the year 2022. Prompts to the checklist's three phases were posted on the walls of all operating rooms (ORs), as recommended by the Health Quality and Safety Commission's Safe Surgery initiative. Each step of the checklist was administered jointly. The anesthesiologist was in charge of sign-in, the surgeon of time-out, and the nurse of sign-out. Every person working in the operating room had never heard of WHOBARS and had no idea how to use it. The WHOBARS was introduced and used by the independent observers in the same manner as explained above. An academic pharmacist and a medical education researcher make up the two independent observers (trained in psychology). Neither of the outside evaluators had any experience in the operating room beforehand.

Case selection

Based on the purposive sampling techniques of related studies (7, 14), we decided to investigate 20 full surgical cases. Adults and children alike who required emergency or elective surgery under general anesthesia during regular business hours were qualified. Once the daily list was up, the team of observers who had agreed to work in the operating room began their shift. Patients were assigned to any available OR based on the availability of medical professionals. To ensure that a wide variety of OR staff was represented, we limited daily observations to a single case from each OR. We did not include studies where either the staff or the patient refused to give their consent.

Expertise development for raters

A total of 12 training videos were used in our prior studies and had already been rated by a group of trained raters before the ratings were done by the two independent observers. Across all 12 training clips, the two independent observers from this study and the trained raters from the original validation trial had an intraclass correlation coefficient of 0.84.

WHOBARS ratings (quantitative)

In each phase of the checklist, two trained observers independently rated the five WHOBARS domains based on their observations of the entire case. Patients had to check in before anesthesia was administered, wait for a designated amount of time to pass before undergoing surgery, and then sign out before being allowed to leave the operating room. Following sign-out, the OR staff evaluated their team's performance using the WHOBARS instrument as well. We queried the OR staff for information such as gender, age, clinical specialty, and number of years of OR experience. The WHOBARS rating scale was employed by both the OR staff and outside observers. Rating guidelines were provided in great detail to the raters.

Interviews (qualitative)

We then invited the OR staff in these situations to a semi-structured interview. Purposive sampling was employed here. There was a checkbox on the OR rater consent form that participants had the choice to indicate their willingness to be interviewed. A researcher with no prior connection to the participants contacted those who checked the box through email 2–6 days after they finished the OR ratings. We kept interviewing until we had enough information (when very few new ideas, opinions, or concepts were emerging from the interviews) and had a diverse sample of clinical roles and experience levels. To guarantee uniformity in the interview approach and ensure comparable interview results, all interviews were performed by the same researcher either in-person or over the phone (based on participant availability and preferences). During each interview, the researcher made careful notes of the interaction. The quotations may represent a selection, accurately reproduced, rather than the entire dataset.

Data analysis

The primary result was examined only using descriptive statistics. Descriptive statistics were used to analyze WHOBARS scores for secondary outcomes, and multivariate linear regression was used to identify which factors were significantly associated

with checklist utilization. The use of checklists as measured by the questionnaire was the primary outcome of interest in our study. The size of the hospital, the number of surgeries performed, the gender of the participants, their WHOBARS scores, how much they learned about patient safety, how satisfied they were with their jobs, and how much stress they felt they were under as a result of the training, all served as covariates.

We opted to use a hierarchical model instead. Likert scale answers were ranked from 0 to 4 for use in multivariate linear regression, with blanks being filled up with the mean score for that hospital. The significance level for the analyzed data was set at 0.05, and the analysis was done using SPSS version 22.

We translated all open-ended survey replies and all focus group information into English. Data were then analyzed using thematic analysis. Culture shift was analyzed using an inductive theme approach. Both researchers were involved in the process of identifying and emphasizing key issues, which were then categorized into overarching themes. We employed a deductive theme analysis, based on the six essential safety procedures for evaluating the effects of interventions.

Results

Quantitative results

In a 350-bed tertiary care hospital, we observed 160 cases. The final dataset included information from 370 people in 160 distinct cases. The sample includes 25 (6.75%) surgical assistants, 13 (3.54%) other health aid observers, 100 (18.37%) nurses, 68 (18.37%) anesthetists, and 164 (44.3%) surgeons. In Table 1, the participant demographics are displayed. No participant had received checklist training before the intervention. They all lacked enough pulse oximeters; therefore, the routine use of pulse oximetry could not be monitored. There was no regular counting of sponges, equipment, or needles. Additionally, the official procedure for debating the risk of challenging intubation, anticipated blood loss, or confirmation of antibiotic therapy was not followed. Respondents claimed that the patient's identification had been verified before the procedure.

Mean hospital WHOBARS scores and the method of evaluation are shown in Table 2.

Qualitative results

Anesthetist

Anesthetists used the checklist before the surgeon performed the surgical incision to fulfill their role. In collaboration with surgeons, they made sure to confirm the patient and type of surgery before each operation so that wrong-person or wrong-site surgery did not occur. It was not uncommon to assess risk for difficult intubation partly because of time constraints of the busy OR and partly because of a lack of skill and urgency of the severe disease requiring them to act rapidly and this important risk assessment was missed. This led to complications which then contributed to mortality. When everyone used the checklist, anesthetists said they felt much more like a responsible member of the team and that improved their morale. An anesthetist reported, "The checklist helps me be on track ensuring that I do not miss a preventable life-threatening situation". The checklist promoted teamwork and aided the way forward for anesthetists. Anesthetists were thankful to their team members for giving them suggestions that saved lives. Anesthetists believed that vital information was overlooked as all eyes were not on the patient's ongoing surgical situation at any crucial moment in time during the surgery in OR, especially the sign-in and sign-out times.

Nurse

Although nurses are ordered to make sure every patient coming in for surgery has a pulse oximeter on them in the OR, they unfortunately lacked the logistics and enough oximeters which was the principal reason why not every patient was provided a pulse oximeter. Surgeons used swabs and instruments and nurses were given the job of correct counting to make sure that what goes in comes out and everything is accounted for but due to time constraints and fear of repercussions, especially from senior surgeons who have worked for a longer time in the OR, the nurses kept silent. According to an interview with a nurse, some members of the OR staff were downright sarcastic about it, which made genuine conversation about the checklist and patient safety more difficult than it already was at that moment in time. Nurses completed the sign-out when the surgeon left the OR. Surgeons only cared about the sign-in and they hastened the remaining procedure not giving nurses enough time to do everything appropriately. A nurse reported, "Surgeons would make jokes when I want to meticulously do each step of the checklist". It used to really annoy nurses that some checklist users would just blindly tick that everything had all been done when it had not been done. The checklist enabled nurses to speak up for the patient and act in their best interests which was not possible before the implementation of the checklist.

Anesthetic assistants, surgical assistants, and other health aids

Anesthetic assistants, surgical assistants, and other health aids remarked that nurses often had to remind the surgeons to complete components of the checklist before, but as time passed, everyone understood what to do and they all worked as a team. The checklist made it easy for anesthetic assistants, surgical assistants, and other health aids to raise concerns about patient safety and communication at different points for better patient care and healthcare delivery in general.

Surgeons

Surgeons thought that it was only the job of the nurse to ensure every patient had a pulse oximeter in place in the OR. Surgeons posited that they generally advised antibiotic prophylaxis for every patient in the OR to prevent bacterial infections. One of the main reasons surgeons used antibiotics only half the time

TABLE 1 Participant demographics.

Gender	Age	Clinical specialty	Number of years of OR experience	Hospital size	350 bedded
Female	45	Pediatrics	10	Surgical volume	160
Male	52	Internal medicine	15	Number of participants	370
Female	47	Gynecology	12	Surgeons	164 (44.32%)
Female	44	Psychiatry	14	Anesthetists	68 (18.37%)
Male	50	Cardiology	18	Nurses	100 (27.02%)
Male	46	Ophthalmology	16	Surgical assistants	25 (6.75%)
Male	45	Orthopedic surgery	11	Other health aids	13 (3.54%)

TABLE 2 Mean hospital WHOBARS scores and the method of evaluation.

Hospitals	Number of respondents per hospital	The method of evaluation	WHOBARS sign-in	WHOBARS time-out	WHOBARS sign-out	Overall WHOBARS score
A	7	Real-time case in OR	7.2	6.8	7.0	7.0
B	8	Simulation	5.6	5.8	6.5	6.2
C	4	Total median scores (range) (IQR)	6.2 (1.6–7) (6–7)	5.8 (1.4–7) (5.8–7)	6.2 (1.6–7) (2.5–7)	5.6 (1.6–7) (4.9–7)

was because they thought administering antibiotics to every patient in the OR was not without its own downsides. They thought that blind antibiotic use in every patient coming in for surgery could lead to unwanted antibiotic resistance which could lead to the proliferation of superbugs that are more difficult to treat than the usual antibiotic-sensitive pathogens. Surgeons demonstrated an understanding that risk evaluation for blood loss had to be done for every patient, regardless of their status but that restricted their already constrained time allotted per surgery. Surgeons reported that they advised every serious patient ready supply of blood in case there arose a need for a blood transfusion during surgery. This protocol, however, was not followed for every patient due to the lack of resources. Every patient had different clinical status and not every patient required massive blood transfusions during surgery; hence, the risk of blood loss was evaluated only for serious patients. The most followed question of the checklist by surgeons was the identification of the patient and type of surgery with the anesthetist on board before a surgical incision was made. They stated that this was followed the most as they thought it was less time-consuming as well as the most yielding in terms of preventing never-events. Surgeons stated that certain individuals from the OR team appeared to be genuinely curious about the details and it seemed that some members of the OR staff were satisfied to simply go through the motions to get it over with as soon as possible, despite the fact that following such an approach completely undermined the purpose of the checklist exercise. For sign-outs, there was occasionally a sense of urgency as surgeons strived to finish the paperwork before the patient left the room. Obviously, there was a chance that something of importance could be overlooked if things were rushed, but it was assumed that such an event would not happen as much to cause an event of major clinical concern. A surgeon reported, "I am sure no life-threatening issue can arise if I just do the major things right".

Comparison between qualitative and quantitative results

Upon comparison of the quantitative results after the introduction of the WHOBARS rating and qualitative results from the interview, it is evident that the interviews provide insight into the data obtained using the quantitative method. We attempted to explain the quantitative data with the help of qualitative data under themes consistent with the questions of the checklist.

After the introduction of WHOBARS, 50.81% of respondents indicated that they always used the checklist in full (Table 3). With respect to performing the individual six basic safety processes, identification of the patient and type of surgery verified with surgeons on board before each operation (67.83%) was the most common to be done all the time. Evaluating the risk of difficult intubation before administration of anesthesia was the least commonly reported to be done all the time (39.72%). The frequency of self-reported use of the checklist and the six basic safety processes are shown in Table 3.

Using the checklist in the operating room

Results from the quantitative data show that 50.81% of respondents followed the checklist "always in full" and another 30.81% followed "always in part" after the introduction. In the interviews, respondents including nurses, surgeons, anesthetists, and anesthetic assistants mentioned that it played a positive role in their practice. Nurses and surgeons posited the fact that the use of a checklist helped OR staff recenters with a common goal of preventing adverse events and ensuring proper care of the patient. All members of OR who responded mentioned in

TABLE 3 Frequency of self-reported use of the checklist and the six basic safety processes.

Question numbers		Always in full	Always in part	Sometimes	Occasionally	Never	No response
1	Are you using the checklist in the operating room?	188 (50.81%)	114 (30.81%)	50 (13.51%)	7 (1.89%)	6 (1.62%)	5 (1.35%)
		Always	Most of the time	Sometimes	Occasionally	Never	No response
2	Identification of the patient and type of surgery verified with surgeons on board before each operation?	251 (67.83%)	74 (20%)	20 (5.40%)	11 (2.97%)	9 (2.43%)	5 (1.35%)
3	Risk of difficult intubation for the patient evaluated before giving anesthesia?	147 (39.72%)	54 (14.59%)	69 (18.64%)	49 (13.24%)	37 (10%)	14 (3.81%)
4	Risk of large blood loss evaluated before starting surgery?	189 (51.08%)	72 (19.45%)	49 (13.24%)	24 (6.48%)	17 (4.59%)	19 (5.16%)
5	Antibiotic prophylaxis was given before starting surgery?	194 (52.43%)	97 (26.21%)	38 (10.27%)	14 (3.78%)	17 (4.59%)	10 (2.7%)
6	Needles/swabs/ instruments counted before and after surgery?	189 (51.08%)	62 (16.75%)	74 (20%)	25 (6.75%)	19 (5.13%)	11 (2.97%)
7	Pulse oximeter being used in the operating theater?	173 (46.75%)	93 (25.13%)	26 (7.02%)	38 (10.27%)	28 (7.56%)	12 (3.24%)

A total of seven questions were asked and the responses were divided into six categories. The numbers without the brackets denote the sample size of respondents in the respective column and the numbers in brackets denote the percentage of those respondents among the total sample size.

one or another way that the use of a checklist helped them raise concerns, if any, that arose during the operation. Anesthetic assistants who responded also added that the use of checklists on a wider scale meant that they did not have to remind surgeons about checklist use since they already knew and implemented it in the OR.

Identification of the patient and type of surgery

Results from the quantitative data show that 67.83% of respondents "always" followed the checklist about patient identity and type of surgery and another 20% followed it "most of the time" after introduction. In the interviews, surgeons and anesthetists mentioned that they did this as it was the easiest in terms of time consumption and the most yielding in terms of preventing never-events like the wrong-patient and wrong-site surgeries. Anesthetists echoed somewhat similar reasons and went on to mention that they did this as part of the sign-in process. When surgeons also did it as part of the sign-out process, this added extra safety and better prevented never-events.

Evaluation of difficult intubation risk for the patient evaluated before giving anesthesia

Results from the quantitative data show that 39.72% of respondents "always" followed the checklist after the introduction and another 15.42% followed the checklist "most of the time" about the evaluation of difficult intubation risk for patients before giving anesthesia. In the interviews, anesthetists mentioned the reasons why this was the case and the main reason mentioned for using almost only half of the time was time constraints. The other reasons mentioned were lack of skill and the urgency with which the patient presented to the OR. A severely diseased patient requiring immediate surgery did not provide enough time to assess intubation risks in detail as the goal is to do surgery as quickly as possible.

Evaluation of the risk of large blood loss before starting surgery

Results from the quantitative data show that 51.08% of respondents "always" followed the checklist about the risk of large blood loss during surgery and another 19.45% followed it

"most of the time" after introduction. In the interviews, surgeons demonstrated the knowledge of the significance of evaluation for the risk of large blood loss for every patient. Reasons that acted as a hindrance to 100% adoption of this practice include, but are not limited to, lack of time, resources, type of surgery, clinical status, and the general thought that not every patient needs massive blood transfusions.

Antibiotic prophylaxis before surgery

Results from the quantitative data show that 52.43% of respondents "always" followed the checklist after the introduction regarding the administration of prophylactic antibiotics before surgery and another 26.21% of respondents followed it "most of the time". In the interviews, surgeons posited that they generally advise antibiotic prophylaxis for patients in the OR to prevent bacterial infections but the fear of unwanted antibiotic resistance and the proliferation of superbugs prevented them from adopting it 100% of the time.

OR material count before and after surgery

Results from the quantitative data show that 51.08% of respondents "always" followed the checklist after the introduction regarding instruments, swabs, and needles count and another 16.75% of respondents followed it "most of the time". In the interviews, nurses reported that their job of correct counting of instruments before and after surgery could not be followed all the time due to time constraints and fear of repercussions, especially from senior surgeons who have worked for a longer time in the OR. Surgeons on the other hand stated that they tried and made sure not to leave instruments inside but the complex OR environment and lack of communication led to adverse events such as leaving surgical instrumentation inside a patient's body after surgery is over.

Use of pulse oximeter in the OR

Results from the quantitative data show that 46.75% of respondents "always" followed the checklist after the introduction about the use of pulse oximeter in the OR and another 25.13% of respondents followed it "most of the time". In the interviews, respondents stated that they try their best to ensure every patient has a pulse oximeter in place while they are in the OR but the principal reason that this is not brought to fruition is lack of resources.

Discussion

In this article, we report a longitudinal investigation into the steady use of the Surgical Safety Checklist in Pakistan. According to our knowledge, this is one of the first in-depth analyses of checklist usage and surgical safety procedures conducted in Pakistan. Following the introduction of WHOBARS, the checklist was used to a modest extent, with 50.81% of participants completing it entirely. Hellar et al. (15) noted a higher SSC use rate of 68.8–99.4% (15) in Tanzania. Another study reveals that the checklist is used 65% of the time on average (16). The WHO checklist promotes adherence to fundamental safety procedures and seeks to increase operating room safety by fostering better cooperation and communication. Traditional medical training places a strong emphasis on the need for error-free practice and employs strong peer pressure to ensure accuracy in both diagnosis and treatment (17). Failures in communication can result in avoidable patient damage on their own. They can also be the root cause of subsequent injuries. Medicine errors can result from inadequate communication among doctors, pharmacists, nurses, and patients regarding the name, dose, delivery method, and timing of medication administration (18). Adherence and teamwork were listed by Treadwell et al. (19) as determinants of successful SSC results (19). Greater situation awareness is also made possible by communicating task-related information (20).

Implementing checklists in LMICs is hampered by a hierarchical culture, a lack of resources, and a lack of understanding (21). The first step in eliminating retained surgical materials is accurate counting and documentation, although this is rarely done in many LMICs. Counting needles, swabs, and other tools, as well as the scheduling of antibiotic prophylaxis, came up frequently in our focus group discussions. Our research showed that 52.43% of individuals considered evaluation of significant blood loss before surgery began. Additionally, 51.08% of participants in our study counted needles, swabs, and equipment both before and after surgery. We discovered that 46.75% of participants regularly used pulse oximeters in operating rooms. Due to the significant percentage of "no responses," it is assumed that these fundamental safety measures are implemented less frequently than 50.81% of the time. Therefore, there is still room for development, and future checklist courses ought to emphasize this communication-related aspect. The findings of this study, when compared to other studies, reveal both similarities and differences. Similar to previous research, the completion rate of the checklist in this study was around 50.81%, which aligns with the range of checklist usage rates reported in other studies. The importance of communication and teamwork in enhancing operating room safety was emphasized in both this study and previous research. Both highlighted the negative consequences of communication failures and the positive impact of adherence to teamwork principles. Additionally, the need for improvement in implementing fundamental safety measures was a common theme. Inadequate counting and documentation of surgical tools, evaluation of blood loss, and the consistent use of pulse oximeters were identified as areas where enhancements can be made. However, this study also highlighted the specific challenges faced in low- and middle-income countries (LMICs), such as hierarchical cultures, resource limitations, and lack of understanding. These challenges were not explicitly mentioned in other studies. The use of focus group discussions in this study provided qualitative insights that complemented the quantitative data from other studies. Overall, the findings from this study support the existing knowledge about the importance of checklist implementation and teamwork

while identifying specific areas for improvement, particularly in communication-related aspects, to enhance operating room safety in the future.

The use of checklists was linked to a better understanding of patient safety, hospital size, surgical volume, WHOBARS, greater personal satisfaction, and lower workplace stress. We were able to comprehend the dynamics underlying the OR rater scores, thanks to in-depth interviews. The critical roles of senior physicians were the quality of checklist administration, allowing staff to speak up, and connecting checklist administration to patient outcomes. These were also some of the elements our qualitative research discovered as reasons explaining both positive and negative staff impressions. We think that if used by OR personnel, self-ratings of checklist administration using this tool that specifically describes these behaviors might help to improve them in the administration of the checklist. Participants emphasized the need for staff members to actively participate in the checklist as part of a genuine conversation to prevent it from degenerating into a pointless exercise.

The checklist, according to nurses and anesthetists, was important in forming the team and bringing everyone together. In a Finnish trial, survey questions were distributed to treating personnel before and after the WHO checklist was implemented. Their understanding of team member names and responsibilities as well as the patient's identity, history, medications, and allergies significantly improved (22). Nevertheless, they noted that senior consultants did not take the checklist seriously and did not engage in full participation. Our research revealed that nurses frequently felt hesitant to voice their concerns.

Communication errors may be significantly influenced by a reluctance to speak up (23). The degree to which a nurse speaks up has been shown by Kolbe et al. to be a predictor of technical team performance (24). Additionally, we discovered that surgeons readily voice their worries since they believed it was their obligation. We discovered that only 39.72% of participants thought about the possibility of challenging intubation before administering an anesthetic.

On inquiring the operating staff about potential obstacles to adopting the checklist, we learned that ignorance of the checklist, a lack of knowledge of how to use it, a lack of drive, and a sense of its insignificance were the main obstacles. This finding is in contrast to research conducted in England, which found that the most frequent obstacle to the checklist's execution was opposition from senior faculty (25) followed by a shortage of staff members with the necessary knowledge and training. The opposite conclusions were drawn by a second French investigation as well. Some components of the checklist appeared to be consistently covered by pre-existing processes in surgical settings, making their adoption ineffectual and staff members' perceptions of it as checklist duplication unfavorable. Other obstacles were a lack of team member communication and the notion that the checklist was pointless and laborious to complete (26).

To improve patient safety, the WHO created the Surgical Safety Checklist. However, there was not enough knowledge about the formal execution of the checklist in our operating rooms inside our organization. Therefore, the main goals of our quality improvement project were to evaluate the level of adherence to the WHO Surgical Safety Checklist components within our current practice and to increase knowledge of its application. The ultimate goal of this research was to advance patient safety standards by determining any potential improvement in compliance following our educational intervention.

Comparing the findings in our study to those of other studies, several similarities and differences can be observed. Both our study and other research emphasize the importance of checklists in improving patient safety and enhancing team collaboration. The use of checklists was associated with a better understanding of patient safety, increased personal satisfaction, and reduced workplace stress in our study. Similarly, other studies found that checklists improved the understanding of patient information and communication within the team. However, there are differences in the identified obstacles to checklist adoption. Our study highlighted issues such as ignorance, lack of knowledge, and perceived insignificance, while other studies mentioned opposition from senior faculty and a shortage of trained staff. Additionally, our study revealed hesitancy among nurses in voicing concerns, which aligns with other research indicating that reluctance to speak up can lead to communication errors. These findings highlight the importance of addressing barriers to checklist implementation and promoting a culture of open communication within healthcare teams.

Additionally, our study has several drawbacks. A major drawback of our mixed method approach to this study is that qualitative information on a specific person's beliefs, experiences, and behaviors could not accurately reflect the general group effect predicted by a larger sample size in the quantitative portion of the study. Another drawback of our study is that interview partner selection was not random. It was voluntary and interviews were only conducted on those who voluntarily opted to give an interview. This is a potential source of selection bias in our study. Future studies should focus on random partner selection to eliminate this bias.

Conclusion

Our study's findings indicate that after the introduction of WHOBARS, 50.81% of participants use the WHO surgical safety checklist "always in full" every time. The use of a multi-disciplinary course for checklist implementation resulted in 50.81% of participants always using the checklist. If reproducible in other countries, widespread implementation in LMICs becomes a realistic possibility. Early results from the training course indicate the potential for widespread checklist implementation and counting instruments in LMICs, but more study is required to assess long-term sustainability.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethical Review Board of LNUH dated, 1st June 2022 ref no ERC: DSWIRB/2022/03061. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors have equally contributed to the manuscript and have approved the final manuscript to be published.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Achieving global surgical excellence: an evidence-based framework to guide surgical quality improvement programs in low and middle income countries

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Objectives: There is a lack of evidence-based guidelines for enhancing global surgical care delivery. We propose a set of recommendations to serve as a framework to guide surgical quality improvement and scale-up initiatives in low and middle income countries (LMICs).
Methods: From January-December 2019, we reviewed the available literature and their application toward LMIC settings. The first initiative was the establishment of Best Practices Recommendations intended to summarize best-level evidence around quality improvement processes that have shown to decrease morbidity and mortality in LMICs. The GRADE level of evidence and strength of the recommendation were assigned in accordance with the *WHO handbook for guidelines development*. The second initiative was the scale-up of principles and practices by establishing international expert consensus on the optimal organization of surgical services in LMICs using a modified Delphi methodology.
Results: Recommendations for three topic areas were established: reducing surgical site infections, improving quality of trauma systems, and interventions to reduce maternal and perinatal mortality. 27 studies were included in a quantitative synthesis and meta-analysis for interventions reducing surgical site infections, 27 studies for interventions improving the quality of trauma systems, and 14 studies for interventions reducing maternal and perinatal mortality. Using Delphi methodology, an international expert panel established consensus that district hospitals should place the highest priority on developing surgical services for low complexity, high volume conditions. At the national level, emergency and essential surgical care should be integrated within national Universal Health Coverage frameworks.
Conclusions: This project fills a critical cap in the rapidly developing field of global surgery: gathering evidence-based, practical, and cost-effective solutions that will serve as a guide for the efficient planning and allocation of resources necessary to promote quality and safe essential surgical services in LMICs.

KEYWORDS
global surgery, patient safety, quality improvement, low- and middle-income countries, safe surgery

1. Background

Since 2015, increasing surgical capacity in low- and middle-income countries (LMICs) has received increased attention in the international community with the inception of several landmark initiatives including the Disease Control Priorities, third edition (DCP3), on Essential Surgery and the Lancet Commission on Global Surgery (1, 2). In response, many countries have undertaken the creation of national policies and initiatives to strengthen infrastructure for surgical systems (3, 4). Similarly, private organizations, non-governmental organization (NGOs), universities, academic societies, surgical colleges and other on-the-ground providers have worked to increase capacity for surgical, obstetric, trauma, and anesthesia care in LMICs (5–8). While strides have been made in the assessment of surgical capacity and the establishment of national priorities for enhancing surgical care delivery, there is a lack of evidence-based guidelines to guide the scale up of high quality and safe surgical, obstetric, trauma, and anesthesia care.

Quality improvement is essential to improving morbidity and mortality in surgical systems (9, 10). Kruk et al. published an impactful work assessing the quality of health systems in the Sustainable Goals Era and found that healthcare in LMICs is often inadequate, of variable quality, and exacerbated in vulnerable populations (11). Confidence in their healthcare system is a valuable judge of a nation's overall performance, and this paper reports that one in three people in LMICs indicated negative experiences with their respective healthcare systems with regard to accessibility, respect, and communication (11, 12). There is also significant variation in surgical outcomes, with adults up to three times, and children seven times more likely to die after emergency abdominal surgery in LMICs compared to high-income countries (HICs) (13). It is estimated that 23 million disability-adjusted life-years are lost each year due to in-hospital adverse events alone and that two-thirds of these occur in LMICs (10). One challenge to establishing international best practices is that the surgical landscape looks vastly different across settings based on existing health infrastructure and the number and distribution of health care providers (8, 10–12). Some countries are more mature in their surgical systems, with well-established trauma systems, outcomes surveillance, and effective referral systems (11, 12). Other countries may rely on a patchwork of organizations, each covering different domains in surgical service delivery (5, 7, 12). One of the keys to developing high quality healthcare systems is the ability to scale-up at a respectable rate without losing impact. White et al. performed a thorough systematic review and found that from 1960 to 2020, there were only 31 studies that reported scale-up interventions as quality improvement measures, with the implementation of the WHO surgical safety checklist as the most common intervention (14). Similarly in a systematic review by Brima et al, of the 49 articles that reported hospital-based quality improvement studies in Africa, use of the surgical safety checklist comprised 29% and reduction of surgical site infections comprised 25% (15). Other interventions well-known to high income settings such as antimicrobial stewardship programs and streamlined postoperative care protocols are lacking in LMICs (14, 15). As all countries move toward self-sufficient surgical systems, practical and adaptable guidelines are needed to inform quality improvement initiatives across unique national, regional, and local settings.

In December of 2018, the G4 Alliance and the International Society of Surgery (ISS/SIC) established the International Standards and Guidelines for Quality Safe Surgery and Anesthesia (ISG-QSSA) Working Group. The group consisted of clinicians, epidemiologists, Ministers of Health, and research methodologists. The group was tasked to gather and compile existing evidence-based guidelines and recommendations for quality improvement in LMICs. From January to December 2019, the ISG-QSSA held a series of meetings to review the available literature and their application toward LMIC settings. Ultimately, two research initiatives were established. The specific objectives of the Best Practice Recommendations initiative were to evaluate the literature on quality improvement interventions, processes, and structures which reduce mortality and morbidity in LMICs. A secondary objective was to evaluate the balance between harms and benefits of interventions, patient and provider preferences and concerns, and the feasibility of introducing the interventions into LMIC settings. Subsequently, the objective of the scale-up principles and practices initiative was to establish international expert consensus on a set of statements describing the optimal distribution and prioritization of surgical services in LMICs based on prior published evidence on the efficacy of decentralizing or regionalizing surgical services (16–19). The statements covered three major areas: (1) the optimal distribution of surgical services, (2) the optimal prioritization of surgical services, and (3) policies and practices for enhancing surgical scale-up. This paper describes the research initiatives and findings of the G4 Alliance and the International Society of Surgery (ISS/SIC) International Standards and Guidelines for Quality Safe Surgery and Anesthesia (ISG-QSSA) Working Group (20, 21). We propose a set of recommendations to serve as a framework to guide surgical quality improvement and scale-up initiatives in LMICs.

2. Methods

2.1. Best practice recommendations

A systematic review was undertaken by the ISG-QSSA Working Group using the PubMed, Embase, Cochrane, WHO regional databases, Google Scholar, and Grey literature databases to summarize the interventional data from LMICs that have shown to improve morbidity and mortality. Three systematic reviews were ultimately completed and recommendations were created based on the available evidence. To comply with current standards for evidence assessment in the formulation of policy recommendations, methodology adapted from the *WHO Handbook for Guidelines Development* was used (22). A Guideline Development Group, consisting of 8 experts in the field, were tasked to collate the most relevant and significant

clinical questions and assign expert review to externally validate or reject the proposed questions. Review questions were developed within a framework population (restricted to LMICs), presence or absence of interventions under investigation, and mortality and morbidity outcomes. A consensus meeting was held in 2020 to confirm the findings of the systematic reviews and associated recommendation and assess the quality of evidence using GRADE methodology using independent reviewers (23–26). Of the eight criterion for rating the quality of evidence as described by the GRADE methodology, we focused on the three most dependable criteria as suggested by Malmivara et al. (24) We used risk of bias, inconsistency of findings, and publication bias to up or downgrade the quality of studies included (24, 25). Final recommendations were approved by the ISG-QSSA and formally ratified by the G4 Alliance Permanent Council on November 5th, 2021.

2.2. Scale-up principles and practices

33 international surgical experts convened in Suva, Fiji at a meeting hosted by the Fiji Ministry of Health in March 2020 where a roundtable discussion was held to refine modified Delphi statements around the topics of complexity, volume, and acuity of surgical care in LMICs. By providing input on their needs and the potential utility of the findings, 27 statements were collaboratively created which covered the global definitions of organization, distribution, and prioritization of surgical services in LMICs. Next, an open call was made for experienced surgeons and public health experts in the LMIC setting, and nominees by the G4 Alliance and Ministries of Health were sent a survey to confirm their credentials and experience. Using specific criteria such as: geographic scope, relevant expertise, work setting, and recognized impact, the final 53 participants were chosen representing 27 different LMICs. The experts were chosen for their recognized authority, clinical expertise in a range of surgical services, diverse geographical scope, and work in both public and private sectors. Half of the participants represented general surgery while the other half represented other surgical specialties. The participants were distributed across Africa, Asia, Europe, the Americas, and Oceania. A two-round Delphi process was used to establish consensus among this international panel of surgeon experts from LMICs. The first round involved independent ratings of the agreed upon statements without any interaction with the other participants. Participants chose the following options for each of the statements provided: strongly agree, agree, neutral, disagree, and strongly disagree. They were also instructed to make comments or edits to the proposed statements. The second round enabled participants to see de-identified comments from other involved members, but again, they provided ratings independently without engaging in discussion. The process was completed after two rounds because of the high rate of agreement between the 53 independent reviewers. Data was collected on an online platform, REDCap, which ensured anonymity during the two round process.

3. Results

3.1. Best practice recommendations

Recommendations covering three topic areas were established: (1) reducing surgical site infections, (2) improving quality of trauma systems, and (3) interventions to reduce maternal and perinatal mortality. For interventions reducing surgical site infections, 27 studies were included in a quantitative synthesis and meta-analysis. For interventions improving the quality of trauma systems, 27 studies were included. For interventions reducing maternal and perinatal mortality, 14 studies were included. The following heat maps demonstrate the countries in which research studies were conducted in each topic area (**Figures 1–3**).

Table 1 describes the final eleven Best Practice Recommendations. The GRADE level of evidence and strength of the recommendation are documented in accordance with the *WHO handbook for guidelines development*. A "strong" recommendation was made when it was clear that the net desirable consequences of the strategy outweighed those of no intervention. A "conditional" recommendation was made when it was less clear whether the net desirable consequences of the specified strategy outweighed those of no intervention.

3.2. Scale-up principles and practices

Recommendations covering three topic areas were established: (1) the optimal distribution of surgical services, (2) the optimal prioritization of surgical services, and (3) policies and practices for enhancing surgical scale-up. **Table 2** recommends the organization and prioritization of surgical services based on complexity, volume, and acuity of procedures. Organization was categorized as regionalized vs. decentralized and prioritization was categorized as very high, high, or low.

3.2.1. Recommendations for the optimal distribution of surgical services

The expert panel established consensus that low complexity surgical conditions should be decentralized, or managed by district centers close to communities. High complexity conditions should be regionalized or managed by specialized regional centers. In the case of trauma and emergency surgery, district centers should have the capacity to adequately stabilize patients and facilitate safe transfer of patients to regional centers for complex management.

3.2.2. Recommendations for the optimal prioritization of surgical services

The expert panel established consensus that district hospitals should place the highest priority on developing surgical services for low complexity, high volume conditions. There was general agreement that managing these conditions at district centers would relieve tertiary centers of these demands. Respondents also

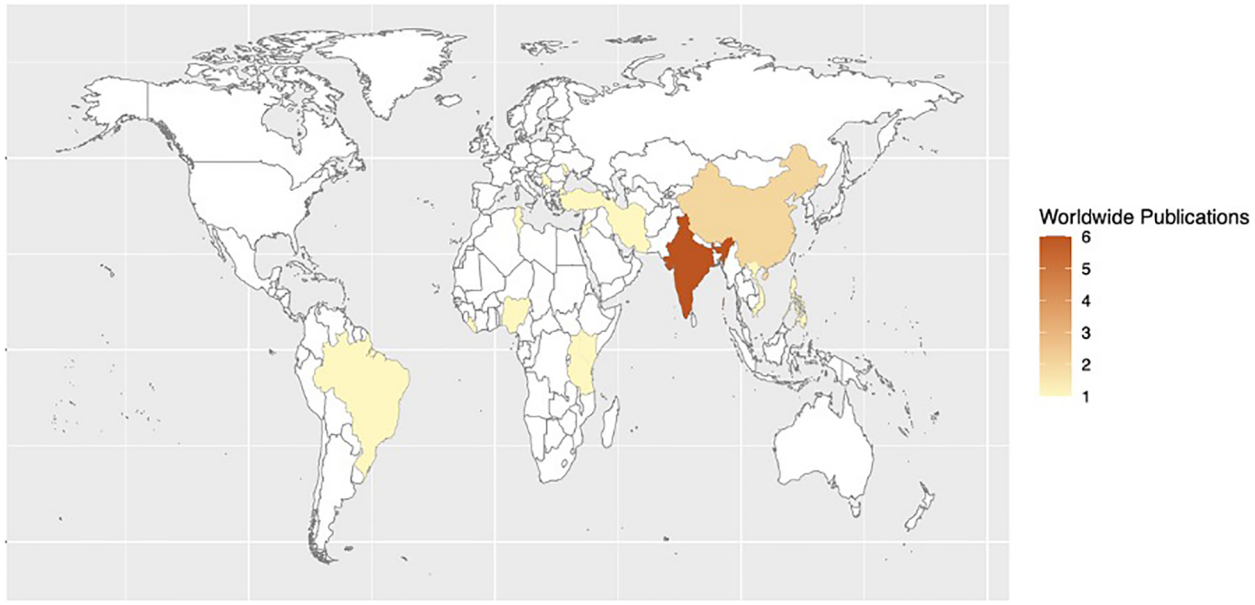

FIGURE 1
Heat map of studies assessing quality improvement processes, interventions, and structure for reducing morbidity and mortality from surgical site infections in LMICs.

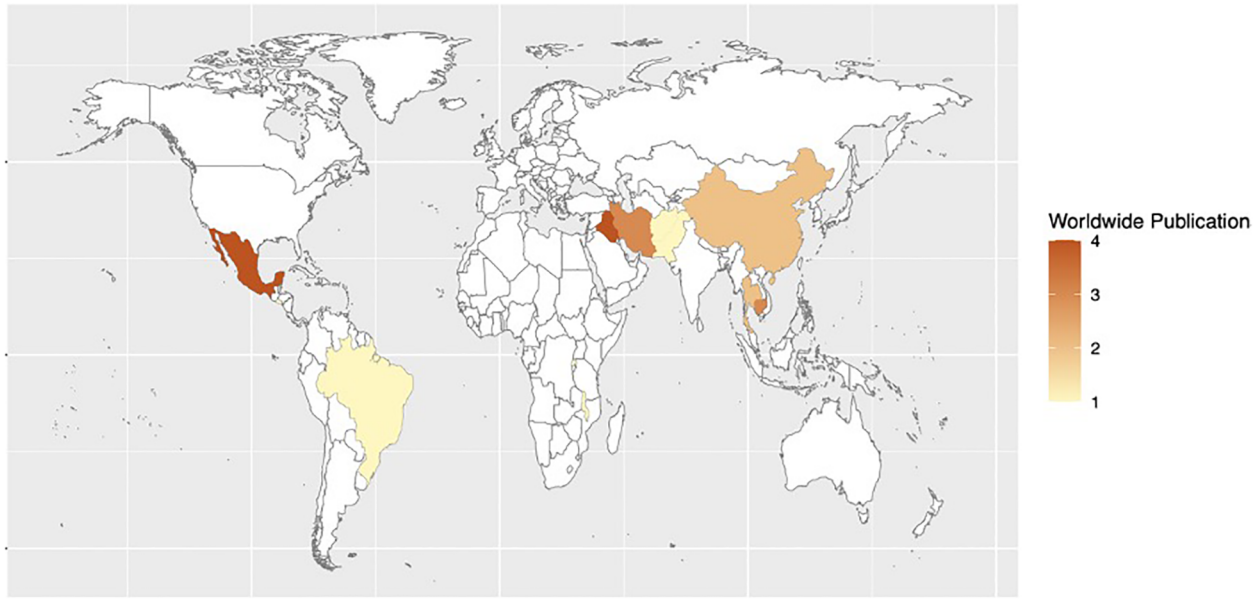

FIGURE 2
Heat map of studies assessing quality improvement processes, interventions, and structure of trauma systems in LMICs.

recommended that district centers place high priority on developing services for low complexity, low volume conditions such as non-trauma orthopedic surgery.

Recommendations were also made for the role of district centers in triaging high complexity conditions. District centers should prioritize establishing systems for screening and referral of high complexity surgical cases to specialized centers. In the case of complex trauma, district centers should place priority on developing capacity to stabilize patients and facilitate transport to regional centers.

3.2.3. Policies and practices for enhancing surgical scale-up

A set of principles for governments and organizations implementing surgical scale-up were developed. At the national level, emergency and essential surgical care should be integrated

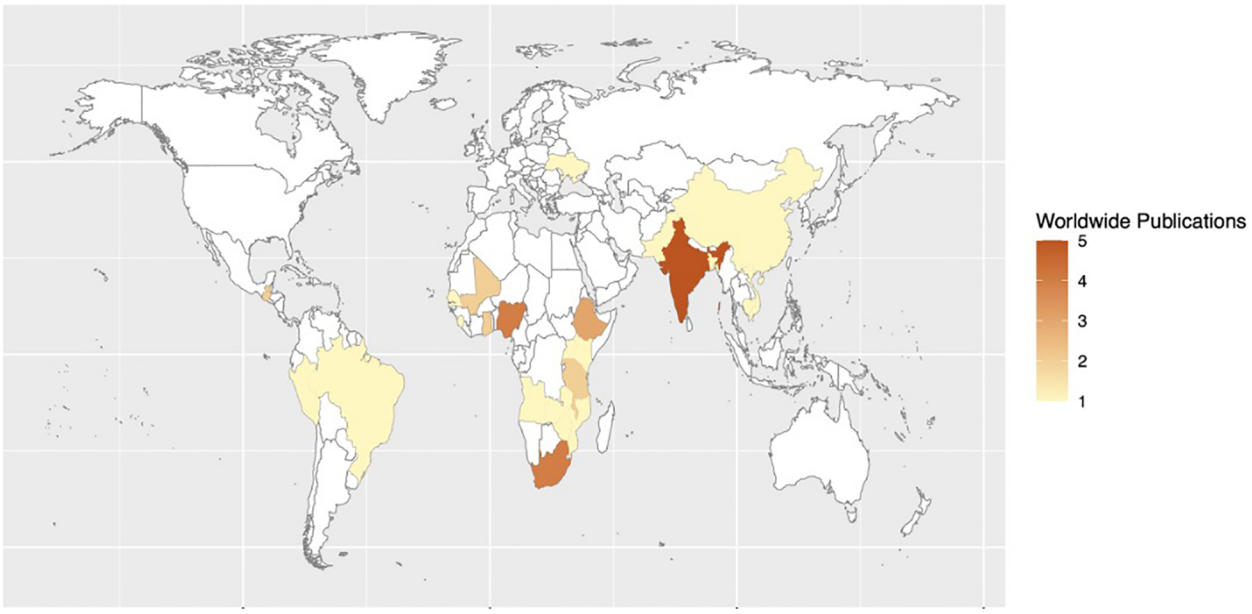

FIGURE 3
Heat map of studies assessing the impact of quality improvement processes, interventions, and structure on maternal and perinatal mortality in LMICs.

TABLE 1 The G4 alliance best practice recommendations for quality improvement processes in LMICs.

Recommendation statement	GRADE certainty of evidence	Strength of recommendation
1. The G4 Alliance recommends the implementation of the WHO Surgical Safety Checklist to improve postoperative morbidity and mortality in low- and middle- income countries (LMICs)	High	Strong
2. The G4 Alliance recommends the establishment of a Hand Hygiene Programme in hospitals as a cost-effective measure to reduce the incidence of hospital acquired infections	Moderate	Strong
3. The G4 Alliance recommends the creation of an antimicrobial stewardship programme (ASP) alongside the development of antibiotic prophylaxis guidelines as a cost-saving strategy	Moderate	Strong
4. The G4 Alliance recommends the establishment of an appropriate prehospital trauma system to reduce morbidity and mortality in trauma patients in LMICs	Moderate	Strong
5. The G4 Alliance recommends the training of first responders to reduce morbidity and mortality in LMIC trauma patients.	Low	Strong
6. The G4 Alliance recommends the training of trauma providers to reduce morbidity and mortality in trauma patients in LMICs.	Moderate	Strong
7. The G4 Alliance recommends the institution of trauma audits as a quality improvement strategy to reduce trauma mortality and preventable trauma mortality in trauma patients in LMICs	Moderate	Strong
8. The G4 Alliance suggests the implementation of community-based programs in the training of traditional birth attendants (TBAs) to incorporate them into the health system in low-income countries where TBAs are acceptable and may be the sole provider for women in childbirth to reduce maternal and neonatal mortality rates	High	Conditional
9. The G4 Alliance recommends the implementation of maternal health quality improvement programs (such as maternal death reviews, combined with best practices implementation) to reduce hospital-based maternal mortality	High	Strong
10. The G4 Alliance recommends the upgrading of facilities and staff competencies to meet the standards for providing comprehensive emergency and newborn obstetric care (CEmONC) to increase the quality of care provided, decrease the number of unnecessary Caesarean sections, and decrease obstetric and newborn case fatality rates	Low	Strong
11. The G4 Alliance recommends the education and training (skills and drills training, simulation-based training, post-graduate training programs) of appropriate health workers (obstetricians, midwives, associate clinicians) in maternal and neonatal health in all levels of care to reduce maternal and child mortality	Moderate	Strong

within national Universal Health Coverage (UHC) frameworks. National referral policies should be established to decrease delays in care, lower the cost of care, and improve outcomes. For surgical societies and university surgical programs in LMICs, in-country outreach is encouraged to reduce the backlog of neglected surgical diseases in underserved areas. Surgical societies or governments should establish registries and databases to better assess disease burden and specific facility performance, forming the backbone of performance assessment and monitoring.

TABLE 2 Recommendation matrix for surgical services based on complexity, volume, and acuity.

Complexity	Volume	Acuity	Example service	Organization	Priority for district center implementation	Comment
Low	High	Low	Preventive/screening Basic general surgery (e.g., hernia, common benign tumors) Basic ophthalmologic surgery (e.g., cataracts)	Decentralized	Very high	All communities need access to low complexity, high volume, low acuity surgical services. The low complexity of these services make them especially appropriate as the barriers to implementing them are lower.
Low	High	High	Basic trauma services Basic obstetric services Basic emergency surgery services (e.g., appendectomy)	Decentralized	Very high	Low complexity, high volume, high acuity services cannot be reasonably handled by referral. Regional centers have volume constraints and these problems are more efficient and cost-effective to handle at the district center, providing a chance for. improved outcomes. Basic services need to be available at the district center.
Low	Low	High	Basic emergency surgery services	Decentralized	High	Low complexity, low volume, high acuity services are best managed at the district center using basic services.
Low	Low	Low	Non-trauma orthopedic service	Decentralized	High	Low complexity, low volume, low acuity surgical services should be within the purview of a district center since it is a basic level of service.
High	High	Low	Common cancers (e.g., lung and breast cancer)	Regionalized	Low	High complexity, high volume, low acuity services are much needed in any community, but the high complexity and cost of implementing them becomes a lower priority. A proper screening and referral system at the community level should be implemented.
High	Low	Low	Complex oncologic and reconstructive services (e.g., pancreatic, liver cancer surgery)	Regionalized	Low	High complexity, low volume, low acuity services are served best by a national referral service.
High	Low	High	Complex emergency surgical services	Regionalized	Low	High complexity, low volume, high acuity services can be handled by a referral system.
High	High	High	Complex trauma services	Regionalized	Low	High complexity, high volume, high acuity services can adequately be handled by a system that can stabilize patients at a district center and transport them to a regional referral center.

3.3. Summary of recommendations

In summary, the ISG-QSSA proposes the following evidence-based recommendations to guide surgical quality improvement and scale-up in LMICs based on national, regional, district, and facility-level recommendations. On the national level, we propose integration of emergency and essential surgical care into national Universal Health Coverage (UHC) frameworks and the establishment of national referral policies that decrease delays in care, reduce costs, and improve outcomes. On the regional level, we propose the establishment of prehospital trauma systems, training of first responders, and training of trauma providers; regional center development of surgical services for high complexity cases; and the establishment of registries and databases to assess disease burden and facility performance, forming the backbone of quality improvement assessment and monitoring. On the district level, we propose district center development of surgical services for low complexity, high volume cases, procedures for stabilizing patients and facilitating safe and timely transfer in the case of complex trauma and emergency surgery, and the development and implementation of antibiotic prophylaxis guidelines. Lastly on the facility level, we propose the implementation of the WHO Surgical Safety Checklist, establishment of a hand hygiene program, creation of antimicrobial stewardship programs, upgrading of health care facilities to meet standards for providing comprehensive emergency and newborn obstetric care, implementation of maternal health quality improvement programs such as maternal death reviews, and institution of trauma audits.

4. Discussion

The recommendations put forth by this study are designed to provide a flexible framework that can be utilized by members of the global surgical community. They encompass surgery, anesthesia, trauma, and obstetrics recommendations, and utilize prioritization and distribution as a way to suggest both top down and bottom-up change. While all recommendations reflect evidence-based strategies to improve quality of surgical care in LMICs, individual recommendations pertain more specifically to unique tiers of a health care system. The designations of "national", "region", "district" and "facility-level" as mentioned above are flexible and can be defined more specifically according to the unique health system in which these recommendations will be applied. Additionally,

individual recommendations may be relevant across multiple tiers and can be implemented in a parallel fashion, for example at both facility- and district-levels. Although the WHO highlighted the need to focus on scale-up over 15 years ago, there has been a lag between concept and reality (11, 12, 14). Implementation science education and experience may have been less common in decades past, but current research clearly indicates the need for these established frameworks to be at the center of any study design that aims to achieve sustainable implementation efforts (14, 27–29). With the matrix of recommendations reported in our study, we hope to add stepping stones that enables researchers, policymakers, and healthcare providers to create plans that synergize from each domain.

One of the strengths of this manuscript is the development of a set of building blocks that can help inform changes on both institutional and bureaucratic levels. The acknowledgement that there is no one size fits all technique to developed safe surgical systems is the first step to creating sustainable change. The WHO handbooks on diverse surgical topics have begun to set a foundation for strengthening surgical systems but there is more specificity needed to turn theory into action, which we hope to bridge with studies such as this (2, 10, 22, 29, 30). We aimed to contribute to existing literature by isolating publications from LMICs and following up with current knowledge, attitudes, and perceptions from LMIC experts who have the historical and current landscape of surgical care in their respective countries through a modified Delphi process. We envision the creation of a global implementation strategy for these recommendations that will complement the vast network of existing surgical communities. The G4 Alliance, as an organization, is working towards creating toolkits that will help individual hospitals, as well as national healthcare systems, enhance the already existing infrastructure to be able to practice and deliver healthcare at the highest of their capabilities (20). With the focus on surgery as an essential component of primary care, this solution-driven initiative will ultimately reduce the backlog of surgical neglected diseases by 2030 (27–30).

This study has several limitations including the fact the literature on quality improvement from LMICs is relatively sparse and does not include all the areas of perioperative care. Although the literature represented every region in the world, the geographic representations were skewed as resource limitation for research exists in certain areas of the world more than others. In addition, the members of the expert committee were predominantly from Africa and the situation may not be generalizable to distinct regions with unique baseline needs. Also, none of the panelists were trained specifically in obstetrics, while many do perform routine Cesarean sections. Nevertheless, the best practice recommendations covering maternal and perinatal care should be further vetted by LMIC obstetric experts. Most importantly, the majority of authors on this manuscript are from high-income countries. Although we received global participation during the multi-year process, the organization and drive for this manuscript ultimately stems from stakeholders in high-income countries, which highlights other issues in global surgery and collaborative research which we do not want to perpetuate. The Fiji Ministry of Health was actively involved in seeing the project through and we do aim to acknowledge the valuable time and effort involved for the coordination of the in-person portion of this study.

In this project, we started with a systematic review of the literature with the understanding that it may not be an accurate representation of healthcare systems in LMICs today. Research has shown that even with currently published data, we know very little about the actual patient experience in LMICs and the efficiency and competence of the overall healthcare system (11, 12, 14). Nevertheless, we do believe that having a starting point is essential to create targeted goals and inform new and higher quality research studies. We hope that this manuscript can serve as one tool in addressing the wide range of inequities and deficiencies across continents, not as a punitive measure, but as a call to action for both public and private sectors to work together in creating an achievable roadmap toward making a healthcare system that is for the people it serves. In conclusion, this project fills a critical cap in the rapidly developing field of global surgery: gathering evidence-based, practical, and cost-effective solutions that will serve as a guide for the efficient planning and allocation of resources necessary to promote quality and safe essential surgical services in LMICs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

JH: concept design, data analysis, manuscript editing, final approval. L-YW: concept design, data analysis, manuscript writing, final approval. AR: concept design, data analysis, manuscript writing, final approval. JJ: concept design, data analysis, manuscript editing, final approval. MF: concept design, manuscript editing, final approval. CY: concept design, manuscript editing, final approval. AH: concept design, manuscript editing, final approval. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Using participatory action research to empower district hospital staff to deliver quality-assured essential surgery to rural populations in Malawi, Zambia, and Tanzania

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Background: In 2017 the SURG-Africa project set out to institute a surgical, obstetric, trauma and anesthesia (SOTA) care capacity-building intervention focused on non-specialist providers at district hospitals in Zambia, Malawi and Tanzania. The aim was to scale up quality-assured SOTA care for rural populations. This paper reports the process of developing the intervention and our experience of initial implementation, using a participatory approach.

Methods: Participatory Action Research workshops were held in the 3 countries in July–October 2017 and in October 2018–July 2019, involving representatives of key local stakeholder groups: district hospital (DH) surgical teams and administrators, referral hospital SOTA specialists, professional associations and local authorities. Through semi-structured discussions, qualitative data were collected on participants' perceptions and experiences of barriers to the provision of SOTA care at district level, and on the training and supervision needs of district surgical teams. Data were compared for themes across countries and across surgical team cadres.

Results: All groups reported a lack of in-service training to develop essential skills to manage common SOTA cases; use and care of equipment; essential anesthesia care including resuscitation skills; and infection prevention and control. Very few district surgical teams had access to supervision. SOTA providers at DHs reported a demand for more feedback on referrals. Participants prioritized training needs that could be addressed through regular in-service training and supervision visits from referral hospital specialists to DHs. These data were used by participants in an action-planning cycle to develop site-specific training plans for each research site.

Conclusion: The inclusive, participatory approach to stakeholder involvement in SOTA system strengthening employed by this study supported the design of a

locally relevant and contextualized intervention. This study provides lessons on how to rebalance power dynamics in Global Surgery, through giving a voice to district surgical teams.

KEYWORDS

participatory action research, essential surgery, anesthesia, obstetrics, trauma, nursing, sub-Saharan Africa, engaged research

1. Introduction

An estimated 95% of people in low and middle-income countries (LMICs) lack access to safe surgery, with most unmet need among rural populations, especially in Sub-Saharan Africa (SSA) (1). To meet this need the World Health Assembly recommended expanding the capacity of district-level hospitals (DHs) (2). As the first point of contact for common conditions amenable to surgery, DHs can play a key role in enhancing surgical service coverage and financial protection for rural populations, particularly marginalized and hard-to-reach groups, thus advancing the goal of universal health coverage.

However, workforce shortages and increased pressures on health systems are limiting factors in SSA. These have led to increased professional differentiation at district hospitals, with task-sharing/task shifting of specialist duties to non-specialists (e.g., non-physician clinicians – NPCs and generalist medical officers – GMOs) (3, 4). The cost of surgical training of non-specialists is considerably less than the cost to train specialist surgeons (5, 6). For common, selected surgical procedures, they can achieve similar (effective and efficient) outcomes to SOTA specialists (7), if trained and supervised (4, 8). Yet, non-specialist surgical providers at DHs often work in isolation with few opportunities for professional development and support (9, 10), leading to concerns over the quality and safety of their work once deployed (11).

To address this gap, in 2017 the SURG-Africa project set out to institute a surgical, obstetric, trauma and anesthesia (SOTA) care system strengthening intervention in Zambia, Malawi and Tanzania, focused on non-specialist workforce training, supervision and mentoring (protocol published elsewhere (12)). The aim was to design, implement and evaluate in-service training models to scale up quality-assured SOTA care, appropriate to district hospitals.

In this paper we report the process of developing the in-service training model and our experience of initial implementation, using an inclusive and participatory approach.

1.1. Strategies to maximize benefits

Both the Lancet Commission on Global Surgery (11) and national policies (13, 14) state that the ability of non-specialist providers to consult with specialists is critical to the success of task-sharing/shifting models of SOTA care delivery. Quality control systems need to be in place, especially for the management of complicated or unusual surgical or anesthetic procedures. In theory, in the study countries, this should be done through outreach programs, during which SOTA specialists from central and provincial levels periodically visit district facilities to manage the backlog of advanced cases and provide supervision. Our intervention aimed to introduce a more efficient and innovative approach to outreach, designed to go beyond simple supervision visits by specialists to undertake cases at district hospitals; and instead to promote the transfer of knowledge and skills from the specialists to the non-specialist providers, to gradually build local capacity to handle a wider range of SOTA cases and improve referral practices. This was achieved through prioritizing in-service training in visits from specialists.

Additionally, to increase efficiency and speedy and informed decision-making, a managed consultation network was established to ensure regular communication among specialist supervisors and non-specialist district providers in-between visits. Consultations supported collaborative decision-making (whether or not to operate locally, correct case management or referral preparation); and enabled better coordination across care levels in case of patient referral (12). Several strategies were adopted to ensure the relevance, acceptability and sustainable benefits of the intervention as described below.

1.1.1. Development of the training approach

Firstly, the development of the training model was informed by key principles from adult learning and behavioral theories (15). Training sessions included a theoretical and practical aspect, since interactive sessions, which allow participants to practice and hone skills, are more effective at influencing change in professional practice and health care outcomes than purely didactic sessions (16). Training was organized in small groups to allow interaction, experimentation and critical reflection, given the compelling evidence that adults change practice by active learning rather than being taught (17–19).

In line with social influence theories, which assert that individuals' beliefs and behaviors are influenced by persons in their social network and society at large (20), the intervention was delivered by respected peer leaders, i.e., specialist SOTA providers from central and general hospitals, who oversaw the referral networks of the participating DHs. The use of local specialists, rather than international experts (21), was an explicit strategy to maximize the long-term sustainability of the intervention.

Critically, local government rates were applied for the specialists delivering the program of visits, to facilitate implementation by the ministry of health (MoH) after the end of the project. Also, all supervisors were trained in pedagogy, feedback, supportive supervision, communication and adult learning techniques. This empowered them to be agents of change within their networks, facilitating transmission of the model to their referral hospital colleagues, necessary for supervision in a scaled up program.

1.1.2. Promoting engagement and local ownership

Adult learning theory states that adults perform better on learning tasks that are meaningful and which fall within their domain of

interest (22). Therefore, adult learners should be involved in planning curricular directions and should be encouraged to diagnose their own learning needs and objectives, to increase the relevance of the training content and stimulate learners' motivation to engage (22).

This principle resonated with our desire to make the training program as relevant as possible to the needs of the different cadres of district level SOTA providers taking part in the intervention. It was also important for us to ensure alignment of the intervention with the needs and priorities of the wider SOTA care system stakeholders in the study countries, including local authorities, professional associations and hospital administrators.

Recent discourses on the colonial legacies of global health have highlighted that health interventions that are donor driven and not locally owned risk inadvertently supporting the delivery of healthcare in a way that undermines local care system sustainability and heightens dependence on external help (23, 24). Sustainable system strengthening interventions necessitate feasible and realistic approaches, informed by local MoH and stakeholders' views of and proposed solutions to their health problems (23); and require them to take ownership and leadership of the interventions (25). This requires their active engagement throughout the research process.

Therefore, SURG-Africa adopted a participatory action research approach as an overall conceptual umbrella to the design, implementation and evaluation of the in-service training and supervision intervention and associated research. Participatory action research (PAR) is a form of collaborative inquiry enabling those involved in the problem under study to be part of the research process; and the research is conducted *with* people rather than *on* them (26, 27). The aim is to study and foster positive change in a particular group, organization or team (28) by democratizing knowledge production and fostering their empowerment (29).

Participatory research approaches have been widely and effectively applied to address public health priorities (30), health systems strengthening and to improve health workforce performance (31). However, to our knowledge, application of this methodological approach in the field of Global Surgery research is new and can provide valuable lessons for strengthening SOTA care for neglected populations in SSA.

2. Methods

We held iterative PAR workshops in each country at baseline (design), midpoint (implementation) and endline (evaluation) stages of the training intervention. This paper focuses only on the baseline and midpoint PAR workshops, and explores how stakeholders and researchers used the PAR findings to co-develop and strengthen the intervention design, specific to each country.

2.1. Workshop participants

In the design phase, 2-day PAR workshops were held in Zambia in July 2017, in Malawi in August 2017 and Tanzania in October 2017. Follow up PAR workshops (1 day) were held in October 2018–July 2019. These were attended by a total of 119 stakeholders at baseline and 123 at midline across Zambia, Malawi and Tanzania. Attendees included surgical teams as well as hospital administrators from the 31 intervention district hospitals and the main referral central and provincial hospitals. In this paper the term 'surgical team' refers to the following professionals: surgical, trauma and anesthesia care providers, theater nurses, obstetricians and gynecologists, as applicable to each hospital level.

Attendees were selected by hospital managers overseeing each participating facility on the request of the research team. They needed to be either surgically active or a representative from a district or central level hospital who could help identify potential implementation, governance, and communication challenges for the intervention, so that these could be addressed locally at the earliest opportunity. Representatives of national surgical, anesthetic, nursing and obstetric professional bodies, and of ministries of health, were also invited to contribute to the discussions. A breakdown of workshop participants is provided in Supplementary File 1.

2.2. Targets

The purpose of the baseline PAR workshops in each country was threefold:

- To gain a better understanding of the local context in which the intervention was to be delivered and how this may affect implementation – i.e. policy and operating environment, local surgical care systems' factors, SOTA conditions commonly presenting, extent of existing district hospital SOTA training and supervision.
- To explore the needs (especially training needs) and challenges of district surgical teams in the delivery of care, and proposed solutions, based on their own lived experience and perceptions.
- To co-design the intervention: presenting the proposed model and eliciting reflection, discussion and joint agreement on how this could be improved and delivered.

The midpoint workshops aimed to jointly review and reflect on the intervention implementation and to identify areas needing further modification, in an inclusive manner. In doing so, they also served to validate the findings of the baseline workshops and the overall in-service training model.

Sets of questions for the baseline and midpoint workshops were developed by the research team around these themes; the full list is reported in Supplementary File 2.

2.3. Delivery of the workshops

PAR research follows a cyclical process of observation, reflection, action, evaluation/critical analysis and modification (Figure 1), with each cycle yielding new insights or improvements. PAR begins with "small" cycles that address comparatively minor questions or problems before participants move on to more complex or consequential issues (28).

In this study, the baseline workshops represented the first set of 'cycles'. Researchers and stakeholders joined forces to develop knowledge to inform practice and solve concrete problems - in our case how to expand SOTA care delivery for rural communities through district hospital capacity building. This feature of PAR ensures that the actions of those involved are better informed, if not changed, through the research process (27, 30). Hence, PAR is transformative rather than merely informative (27).

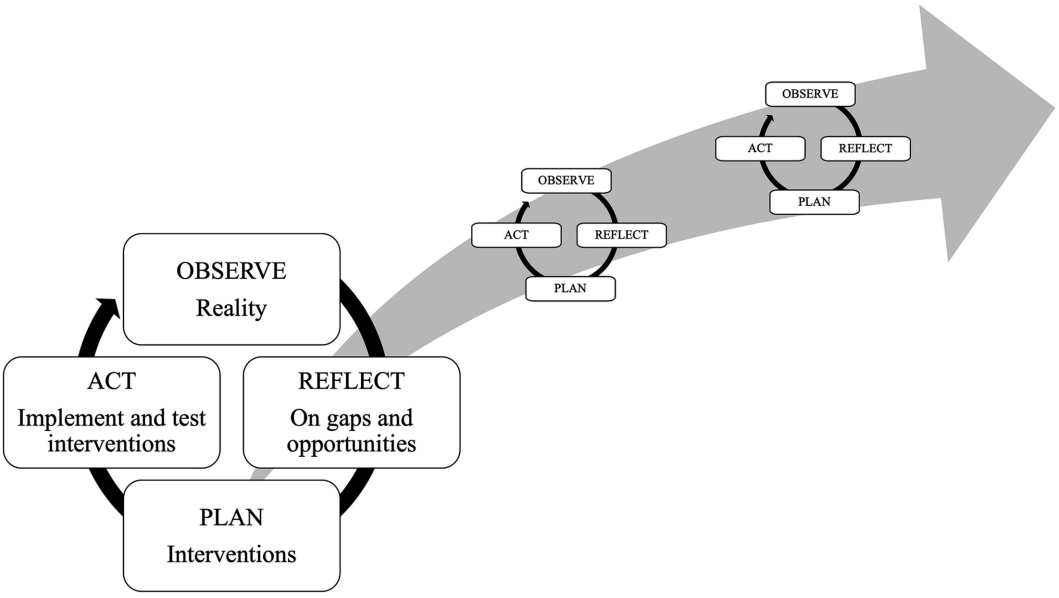

FIGURE 1
The PAR cycle.

Through a series of group work sessions and plenary discussions, structured around a set of carefully predetermined questions (Supplementary File 2), workshop participants were led through a process of collaboratively:

- Gaining situational awareness of the DH surgical system and common challenges and priorities.
- Exploring the current provision of training, supervision, and mentoring available to DH surgical teams.
- Identifying gaps and opportunities for training, supervision, and mentoring that could be addressed by the intervention.

This was then used to inform the refinement of the intervention and agree on an action plan for the supervisory visits.

The workshops firstly involved group work with DH mentees on their own, i.e., those who would receive supervisory visits, pairing the representatives from 2 DHs. This was followed by group discussions involving DH mentees, central/provincial hospital mentors and other stakeholders. The PAR workshops were iterative in that mentees had the opportunity to discuss questions on day 1 and then these were followed up on day 2, when mentors and other stakeholders joined the discussions.

This sequence was to allow DH surgical teams the time and opportunity to gradually build up their confidence as a group, to enable them to share their views with more senior specialists from higher-level hospitals, and with national level stakeholders, in a safe space. This encouraged open communication and the overcoming of hierarchical and sociocultural barriers. We also used cadre-specific group discussions to elicit experiences and views common across DH cadres such as anesthesia providers, surgical care providers and theater nurses. Each round of group work was followed by a plenary session (as in Table 1) to validate group observations through collective discussions and consensus.

The midpoint PAR workshops followed a similar structure but discussions were condensed into 1 day. The focus was on reviewing progress in the intervention to-date, sharing experiences, lessons learned and identifying any areas for improvement. Action planning and recommendations for the coming 6 months of SURG-Africa visits were made.

2.4. Data collection and analysis

The workshops were run at a central location in each country, facilitated by a team of 5–6 (international and local) researchers and key representatives of the stakeholders groups. Data sources collected included: the participants' written notes of their group discussions, the visit plan templates, the facilitators' notes and transcriptions of verbal presentations given by each discussion group.

No individual identifiable information was collected and only aggregated data (from the breakout sessions or plenary discussions) were gathered and analyzed. To avoid deductive disclosure, the breakout groups were identified using numerical codes (e.g., group 1, 2, 3 etc.). Two researchers collated the written qualitative data from the three workshops into MS Word and spreadsheet documents. A thematic content analysis was conducted in the software QSR Nvivo 11, a qualitative research management tool. The research targets (as above) and group work questions (in Supplementary File 2) were used to guide the analysis, this was then enriched with new emerging nodes during the coding process.

3. Results

3.1. Local context and operating environment

An important issue that emerged from the baseline PAR workshop discussions was the skills, availability and management of the different

TABLE 1 Overview of the PAR workshop.

Overview of the PAR workshop		
Day 1 - District hospital teams (i.e., mentees) only	Day 2 - All participants	Outputs
Introductions, overview of the proposed intervention model and PAR process (setting expectations and clarifying limitations) – *Mentee groups by pairs of district hospitals:* Discussion 1: Snapshot of the surgical system in the country Discussion 2: What supervision and mentoring is happening in hospitals, and explore possibilities – Plenary – Discussion 3: Training (reflection on existing training, and needs and possibilities) Discussion 4: Detailed planning for the SURG-Africa intervention (developed timetable for 2-day visit) – Plenary	Introductions, the role of supervision, mentoring and training to scale up safe surgery, and recap of previous day's proceedings – Presentations on DH training, supervision and mentoring needs from the perspective of referral hospitals – Presentations on the role of the supervisory teams – *Mentees-mentors and other stakeholder groups split by cadre (surgery/trauma/obstetrics, anesthesia, theater nursing):* Discussion 1: Supervision and mentoring needs and opportunities for DHs Discussion 2: Training needs and opportunities for DHs – Final discussion (all together) on intervention design	- Draft action plan/timetable for the visits tailored to each intervention DH - Recommendations for the intervention design - Identified key contacts at district and referral hospitals, for logistical planning and implementation

staff cadres in the sample DHs across the three countries. Most hospitals reported uneven skills level across staff cadres and reliance on few skilled personnel for SOTA services. While there was an adequate pool of general nurses available in DHs in the three countries, it was reported that theater nurses were commonly rotated within hospitals and provided cover whenever necessary rather than being permanently assigned to theater duties. This hindered continuity of service and nurses' ability to acquire and retain essential theater skills.

Stakeholders stated that the type of SOTA procedures done in individual hospitals depended on the availability of skilled staff, but they were in insufficient numbers to deal with the volume of work. Intermittent availability of surgical supplies and breakdown in critical equipment were also common across the three countries.

All these factors affected the quantity and quality of surgeries performed at the district level. They also increased the frequency of referrals of cases to higher care levels, contributing to congestion at central level facilities and higher costs for patients.

Stakeholders confirmed that, at the time, no national guidelines or set standards were in place to guide the work of the district surgical team, and they felt that the development of such material would be extremely helpful in improving the quality of surgical care. International guidelines on quality of care, such as the WHO surgical safety checklist, were known but usually not followed.

3.2. Experience of previous in-service training, mentoring, and supervision

All workshop groups across the three countries reported a lack of in-service training available to develop essential skills such as pre, intra and post-operative care, and the surgical skills to manage common surgical, obstetric and trauma conditions seen at DHs. They also reported limited or no training opportunities in the use and care of surgical and anesthesia equipment, essential anesthesia care and infection prevention control. The groups reported a lack of access to mentoring, and lack of feedback on surgical cases referred to higher-level facilities.

In regards to supervision, some of the workshop participants reported that on-the-job support was offered by occasional visiting doctors, often from NGO programs (e.g., AMREF flying doctors or ONSE project in Central Malawi). However, priority in these visits was usually given to clearing the surgical lists rather than on the sharing of knowledge with district hospital staff. Also, these programs were often irregular, due to overstretched government resources or intermittent donor funding. Despite the limited scope of such initiatives and their irregularity, when supervisory visits did take place in some hospitals, participants stated that the visits were appreciated as this enabled preparation of cases and some (albeit limited) learning. A reported drawback was that there was often not much feedback and no communication on the patient's progress after these visits.

3.3. Action planning and co-design of the intervention

Through an action-planning cycle the workshop participants identified and prioritized the training needs that could be addressed by the project through regular in-service training, mentoring and supervision visits over an intervention period of 24 months. The participatory action process led to critical changes and adjustments to the intervention design, as follows.

3.3.1. Training content

3.3.1.1. Original proposal

The Lancet Commission on Global Surgery proposed a core set of high volume, cost-effective essential procedures which, being less technically complex, could be delivered at DH level (11). Hence, the training was to be focused on these essential general surgical and obstetric procedures, and trauma management and stabilization, with the aim of increasing the range of SOTA services offered at district level. In addition, the training was to cover a range of non-technical skills such as management skills, professionalism, patient-centeredness, data collection and use of surgical information systems.

3.3.1.2. Post-PAR intervention design

The workshop groups recommended that, given the varying skills level of district surgical teams, the training content should include new essential SOTA procedures. But it was also important to provide refresher training on core SOTA skills, as well as addressing other knowledge gaps. Examples of priority training areas identified in the workshops are presented in Table 2.

In terms of non-technical skills, the groups emphasized that rather than focusing on hospital management teams or other staff, in the first instance the training should start with the surgical teams. They identified the need to encourage more teamwork within the district hospital teams, as well as across care levels, since district and higher level hospitals tended to work in isolation, with little communication and coordination. The basics of infection prevention and control were to be reiterated, including promoting the use of the surgical safety checklist as standard practice. Attention was also needed on ways to promote accountability and reduce reluctance to embrace new practices.

3.3.2. Training visits design

3.3.2.1. Original proposal

To develop an in-service training guide and curriculum that would be followed as standard by all of the participating district hospitals for each training visit.

3.3.2.2. Post-PAR intervention design

It was decided that the training visits were to be planned according to the training needs identified by each intervention hospital as most urgent. This implied changing the intervention approach from a top-down, standard training model to an individualized and needs-based one. Each DH team and their mentors developed a typical visit itinerary and range of activities/components and discussed logistics that worked best for their specific hospital needs.

3.3.3. Timing of training visits

3.3.3.1. Original proposal

The DHs would have periodic (3–6 monthly) field visits from mentors.

3.3.3.2. Post-PAR intervention design

Negotiations during the workshop determined the duration (2 days) and the frequency (every 3 months in Zambia and Tanzania, every 2 months in Malawi) for the visits. These discussions took into account the SOTA specialists' availability, visit costs and feasibility to subsequently determine the best visit time frames.

3.3.4. Mentees for training

3.3.4.1. Original proposal

The training was aimed at a broad range of DH staff involved in the provision of and support to surgery at DHs, including: NPCs and doctors who undertake surgeries, anesthetic staff, post-operative ward nurses, administrators responsible for supply chain management, maintenance, transport, medical records, management information systems.

3.3.4.2. Post-PAR intervention design

To maximize the limited time available during the visits and to ensure meaningful (and impactful) engagement, the workshop groups recommended that the training approach be more targeted, focusing on clinical staff (SOTA providers and theater nurses) in the first instance. This was based on an understanding of the challenges of existing team dynamics and training gaps gathered during the PAR workshop, and the recognition of the need to offset the influence of staff rotation and turnover on retention of district surgical teams' knowledge.

3.3.5. Mentors for training

3.3.5.1. Original proposal

The mentors would be specialist surgeons working at referral hospitals, supported by one or more anesthesiology and obstetric specialists.

TABLE 2 Examples of reported district training needs and priorities.

Reported training needs and priorities		
Surgical, trauma, obstetric providers	Anesthesia providers	Nurses working in theater
• Basic surgical skills • Advanced Trauma Life Support training (in Tanzania) • Emergency cases (surgical and obstetric) • Resuscitation • Investigations and diagnostics, including referral decision-making • Ultrasound training	• Recognition and management of the severely injured patient • Pre-, intra- and post-operative care (including preparation of patient, spinal and general anesthesia, monitoring) • Record keeping and data • Fluid management • Using anesthesia equipment	• Skills to deal with surgical emergencies • Basic handling of surgical instruments • Familiarization with common surgical procedures presenting at district level • Essential skills on scrubbing, gowning, gloves and use of drapes • Post-op care

3.3.5.2. Post-PAR intervention design

The workshop groups determined which cadres and how many mentors should be in the visiting specialist team, with country-specific team composition. Instead of 1–2 mentors in each team, the teams were expanded to 3–4 persons to include a theater nurse alongside the surgeon and anesthetist, and often additionally included either an orthopedic surgeon (in Tanzania) or an obstetrician as needed.

In Malawi, theater nurse training was identified as most urgent, but there was limited capacity locally. Hence, a decision was made to invite theater nursing specialists from Zambia to deliver training of trainers in Malawi to build up local capacity to deliver the intervention.

3.3.6. Training curriculum

3.3.6.1. Original proposal

The training curriculum was to be organized around a range of standalone modules adapted from: (i) a Primary Trauma Course already in use in several countries in the region (32); and (ii) the Essential Surgical Training curriculum being run by the College of Surgeons of East, Central and Southern Africa (COSECSA) as a district hospital training program (33).

The mentors would use the Primary Trauma Care courses and Essential Surgical Training curriculum for each visit. During those visits, the mentors would cover the knowledge, skills, and attitudes in surgical skills and competencies as agreed by national stakeholders and the essential general surgery and obstetrical surgery, and trauma management and stabilization.

3.3.6.2. Post-PAR intervention design

Workshop groups discussed stand-alone courses such as Primary Trauma Care, but it was clear that other knowledge gaps were to be addressed and not all district teams were at the same level or perceived the same needs. The choice to proceed with an individualized, needs-driven approach to training required more flexibility in the curriculum than that originally planned. The groups also emphasized their preference for practical, rather than didactic training. Elements of primary trauma care training were incorporated into the visits rather than centralized courses.

The workshop groups agreed to prioritize the mentees' needs rather than the mentors' preferences, through targeted, personalized mentoring that addressed the mentees' weaknesses. To this end, mentors and mentees were to agree learning goals together to work toward, and jointly agree the 'terms of reference' of the working relationship, so that expectations were clear and realistic.

The workshop groups stated that another critical consideration for the success of the intervention was the need to focus: (1) on supportive supervision, rather than top-down supervision, which was typical in some medical disciplines. This required developing honest and clear communication between mentors and mentees; and (2) on the district surgical team as a whole, rather than individual cadres, since SOTA care delivery is a "team" effort.

3.4. Midpoint PAR proceedings

The midpoint PAR workshops offered an opportunity for stakeholders to reflect on their experience of the intervention to that point and to review progress. The main takeaway message was that overall the (co-designed) intervention model was working well. They observed a number of positive developments such as growing confidence of district surgical teams in the delivery of SOTA care; initial improvements in skills for the selected procedures being practiced with the mentors; increased independent planning of procedures; and reduction in unnecessary referrals thanks to better case management and decision-making practices.

Yet, some challenges persisted, particularly in regards to intermittent availability of supplies and piped water (in Malawi especially). In some cases, the visiting supervisory teams were able to bring with them some supplies to mitigate shortages, but this was not a lasting solution.

Other challenges noted in the implementation of the intervention included: district mentees not being always available during the supervisory visits or not adequately prepared; too few cases booked for the visits to practice; visits postponed or canceled due to scheduling conflicts between mentors and mentees; lack of sufficient care in the post-op recovery areas, including unavailability of monitors; challenges in ensuring that the right person takes responsibility for the theater (e.g., when nursing tasks were task-shifted to the caretaker and cleaner rather than being undertaken by an assigned nurse, with risk of quality/safety being compromised); and the need to streamline consultations over the remote consultation network (in Malawi).

Lessons learned and agreed action points for the future were:

- To foster better communication with District Health Management Teams and district hospital management to address shortages of surgical and anesthesia supplies and equipment, and to encourage better resource planning.
- To facilitate more efficient communication between mentors and mentees in the project's remote consultation network to streamline requests for advice. To this end, it was recommended for the project to introduce the SBAR (Situation-Background-Assessment-Recommendation) technique. All teams were to be duly trained on SBAR and the protocol was to be shared.
- To promote better visit planning – mentors and mentees recognized the need to work closer together to eliminate causes for visit cancellations/rescheduling. District teams were reminded to ensure adequate bookings and patient preparations in view of the visits.
- To ensure continuity of mentorship (i.e., particular mentors assigned to particular district hospitals) as this was important for relationship building and trust.

4. Discussion

The unmet need for SOTA care remains worryingly high in SSA. Our project aimed to address this need by expanding existing service delivery at the district hospital level through a capacity building intervention designed with the input of local stakeholders. The aim of this paper is not to promote one choice of intervention over others, but rather to highlight the value of using an inclusive and participatory approach to the design and implementation of SOTA system-strengthening interventions.

This study used Participatory Action Research to co-design country-specific models of district-level surgical workforce training, supervision and mentoring in Malawi, Zambia and Tanzania. To our knowledge, this is the first use of a PAR framework in the design of a DH in-service training intervention in sub-Saharan Africa.

We intentionally used "local expertise" to bridge practice and research (34), through PAR workshops that brought together health workers from a range of hospital levels, from consultants and specialists working at central hospitals to surgical teams at DHs, to share perspectives. The latter – the mentees who were to receive the supervision – were at the center of the process. Non-clinical decision-makers such as ministry of health representatives were also included in the discussions.

The workshops involved learning by all participants, respecting and valuing diversity in opinions (among different cadres of health providers and different stakeholder groups); supporting interactions among groups that would not normally have opportunity to come together (9) (e.g., district hospital clinicians and referral hospital clinicians); and addressing the importance of local as well as national contexts in health system strengthening interventions.

We sought to mitigate power imbalances by using local facilitators as far as possible, allowing small group discussions that built up over consecutive days; asking participants to summarize their discussions in their own words with their own nominated representatives and asking for representation and contributions from all cadre groups. The workshops involved open discussions and extensive group work (facilitated by researchers) to encourage participants' reflective practice, i.e., cycles of learning, reflection and action about their own experiences. This built self-awareness and promoted creativity in finding solutions to shared problems; and ultimately empowered participants to be actors for change.

From the project perspective, the PAR workshops formed and strengthened relationships between future mentors and mentees and helped to set expectations about the purpose and scope of the intervention. They identified which parts of the district surgical system might be directly addressed by the intervention, and areas which could not be addressed. For example, the project could not provide new health workers, equipment or infrastructure. This collaborative work also developed improved guidance on what procedures should be done at the district level and which should be referred, which is still a topic under debate in many SSA countries (35).

From the surgical system perspective, this multi-disciplinary and multi-level dialog, bridging hierarchies based on seniority and location (central-district level), so as to agree solutions, helped to improve rapport and communication among stakeholders on how to build SOTA care capacity in Malawi, Zambia and Tanzania. The face-to-face interactions enhanced appreciation of the roles and challenges each group faced. Among other things, this helped redefine the role of SOTA specialists – not just "as someone to refer cases to" for the technical and clinical skills of their specialty, but also as trainers and mentors. The supportive professional relationships established by the project provide opportunities for collaboration across hospital levels beyond the life of the project.

Overall, the PAR process in our study allowed the shift of power from those who are more powerful, including specialists, national managers and the research team, to the intended beneficiaries of the intervention – the district surgical teams. These teams identified key priorities, set the direction for change, and refined the final design of the intervention to become more relevant and aligned to their needs. The workshops contributed to defining priority skills and competencies for each district hospital institution and for each cadre.

By adopting a bottom-up approach where the intervention was selected and shaped by local stakeholders' needs and worldviews, rather than imposing top–down solutions, this study enabled the development of a more appropriate and potentially sustainable intervention. It is also a more ethical and equitable approach to health research, than where the interventions are pre-determined and the evaluation process is tightly controlled by the researchers.

Indeed, participatory health research has been commended as a useful tool to overcome what is known as "epistemic injustice" (36). These are situations where certain kinds of 'knowers' are seen as less credible than policy-makers and professionals; and their knowledge is not taken seriously into account, leading to single or one-sided views of reality (37). In PAR the research is done with stakeholders, who are regarded as expert-by-experience (30). As shown in this paper, our study and approach offers a practical example of how to address the power imbalances that are key to the design of sustainable health systems interventions; and, as a by-product, to more equitable health research by enabling all stakeholders to participate in the research process (23, 38).

In our study the PAR process was critical to ensuring the relevance, feasibility and acceptability of the intervention, and its chances of success and sustainability. The final results of the intervention evaluation are presented in a separate publication (forthcoming) but, as shown here, without the comprehensive involvement of the relevant stakeholders' in the co-design process, the intervention would not have fully captured and responded to needs on the ground, with risk of wasted investments. This is particularly important in Sub-Saharan Africa, where public health resources are limited and there is a large unmet need for surgical care.

The use of adult learning theories to inform the intervention, the reliance on local supervisors, and alignment to local government rates for costing the visits, were other important strategies to promote local ownership of the intervention and the chances of its continuation beyond the life of the project.

There are potential limitations in the PAR approach, including the possibility of researcher bias, as the authors were involved in the design of the workshops, and were present at the workshops. However, we sought to minimize this through using local senior SOTA specialists as facilitators, with workshop participants given maximum opportunity in plenary sessions to give verbal summaries and group discussions. To minimize subjectivity, two researchers independently undertook thematic analysis of the qualitative data generated at the PAR workshops.

Despite these limitations, our findings suggest that participatory action research approaches are useful in SOTA systems research, especially when needing to compensate for power hierarchies that can lead to the beneficiaries' needs being neglected, and instead ensuring the design of a user-focused (i.e., stakeholders) intervention. This study has generated many methodological and practical lessons that can be of value to others wishing to pursue stakeholders' involvement in their research and contributes to the global discourse on more equitable global surgery research.

Our PAR findings have been disseminated to national decision makers to support them in making policy decisions and presented these to members of professional bodies, such as national surgical and anesthesia societies, and representatives from Ministries of Health at subsequent workshops in Zambia, Malawi, and Tanzania.

Data availability statement

The datasets presented in this article are not readily available because to protect the confidentiality and privacy of the participants. Requests to access the datasets should be directed to chiarapittalis@rcsi.ie.

Ethics statement

Ethical approval was granted by the Research Ethics Committee of the Royal College of Surgeons in Ireland (approval no. REC1417), the College of Medicine Research Ethics Committee in Malawi (approval no. P.05/17/2179), the University of Zambia Biomedical Research Ethics Committee (approval no. 005–05-17), the Kilimanjaro Christian Medical College Research Ethics and Review Committee (approval no. CRERC 2026) and the National Institute for Medical Research in Tanzania (approval no. NIMR/HQ/R.8a/Vol. IX/2600).

Author contributions

CL, GD, JG, RB, EB, JK, and KC conceived the study. GM, MC, and AJ supported the organization and running of the workshops, CL, GD, JG, EB, JK, and KC facilitated the workshops. CP, GD, GM, MC, and AJ collected the data. CP and GD analyzed the data and wrote the first draft of the manuscript, with support from NC. All the authors proofread the manuscript and approved the final version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1186307/full#supplementary-material

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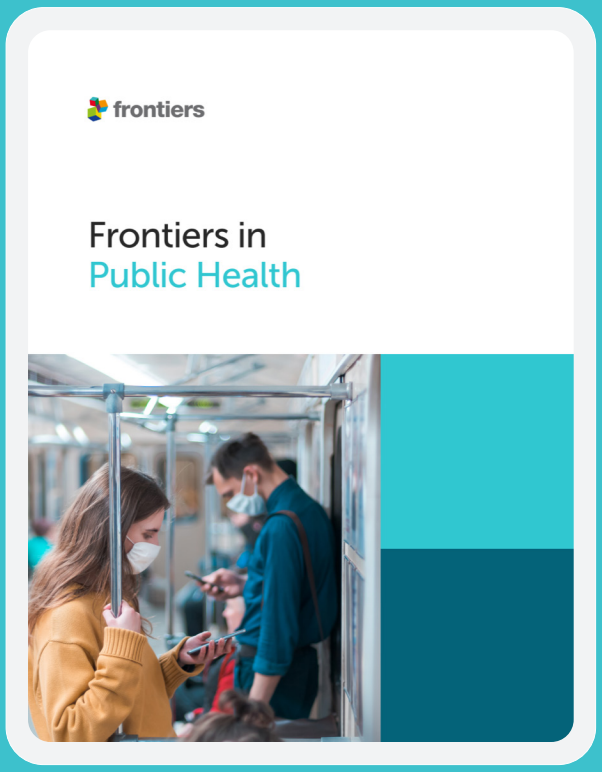

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