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BMJ Global Health

Assessing trauma care systems in low-income and middle-income countries: a systematic review and evidence synthesis mapping the Three Delays framework to injury health system assessments

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ABSTRACT

Background The large burden of injuries falls disproportionately on low/middle-income countries (LMICs). Health system interventions improve outcomes in high-income countries. Assessing LMIC trauma systems supports their improvement. Evaluating systems using a Three Delays framework, considering barriers to seeking (Delay 1), reaching (Delay 2) and receiving care (Delay 3), has aided maternal health gains. Rapid assessments allow timely appraisal within resource and logistically constrained settings. We systematically reviewed existing literature on the assessment of LMIC trauma systems, applying the Three Delays framework and rapid assessment principles.

Methods We conducted a systematic review and narrative synthesis of articles assessing LMIC trauma systems. We searched seven databases and grey literature for studies and reports published until October 2018. Inclusion criteria were an injury care focus and assessment of at least one defined system aspect. We mapped each study to the Three Delays framework and judged its suitability for rapid assessment.

Results Of 14 677 articles identified, 111 studies and 8 documents were included. Sub-Saharan Africa was the most commonly included region (44.1%). Delay 3, either alone or in combination, was most commonly assessed (79.3%) followed by Delay 2 (46.8%) and Delay 1 (10.8%). Facility assessment was the most common method of assessment (36.0%). Only 2.7% of studies assessed all Three Delays. We judged 62.6% of study methodologies potentially suitable for rapid assessment.

Conclusions Whole health system injury research is needed as facility capacity assessments dominate. Future studies should consider novel or combined methods to study Delays 1 and 2, alongside care processes and outcomes.

Key questions

What is already known?

- ► Injuries represent a major global health burden with 90% of deaths occurring in low/middle-income countries (LMICs).
- ► Trauma health system strengthening has improved injury outcomes in high-income settings and could avoid one-third of all trauma deaths if similar case fatality rates could be achieved in all LMICs.
- ► The Three Delays model, widely adopted in maternal and child health research, has been advocated for assessing and strengthening emergency care systems, including following injury.

What are the new findings?

- ► Our review found that conceptual Delay 3 (receiving quality care) was most commonly assessed (79.3%) followed by Delay 2 (reaching care, 46.8%) and Delay 1 (seeking care, 10.8%).
- ► Facility assessment data (primarily or secondarily analysed) was the most common methodological approach overall (36.0%) and for Delay 3 specifically (44.3%), with resource availability the most common study outcome reported overall (45.9%).
- ► For Delay 2 and Delay 1, medical case note review (25.0%) and household surveys (58.3%) were the most common methods used, respectively.

INTRODUCTION

Injuries are a serious global health problem. Trauma causes more deaths globally than HIV, tuberculosis and malaria combined.[1] Low/middle-income countries (LMICs) bear the brunt and account for 90% of these deaths.[1] Non-fatal injuries also represent an enormous burden with 1 billion people sustaining an injury requiring care annually.[2] Road traffic collisions (RTCs) were projected to become the third leading disease burden by 2030.[3] Injury-related morbidity and mortality varies globally, partly attributable to differences in health system response.[2 4–7]

Prevention is an important target for reducing the burden of injuries, however health system-delivered care has a major role

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Key questions

What do the new findings imply?

- Injury care health system research in LMICs has focused on Delay 3 and the healthcare facility with relatively little attention given to Delay 1, despite this being known to be an important contributor to patient care delay in other emergency conditions in LMIC settings.
- To ensure equitable access to injury care, future injury health system studies in LMICs should consider combining well-established facility capacity assessment methods with others that can generate insight into Delays 1 and 2.

in reducing avoidable trauma deaths.[4 8] It is known that survival rates from equivalent injuries in LMICs are lower than those seen in high-income countries (HICs).[4] If this gap in outcomes could be closed, one-third of trauma deaths annually could be avoided.[4] Focus on the system of care following injury has led to major improvements in HICs, particularly for the most severely injured.[9–11] This supports a health system focus on improving injury outcomes in LMICs. Additionally, care provided after trauma is an exemplar tracer condition useful as a marker of health system strength.[12 13] Promoting essential trauma care can benefit other time-critical conditions through wider health system development and is advocated by the WHO.[14] However, there remains little data on access to quality healthcare services for the injured in LMICs. This should be a priority for research.[13]

Health systems are complex and adaptive, with characteristics of non-linear and unpredictable responses to interventions.[15] They are social institutions, influenced by human relationships and behaviours driving their performance.[16] Assessing health systems is important to inform impactful health system improvement.[17] There are multiple frameworks describing health systems, with origins in differing paradigms of understanding and sociopolitical backgrounds.[18] Although a universal framework may not exist, health system researchers should use a framework that fits the purpose of their study.[18]

The Three Delays model frames barriers driving delays to care contributing to adverse outcomes, and was originally described for maternal mortality in LMICs.[19] It specifically considers factors delaying care seeking (Delay 1), reaching a place of care (Delay 2) and receiving appropriate, quality care (Delay 3).[19] While widely adopted across reproductive, maternal, newborn and child health settings,[20–24] the Three Delays have recently been proposed and tested to evaluate emergency healthcare in LMICs, including trauma.[5 6 25 26] Trauma and obstetric emergencies are common in LMICs and have similar health system requirements.[27 28] Relatively few aetiologies cause maternal death and effective treatments are available.[25 29] Although many mechanisms can cause injury, patient management protocols standardise initial treatment priorities, regardless of aetiology.[30 31] Both are acute-onset, time-critical conditions,[5] with overlapping health system response requirements including timely facility transfer,[32 33] anaesthesia[34] and haemorrhage control. However, they differ in funder priority,[35 36] community and cultural understanding,[37 38] and the demographic characteristics of affected individuals.[39]

In the relatively under-resourced and under-researched field of trauma systems in LMICs, identifying ways to assess trauma care systems efficiently, such as through rapid assessment, could encourage locally driven research to identify needs and monitor interventions. Rapid assessments have been described for various health-related conditions and systems for communicable and non-communicable diseases, risk-taking behaviour, humanitarian crises and patient safety.[40–46] They are advocated when data are needed quickly and resource or logistical constraints mean some research techniques are impractical.[41] Such assessments adopt principles of pragmatism, use of multiple data sources, speed and cost-effectiveness.[42] Methodological pluralism is common[44 47] and time scales for completion short—in some cases not more than 1 month,[47] in others, 3[41] or 6[40] months are more typical.

To inform the development of trauma care health system assessment, we undertook a review of the existing literature on assessing LMIC trauma care health systems. The primary aim was to characterise the literature within the Three Delays framework. Secondarily we aimed to assess the potential suitability of methods identified for use within rapid health system assessments.

METHODS

Search strategy and selection criteria

This review report follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[48] The study was registered with PROSPERO (CRD42018112990) and the protocol previously published.[49]

Search methods

The following databases were searched by a senior medical librarian from inception until 9 October 2018: Africa Wide Information (Ebsco), Cochrane (Wiley), Embase (Ovid), Global Health (Ovid), Global Index Medicus (WHO), MEDLINE (Ovid) and Web of Science (Clarivate Analytics) (online supplemental material 1). We used variations from text in titles, abstracts, keywords and subject headings to obtain articles combining the following concepts: (1) trauma and injury, (2) assessments, evaluations, benchmarking or tools, and (3) health system programmes. All languages were included. Animal studies were excluded when possible. We collated and deduplicated articles in EndNote V.X9.[50] We searched the grey literature in four stages[51]: grey literature databases, a customised Google search, targeted websites and consultation with experts.[51] We used the search terms "trauma" OR "injury" AND "assessment" OR "evaluation" AND "health system" in Core, New York Academy of Medicine Grey Literature Report, OpenGrey

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Table 1 Inclusion and exclusion criteria

	Excluded	Included
Study setting according to World Bank income classification	High-income country only.	Includes low or lower middle-income or upper middle-income country.
Type of article	Case reports, academic letter, correspondence or conference proceedings.	Primary quantitative, qualitative or mixed-method study. Literature review. Report or guideline from national or international health organisation.
Subject of study	Measurement of population health profiles and patterns. Research evaluating interventions, diagnostic tests, medicines or technologies.	Whole health system assessment. Assessment of health-seeking behaviour. Assessment of community perception of healthcare access and quality. Assessment of health system access. Assessment of health system care quality including technical and patient-centred care.
Type of conditions or care setting	Mental health. Non-urgent care, primary care, elective care as main focus of assessment. Non-trauma emergency care. Non-accidental Injury in children. Disaster management.	Trauma or injury (used interchangeably) care.

and WorldCat Dissertations and Theses (OCLC). We used the search terms "trauma", "injury", "assessment", "evaluation" and "health system" in combinations for advanced Google searches with and without limiting the domains to .org, .edu, .int and .gov. We screened the top 50 sites per search. We also searched the organisational websites listed in online supplemental material 2 with the same terms. We reviewed reference lists of identified articles and included additional relevant literature.

Eligibility criteria

We included primary quantitative, qualitative and mixed-method studies, as well as secondary literature reviews, published and unpublished, from LMICs. LMICs included low, lower middle and upper middle-income countries according to the World Bank classification at time of review.[52] We excluded studies only set in HICs but included studies with both HICs and LMICs. We included grey literature reports and publications from relevant national and international health organisations. Case reports, letters and conference proceedings were excluded. Studies must have focused on trauma or injury (used interchangeably) care and assessed one or more health system aspects of care specified in table 1.

Identification of studies

Two reviewers (NO'D, MD) used the Rayyan QCRI online open-source web application[53] to screen articles by title and then abstract. Rayyan key term screening removed any identified animal studies. We discussed disagreements until reaching consensus with third reviewer (JW) arbitration where necessary. Two reviewers (all by JW, half each by MD and NO'D) reviewed the full texts. We used Google Translate for non-English articles.[54–56] One reviewer (JW) conducted each grey literature database, Google and focused website search.

Risk of bias

This review focuses on understanding the breadth of diverse research approaches used to assess trauma care health systems and we did not analyse the results of individual studies. The quality of study conduct and trustworthiness of findings was not our aim, and no risk of bias assessment was therefore performed.[57]

Data extraction

We developed and piloted a standardised extraction spreadsheet. We extracted the following study characteristics:

- Author.
- Publication year.
- The number, names, income status (low, lower middle, upper middle and high) and World Bank region[52] for included countries.
- Urban or rural setting.
- Which of the Three Delays were assessed.
- Methodological approach with description.
- Trauma population (all trauma, road traffic only, fractures only, burns only, eye injuries only, trauma as a subset of wider emergency pathology).
- Conceptual framework, tool or guidelines used where applicable.
- Indicators of care quality or quality improvement (QI).
- Subjects under study (about what or whom the study reports as facility according to type (primary, secondary or tertiary), patients, healthcare workers (prehospital or facility-based), community members

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and other stakeholders, or referral mechanisms or patterns).
- Outcome type (description of barriers and challenges, availability of resource, defined measure of care process, mortality, operative care, patient disposal or destination, length of stay or other outcome specified in free text).
- What health system intervention is reported, if any.
- Study cost.
- Time taken for data collection.
- If multiple data sources were used.
- Original study author comments on pragmatism of approach.
- Original study author reported strengths and limitations.

Where more than one response was appropriate, all were captured. Two authors extracted this independently (all by JW, half each by MD and NO'D) from the database search articles. Differences were discussed until agreement was reached.

Analysis of results

Given the review aims, of characterising the literature within the Three Delays framework and assessing the potential suitability of methods identified for use within rapid health system assessments, a narrative synthesis of findings was performed.[58 59]

Synthesis of variables extracted

With regard to the primary review aim, we mapped studies reporting health-seeking behaviour to Delay 1 and studies reporting aspects of reaching care following injury to Delay 2. We mapped studies reporting aspects of receiving formal healthcare, whether in a prehospital, primary, secondary or tertiary facility to Delay 3. Studies could be mapped to more than one delay. We understood and categorised care quality within the Donabedian framework of Structure, Process and Outcome.[60] Structure includes the organisational, human and physical resources required to deliver quality care, process denotes what is actually done and outcome signifies the effect of care on health status.[60]

With regard to the secondary review aim, for principles of rapid assessment (pragmatism, use of multiple data sources, speed and cost-effectiveness), we recorded any data on monetary cost of studies and the time taken for study data collection in days. For retrospective studies, the available data were the time window for the dataset. We classified any study using more than one data source, whether or not they were described as mixed methods, as using multiple data sources. Pragmatic approaches to research need to be real-world problem orientated, producing stakeholder relevant results and be based on practical research philosophy.[61 62] Pragmatic metrics are feasible to collect, not onerous, user friendly, easy to interpret and broadly applicable,[63] providing adequate rather than perfect information.[42] Based on this understanding, we recorded study features that its authors

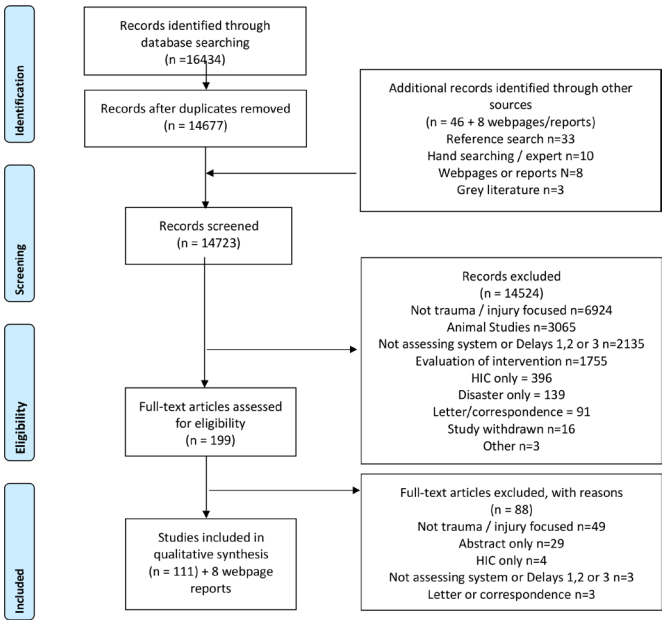

Figure 1 PRISMA flow chart.[48] HIC, high-income country; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

reported as being either pragmatic or non-pragmatic. We judged potential suitability or not for inclusion of study method within a rapid assessment based on rapid assessment principles following discussion between two reviewers (out of JW, NO'D, MD). Study author reported strengths and limitations were further synthesised into categorical themes by one author (JW).

Patient and public involvement

Neither patients nor the public were involved in the design, conduct, reporting or dissemination plans of this literature review.

RESULTS

After duplicate removal, we identified 14677 articles from the database search and 46 from other sources (figure 1). We included 111 studies and 8 relevant non-study documents or websites in the final analysis. Lower middle-income countries were most commonly included (56 of 111, 50.5%) (table 2). Studies originated across the World Bank regions although predominantly (49 of 111, 44.1%) from sub-Saharan Africa (online supplemental table 1 and figure 2) with Ghana being the most studied country (16 of 111, 14.4%). Combined urban and rural were the most common study settings (53 of 111, 47.7%).

Delay 3, either alone or in combination, was the delay most commonly assessed (88 of 111, 79.3%) followed by Delay 2 (52 of 111, 46.8%) and Delay 1 (12 of 111, 10.8%) (figure 3). Most studies were mapped either solely to Delay 3 (45 of 111, 40.5%) or to both Delays 2 and 3 (39 of 111, 35.1%). Only three (2.7%) studies were mapped to all Three Delays. Studies not mapped to any of the Three Delays included four (3.6%) reporting how to assess injury care[64–67] and five (4.5%) reporting

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Table 2 Study findings overview

	Number of studies (%) N=111
World Bank geographical region for countries within each study	
Sub-Saharan Africa	49 (44.1)
Latin America and Caribbean	24 (21.6)
South Asia	21 (18.9)
East Asia and Pacific	19 (17.1)
Middle East and North Africa	16 (14.4)
North America	8 (7.2)
Europe and Central Asia	5 (4.5)
Income strata of included studies	
Lower middle-income countries	56 (50.5)
Upper middle-income countries	50 (45.0)
Low-income countries	20 (18.0)
High-income countries*	9 (8.1)
Study setting (urban/rural)	
Urban	49 (44.1)
Rural	4 (3.6)
Both	53 (47.7)
Unknown	5 (4.5)
Studies per conceptual delay	
Delay 1—any	12 (10.8)
Delay 1 only	4 (3.6)
Delays 1 and 2	4 (3.6)
Delays 1 and 3	1 (0.9)
Delay 2—any	52 (46.8)
Delay 2 only	6 (5.4)
Delays 2 and 3	39 (35.1)
Delay 3—any	88 (79.3)
Delay 3 only	45 (40.5)
Delays 1, 2 and 3	3 (2.7)
Not assigned to a Delay	9 (8.1)
Population studied	
All trauma and injuries	87 (78.4)
Road traffic only	13 (11.7)
Fractures/orthopaedics only	6 (5.4)
All trauma, but as a subset of wider emergency pathologies	2 (1.8)
Burns only	2 (1.8)
Eye injuries only	1 (0.9)
Framework-guiding study†	
Any framework	68 (61.3)
WHO Essential Trauma Care	28 (25.2)
Trauma Injury Severity Score method (TRISS)	10 (9.0)

Continued

Table 2 Continued

	Number of studies (%) N=111
WHO Tool for Situational Analysis to Assess Emergency and Essential Surgical Care	8 (7.2)
Author-developed framework	6 (5.4)
WHO Quality Improvement (QI) guidelines	5 (4.5)
American College of Surgeons Committee on Trauma guidelines	4 (3.6)
Personnel, Infrastructure, Equipment and Supplies Index	4 (3.6)
International Assessment of Capacity for Trauma	3 (2.7)
Trauma Society of South Africa Guidelines	2 (1.8)
WHO guidelines for community surveys	2 (1.8)
French Pre Hospital Emergency Care guidelines	1 (0.9)
US model trauma care system plan as framework	1 (0.9)
WHO (2007) field manual for capacity assessment of health facilities in responding to emergencies	1 (0.9)
Arizona Trauma Centre Standards	1 (0.9)
Surgeons Overseas Assessment of Surgical Need	1 (0.9)
Quality or QI?	
Care quality—any	95 (85.6)
Care quality—structure	64 (57.7)
Care quality—process	39 (35.1)
Care quality—outcome	26 (23.4)
QI	17 (15.3)
What is the subject of study?	
Includes any facility	84 (75.7)
Includes tertiary facilities	70 (63.1)
Multiple facilities (at any level)	65 (58.6)
Includes secondary facilities	60 (54.1)
Secondary and tertiary only	32 (28.8)
Tertiary only	23 (20.7)
Includes primary facilities	18 (16.2)
Primary, secondary and tertiary	15 (13.5)
Secondary facilities only	11 (9.9)
Primary and secondary facilities only	2 (1.8)
Primary facility only	1 (0.9)
Primary and tertiary only	0 (0)
Patients	51 (45.9)

Continued

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Table 2 Continued

	Number of studies (%) N=111
Healthcare workers (HCWs) in facility	47 (42.3)
Prehospital HCWs	27 (24.3)
Referral mechanisms and patterns	20 (18.0)
Community members	13 (11.7)
Non-HCW stakeholders	8 (7.2)
What are the study outcomes?‡	
Availability of resource	51 (45.9)
Mortality	29 (26.1)
Measure of care process	27 (24.3)
Description of barriers and challenges	24 (21.6)
Operative care provision	12 (10.8)
Patient disposal/destination	12 (10.8)
Length of stay	7 (6.3)
Other outcome (specified below)	38 (34.2)
TRISS probability of survival	9 (8.1)
Avoidable mortality	6 (5.4)
QI activity	5 (4.5)
Travel times	5 (4.5)
Disability	4 (3.6)
Complications	4 (3.6)
Distance to facility	2 (1.8)
Reasons for self-discharge	1 (0.9)
Ratio of hernia repair and C-sections as a percentage of total operations	1 (0.9)
Unplanned return to theatre or intensive care	1 (0.9)
Missed injury	1 (0.9)
Ambulance response, scene and transport time	1 (0.9)
ICU stay	1 (0.9)
Observed versus expected mortality	1 (0.9)
Reasons for self-discharge	1 (0.9)
Time from injury to facility	1 (0.9)

*High-income countries were included when studies were set across multiple countries, including LMICs.
†More than one framework per study possible.
‡More than one study outcome possible
ICU, intensive care unit; LMICs, low/middle-income countries.

evidence of QI activity rather than the quality of delivered care.[68–72] Delays according to geographical region are reported in online supplemental table 1.

A heterogeneous range of study methods were identified including quantitative, qualitative and mixed methodological approaches. Across all studies, the most common methodological approach was using facility assessment data, either primarily collected or secondarily analysed (40 of 111, 36.0%) (online supplemental table 2). The study methodologies most commonly mapped to each of the Delays (either alone or in combination) were household surveys for Delay 1, (7 of 12, 58.3%), medical case note review-based methods for Delay 2 (13 of 52, 25.0%), and methods using facility assessment data primarily collected or secondarily analysed (39 of 88, 44.3%) for Delay 3. Studies not assessing Three Delays most commonly included healthcare worker (HCW) surveys reporting QI activity (5 of 9, 55.6%).

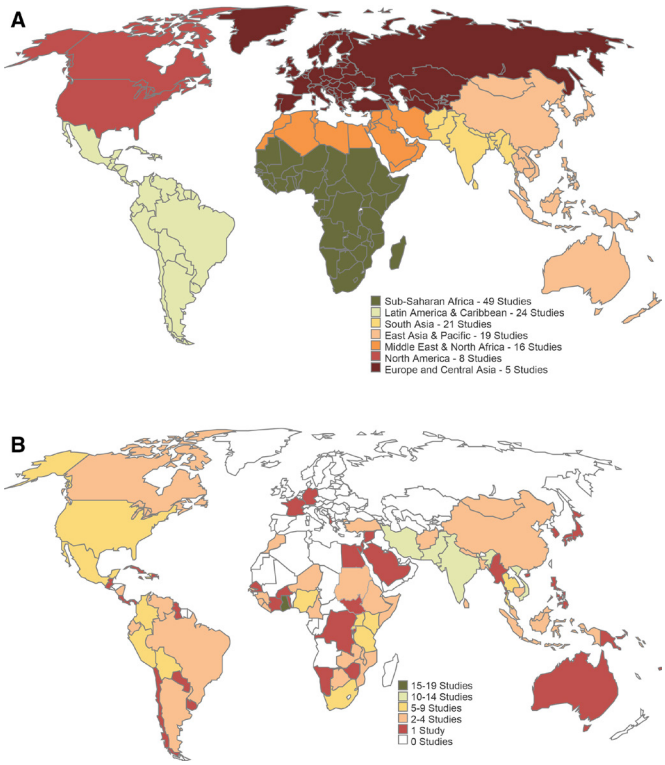

Figure 2 (A) Map of studies according to World Bank regions. (B) Map of studies according to countries.

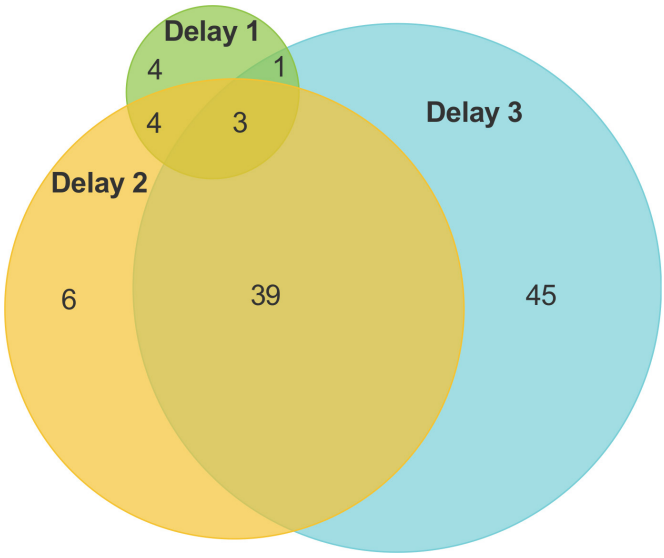

Figure 3 Number of studies per conceptual delay.

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The most commonly studied population encompassed all injuries and trauma, 87 (78.4%), with 13 (11.7%) studying RTCs only, and 6 (5.4%) studying fractures and orthopaedics only. Most studies incorporated a framework within the assessment (68 of 111, 61.3%), the most commonly used was the WHO Essential Trauma Care guidelines and accompanying checklist (WHO ETC) (28 of 111, 25.2%). The predominant subject of studies was facilities (84 of 111, 75.7%) followed by patients in (51 of 111, 45.9%) studies. Care quality was studied in 95 studies (85.6%), mostly through assessing structures of care (64 of 111, 57.7%), rather than care process (39 of 111, 35.1%), or care outcomes (26 of 111, 23.4%). The most common study outcome reported was availability of resources (51 of 111, 45.9%) studies.

We judged most (69 of 111, 62.2%) study methodologies potentially suitable for including within a rapid health system assessment (online supplemental table 3). The most common approaches were patient, staff or stakeholder interviews, meetings, group discussion or surveys,[37 68–84] occasionally combined with care observation[17] or case note review supplementation.[85] Similarly common were facility assessments through survey or interview.[86–111] A further 42 (37.8%) studies were thought to be unsuitable, including 20 retrospective studies relying on case note data,[112–118] established registry data[119–124] or a combination of both,[125–131] and 8 household surveys in local languages.[132–139] Both registries and household surveys were considered time-consuming and resource-intensive to conduct or maintain, with data accuracy commonly problematic with the former.

Cost was not specifically reported in any of the studies. However, some described the approach as low-cost without specifying an amount.[80 140 141] Such approaches included teleconference-based case reviews, preventable death panel reviews, a mixed-method WHO ETC facility assessment and key informant interviews generating a process flow chart.

Studies reported a data collection time frame in 74 (66.7%) cases. The range of time for study data collection varied from 4 days to 12 years. Twenty-four studies using cross-sectional data collection reported data collection periods of not more than 3 months; 18 of these were mapped to Delay 3, whereas only 4 were mapped to Delay 1.

Use of multiple data sources was evident in 34 (30.6%) studies (online supplemental table 4). Facility assessments were the most common data source to be combined with others including: household surveys[139]; Emergency Medical Services (EMS) data[83 139]; Geographic Information System (GIS) analysis[142 143]; travel time analysis[144]; peer case analysis via teleconference[141]; Ministry of Health data[108 143 145]; logbook data[105 106 108]; administrative data[143]; staff interviews[80 86]; clinician knowledge assessment[94] and desk review.[107]

Study authors reported various positive and negative pragmatic aspects of their studies (online supplemental table 5). Positive pragmatic aspects were categorised as leveraging available data or infrastructure to conduct their study, strategies for effective engagement of study stakeholders, and maximising methodological convenience and feasibility. Non-pragmatic aspects of studies reported were categorised as difficult practical challenges of facility-based research methods and practical challenges for study conduct across facilities or communities.

Original study authors reported various strengths to the identified studies (online supplemental table 6). These included combining data sources, in particular adding in-depth qualitative methods for deepening understanding.[79 86 133] Widespread use of tools used in WHO ETC and WHO Tool for Situational Analysis to Assess Emergency and Essential Surgical Care-based assessments was seen as strengths, demonstrating their applicability and comparability across locations and countries.[89 98 100 140 146 147] The inclusion of a variety of sectors, professions and patients in studies was seen by study authors as positive.[67 76 78 84 88 148 149]

Original study authors reported various limitations. These included lacking patient outcomes[17 66 72 80 83 99 102 144 148 150] and not capturing or adjusting for injury severity.[125 133–135 146 147 151] Study authors highlighted that resource availability, commonly studied, does not necessarily equate to the quality of care process or outcome.[88 89 152] Authors reported that facility-orientated studies neglected community and prehospital environments,[80 85 94 101 103 104 108 114 120 124 128 148 153–158] and follow-up.[80 129 147 159] They highlighted that facilities had incomplete or inaccurate data,[114 116 119 122 126 129 140 154 155 159–164] lacking reliable records or data systems.[86 94 106 147 164] Study authors similarly highlighted that HCW views or experiences are subjective[83 88 98 109 112 114 140 148 149 155 162] as are assessment tool ratings including the WHO ETC.[87–89 93 95 96 100–102 105 106 143 152]

Non-study literature included WHO publications or webpages (online supplemental table 7). These predominantly mapped to Delay 3 with only one to Delay 1. The WHO ETC guidelines and checklist underpinned many assessments in this review.[165 166] The WHO guidelines for conducting community surveys on injury and violence[167] provide methodological instruction and survey questions, but without focus on care quality, and were the basis for two surveys in this review.[135 139] The WHO guidelines for trauma QI programmes propose mortality and morbidity conferences, preventable death panel review and tracking of audit filters for driving QI.[168] Studies identified in this review used these guidelines to both study what QI activity undertaken as well as studies applying recommended QI practices such as preventable death panels.[70 72 114 140 162] The other non-study literature identified had not been applied for health system assessment by studies in this review.[14 169–171]

The individual included study characteristics are reported in online supplemental tables 8 and 9.

DISCUSSION

We found 111 studies that assess health system's ability to provide trauma care in LMICs. Very few studies

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considered the whole system as understood within the Three Delays framework and there was a bias towards a sole focus on Delay 3, receiving appropriate care. Multiple heterogeneous methodologies have been used to assess trauma systems and most are potentially suitable for inclusion in a rapid health system assessment.

Given the importance of injuries as a growing global disease burden,[1–3] future LMIC injury research needs to consider the whole post-injury health system. Injury care research has not been embraced by the global health and health system research communities in the same way as other conditions such as communicable disease and reproductive, maternal, neonatal and child health.[1] This neglect of injury care is also reflected by only one sustainable development goal being related to trauma, focused on RTCs and primarily related to prevention.[172] Although prevention is necessary, injuries will inevitably occur and warrant parallel investment in post-injury care.

We found only three studies were mapped to all Three Delays and none explicitly applied the Three Delays conceptual framework. This is problematic as 40% of mortality after trauma in LMICs may be avoidable due to factors within each of the Three Delays.[6] We found very few studies focused on healthcare seeking following injury. Narrow facility-based research should be expanded to include the whole 'surgical ecosystem', working with a multidisciplinary team that includes health system researchers, informal providers and the community.[34]

Many of the studies were concentrated within a few countries. Ghana in particular, despite a burden of injury typical of sub-Saharan Africa (50.5 per 100 000),[173] was relatively heavily represented. This could be explained by well-established academic collaborations publishing multiple studies in specific locations. Such author groups may have shaped the geographical findings of this review more than the injury burden. Meanwhile, few studies had investigated many countries' trauma systems—representing an important gap for future research.

The lack of Delay 1 injury studies contrasts with the maternal health community, from which the Three Delays framework originates. Many barriers to women seeking obstetric care have been identified from sociodemographic and economic factors, community and cultural perceptions of childbirth, gender-based factors, health literacy and previous experiences in healthcare,[19 38 174] which may also be relevant following injury.[7 26] In maternal healthcare, recognition of barriers at Delay 1 has led to effort being directed towards avoiding harmful traditional beliefs and practices,[175] such information is needed if similar efforts are to be successfully deployed after injuries. Compounding the relative paucity of studies exploring the first delay in this review is that almost all were from seven sub-Saharan African countries. This contrasts with a review of 159 studies of health-seeking behaviour in maternal and child mortality using a range of observational and qualitative methods across a broad collection of LMICs.[176] Patient-based and provider-based studies which we found in this review can provide insight into why patients delay seeking care,[6 74 85] but alone will not capture those who never access formal care services. Similarly identified community-based qualitative studies may be well suited to explore the breadth of possible barriers to seeking care.[73] However, quantitative assessment, such as through household surveys, also reported in this review, may be needed to understand the scale and impact of identified barriers.[138] Mixed-method studies with an exploratory sequential design[177] (qualitative exploration to inform the development of quantitative assessment) may be suitable. Other methods such as using verbal autopsy data have been proposed,[6 178] although they miss non-fatal injuries. Given the lack of research identified in this review, further study is urgently warranted to understand the importance of the first delay following injury across LMICs.

Fewer than half of the studies mapped to Delay 2. Some studies in this review used GIS analysis, focusing on geospatial accessibility, considering distance, road quality and trauma locations.[179] A limitation of this method is that proximity to facilities is not equivalent to actual care access.[180] Other important barriers to reaching care exist[7 26 180] which could all impact on the median time from injury to facility admission, a proposed high-quality health system indicator.[13] While patient-focused studies such as seen in this review help to understand the actual patient journey,[74] we did not find attempts to validate GIS techniques with information from actual injured patients, as has been done for other conditions.[181 182] Community-based qualitative studies, which were infrequently found in this review, may similarly be needed to understand the role of bystanders in facilitating reaching care as well as other community level barriers.[73] EMS-derived data from registries, records, service inspection and staff were also identified, informing Delay 2/3-mapped studies.[83 119 126 149] However, formal EMS care is not available in many LMICs and most of Africa.[183] Where present, studies including EMS should include its communication and coordination including any primary facility bypass practices, known to be problematic and poorly studied.[7 26 184] LMIC EMS priorities are known to differ: some function exclusively or primarily for obstetric patients,[175 185–188] some focus on trauma,[189 190] while some cover trauma, obstetric and medical conditions in similar proportions.[32 33] Knowing and reporting this context should be part of incorporating EMS data meaningfully in future studies.

Within Delay 3, facility-based studies and assessments of resource availability predominated in this review, often using the WHO ETC. Surveys for structures of care are common across LMIC health systems research. Such data are problematic, becoming out-of-date quickly and correlating poorly to measures of delivered care quality.[13 191] That said, these facility assessments can be useful, as our review has shown; they can be widely adopted, quick to complete and comparable across settings. However, when conducted alone, they are unsuitable to study Delays 1 and 2, or the process, and

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outcome of delivered care. Such assessments can, for example, describe the presence or absence of care protocols. But whether care delivery matches best practice, or whether staff are sufficiently trained to follow them,[26] would require alternative methods, used by some studies found in this review, such as direct observation[17 159] or case analysis.[141] Non-technical aspects of care quality such as respectful and compassionate care, relating to HCW attitudes and motivation, require the patient perspective.[192] This would similarly be required to assess patient cooperation,[26] rarely studied in this review.[193] Studies reporting care outcomes mostly required time-consuming database development and maintenance or case note extraction, although repurposing administrative data represents a potentially efficient alternative if available.[147] To comprehensively assess Delay 3,[6 7 26] combining methods and perspectives is required.

As a secondary aim, we also assessed the suitability of methodological approaches for use as a rapid assessment able to appraise systems quickly with limited resources to guide policy and practice. We will now discuss how the rapid assessment principles of pragmatism, use of multiple data sources, speed and cost-effectiveness[42] were evidenced in the identified literature.

We identified several positively pragmatic characteristics of studies in our review including leveraging available data or infrastructure (such as open source maps, existing administrative or routine facility data),[141 142 145 147 151] maximising methodological convenience and feasibility (such as pragmatic sampling strategies, and using established tools or criteria),[74 88 89 95 96 164 194] and effectively engaging stakeholders (such as leveraging existing networks, involving key policymakers and use of electronic communication).[17 67 70 78 84 109 110 150] Elsewhere in global surgical research, successful pragmatic collaborative approaches have engaged stakeholders, established networks of researchers and minimised the burden of data collection.[195–197] Although currently facility-centred, they offer a potential means for future wider health system collaborative study. A negatively pragmatic characteristic, particularly for studies using medical case note review, related to practical challenges of obtaining complete data[116 117 159] in a time and resource-efficient manner.[114 122] Extracting high-quality data from immature data systems can be logistically difficult and health data incompleteness and inaccuracy is a problem in many LMICs.[198] Although pragmatic use of routine health information is growing, it remains a small part of the overall LMIC health system evaluation literature.[199] We found only some evidence of significant harnessing of technology for trauma system evaluation. While health technology availability is inversely related to health need,[200] improving access to information technology is a widely recognised strategy to augment global health research capacity.[201] Mobile smart phone applications for health delivery are growing, however their use in research remains in its infancy.[202] Due to time, logistical and human and physical resource implications for household surveys found in this review, they were considered potentially unsuitable for rapid assessment. However, technological innovations could represent an exciting opportunity for growth in such health system research, particularly to help address some of the practical challenges in studies outside of facilities and within communities.[17 111 135]

Most studies in this review did not use multiple data sources, however we found innovative examples of combining data sources to deepen understanding, such as combining household surveys with focus group discussions for qualitative and quantitative insights[133] and GIS analysis with facility assessment data to interpret facility resource capacity in light of population proximity.[142] However, LMIC trauma system research could benefit additionally from incorporating methodological approaches from other global health fields that were not evidenced in this review. One example of a method, not found in this review, but that could be adopted to address the relative lack of care process quality assessment, are clinical vignettes, which can be used for assessing standardised clinician care quality.[203–205] They are more feasible but comparable with standardised patient and case note review for patient–provider interaction assessment and are relatively inexpensive.[206–208] To address the gap we identified in studying the whole health system across the Three Delays, other methodologies advocated for applying systems thinking to health research could be used.[209 210] These could include process maps, graphical representation of an end-to-end description of activities, stakeholders and requirements of a process.[210 211] They have been applied to LMIC health systems evaluation including emergency and surgical care.[212 213] Causal loop diagrams can similarly help visualise dynamic complexity of health systems[210 211] and have been used to evaluate vaccination coverage in India[214] and Fijian public health food policies.[215] Some of the study methodologies we found in our review could also be adapted. An example is preventable death analysis through peer review. It has advantages reported by the identified study authors of triangulating multiple perspectives, being theoretically simple, low cost[140] and broadly applicable to any context.[140] If data completeness[140 155 162] and local expert engagement were secured,[140 162] it could be better aligned toward rapid assessment.

While data collection time was often reported by studies in this review, this would not include the time for planning, ethical approval, material sourcing and analysis which are uncommonly reported. These factors should be considered when planning time frames for rapid assessments. Well-designed surveys, electronic data capture and preplanned analysis could potentially allow quicker collection.[216–219] Qualitative studies across each Delay were judged potentially suitable for rapid assessment in this review.[37 73–75 77 81 85] Although the data are often quick to collect, they may require lengthy transcription and analysis.[220] Nevertheless, rapid assessments frequently and typically include qualitative elements[45 46] and software can help.[220] Trade-offs between principles

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could also allow some methods judged to have high resource requirements, like community-based household surveys, to be potentially accomplished quickly, within 1[138] or 2 months[139] if given sufficient investment.

We found no quantitative data on the monetary cost of studying trauma care systems in this review. This is unhelpful for future researchers wishing to make judgements on comparative cost-effectiveness of future methods for health system assessment or indeed subsequent interventions. Guidance for costing research in LMICs is available[221] and researchers can draw on other data sources to consider cost implications for each method. However, varying costs of living, salary and consumables should be considered between settings. A facility-capacity assessment study, focused on surgery, assessed 44 district hospitals in Rwanda for US$5000.[222] However, this may not be typical of health facility assessments reportedly starting at US$100 000 per national survey and often many times more.[13 223]

This study has several limitations. Although we extensively searched a large volume of literature, we could have missed some assessment methodologies, including any published subsequent to our search date. While our grey literature search was comprehensive, it was by a single reviewer only. However, due to the breadth of studies identified and included, we remain confident that the results adequately address the study aims. The assignment of studies into conceptual delays and suitability for rapid assessment is subjective. We have tabulated the findings to allow others to reclassify but consider this unlikely to affect overall review insights. Literature set exclusively in HICs was excluded to allow this review to be feasible. Learning from assessment methods seen in HICs only may have been missed. Some HIC frameworks such as the American College of Surgeons and Arizona guidelines have been advocated for use in LMICs.[194 224] However, other authors using HIC-orientated methods questioned their applicability.[225] The review also did not include time-critical or emergency care studies not specific to trauma, although we acknowledge that injuries can be studied together with wider emergency care.[25] As this review excluded studies not specifically focusing on injuries, other approaches may have been missed, particularly in areas that were not well covered such as Delay 1.[226] Methods in this review overlapped conceptual delays, particularly across the Delay 2 and 3 categories. Finally, we have not clearly characterised the relative amount of focus on each delay for each study, although in many cases the facility-based focus predominated. Nevertheless, researchers wishing to incorporate multiple conceptual delays into an assessment can adapt methods to capture the required data focus.

CONCLUSION

This study has identified literature assessing trauma care systems in LMICs, mapped them to the Three Delays framework and considered their suitability to rapidly assess a health system. Few studies considered the whole health system as understood by the Three Delays framework with assessments of facility capacity dominating the literature. More methodological approaches and data are needed to better understand the importance of delays in particular to seeking care. Most studies used methods that could potentially be applied within a rapid assessment. However, future studies should consider combining methods to generate insight into Delays 1 and 2, as well as evaluation of the quality of care processes and outcomes.

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REFERENCES

1 Gosselin RA, Spiegel DA, Coughlin R, *et al*. Injuries: the neglected burden in developing countries. *Bull World Health Organ* 2009;87:246.
2 Haagsma JA, Graetz N, Bolliger I, *et al*. The global burden of injury: incidence, mortality, disability-adjusted life years and time trends from the global burden of disease study 2013. *Inj Prev* 2016;22:3–18.
3 Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006;3:e442.
4 Mock C, Joshipura M, Arreola-Risa C, *et al*. An estimate of the number of lives that could be saved through improvements in trauma care globally. *World J Surg* 2012;36:959–63.
5 Fraser A, Newberry Le Vay J, Byass P, *et al*. Time-critical conditions: assessment of burden and access to care using verbal autopsy in Agincourt, South Africa. *BMJ Glob Health* 2020;5:e002289.
6 Edem IJ, Dare AJ, Byass P, *et al*. External injuries, trauma and avoidable deaths in Agincourt, South Africa: a retrospective observational and qualitative study. *BMJ Open* 2019;9:e027576.
7 Odland ML, Whitaker J, Nepogodiev D, *et al*. Identifying, prioritizing and visually mapping barriers to injury care in Rwanda: a multi-disciplinary Stakeholder exercise. *World J Surg* 2020;44:2903–18.
8 Henry JA, Reingold AL. Prehospital trauma systems reduce mortality in developing countries: a systematic review and meta-analysis. *J Trauma Acute Care Surg* 2012;73:261–8.
9 Cole E, Lecky F, West A, *et al*. The impact of a Pan-regional inclusive trauma system on quality of care. *Ann Surg* 2016;264:188–94.
10 Celso B, Tepas J, Langland-Orban B, *et al*. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma* 2006;60:371–8. discussion 78.
11 Moran CG, Lecky F, Bouamra O, *et al*. Changing the System - Major Trauma Patients and Their Outcomes in the NHS (England) 2008–17. *EClinicalMedicine* 2018;2-3:13–21.
12 Sayed MJE. Developing emergency and trauma systems internationally: what is really needed for better outcomes? *J Emerg Trauma Shock* 2017;10:91–2.
13 Kruk ME, Gage AD, Arsenault C, *et al*. High-Quality health systems in the sustainable development goals era: time for a revolution. *Lancet Glob Health* 2018;6:e1196–252.
14 World Health Organization. Emergency and trauma care, model trauma system policy, 2018. Available: http://www.who.int/emergencycare/trauma/essential-care/model/en/ [Accessed 14 Sep 2018].
15 Adam T. Advancing the application of systems thinking in health. *Health Res Policy Syst* 2014;12:50.
16 Gilson L. Trust and the development of health care as a social institution. *Soc Sci Med* 2003;56:1453–68.
17 Remick KN, Wong EG, Chuot Chep C, *et al*. Development of a novel global trauma system evaluation tool and initial results of implementation in the Republic of South Sudan. *Injury* 2014;45:1731–5.
18 van Olmen J, Marchal B, Van Damme W, *et al*. Health systems frameworks in their political context: framing divergent agendas. *BMC Public Health* 2012;12:774.
19 Thaddeus S, Maine D. Too far to walk: maternal mortality in context. *Soc Sci Med* 1994;38:1091–110.
20 Combs Thorsen V, Sundby J, Malata A. Piecing together the maternal death puzzle through narratives: the three delays model revisited. *PLoS One* 2012;7:e52090.
21 Wilmot E, Yotebieng M, Norris A, *et al*. Missed opportunities in neonatal deaths in Rwanda: applying the three delays model in a cross-sectional analysis of neonatal death. *Matern Child Health J* 2017;21:1121–9.
22 Waiswa P, Kallander K, Peterson S, *et al*. Using the three delays model to understand why newborn babies die in eastern Uganda. *Trop Med Int Health* 2010;15:964–72.
23 Upadhyay RP, Rai SK, Krishnan A. Using three delays model to understand the social factors responsible for neonatal deaths in rural Haryana, India. *J Trop Pediatr* 2013;59:100–5.
24 Pajuelo MJ, Anticona Huaynate C, Correa M, *et al*. Delays in seeking and receiving health care services for pneumonia in children under five in the Peruvian Amazon: a mixed-methods study on caregivers' perceptions. *BMC Health Serv Res* 2018;18:149.
25 Calvello EJ, Skog AP, Tenner AG, *et al*. Applying the lessons of maternal mortality reduction to global emergency health. *Bull World Health Organ* 2015;93:417–23.
26 Whitaker J, Nepogodiev D, Leather A, *et al*. Assessing barriers to quality trauma care in low and middle-income countries: a Delphi study. *Injury* 2020;51:278–85.
27 Broccoli MC, Calvello EJB, Skog AP, *et al*. Perceptions of emergency care in Kenyan communities lacking access to formalised emergency medical systems: a qualitative study. *BMJ Open* 2015;5:e009208.
28 Broccoli MC, Cunningham C, Twomey M, *et al*. Community-based perceptions of emergency care in Zambian communities lacking formalised emergency medicine systems. *Emerg Med J* 2016;33:870–5.
29 Say L, Chou D, Gemmill A, *et al*. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health* 2014;2:e323–33.
30 Ley Greaves RA, Wilkinson LF, Wilkinson DA. Primary trauma care: a 20-year review. *Trop Doct* 2017;47:291–4.
31 ATLS Subcommittee, American College of Surgeons' Committee on Trauma, International ATLS working group. Advanced trauma life support (ATLS®): the ninth edition. *J Trauma Acute Care Surg* 2013;74:1363–6.
32 Moores J, de Jesus GA. Management of post-partum haemorrhage in the Timor Leste national ambulance service. *Emerg Med Australas* 2018;30:814–9.
33 Glomb NW, Kosoko AA, Doughty CB, *et al*. Needs assessment for simulation training for prehospital providers in Botswana. *Prehosp Disaster Med* 2018;33:621–6.
34 Meara JG, Leather AJM, Hagander L, *et al*. Global surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet* 2015;386:569–624.
35 Voigt K, King NB. Out of alignment? Limitations of the global burden of disease in assessing the allocation of global health aid. *Public Health Ethics* 2017;10:244–56.
36 Stuckler D, King L, Robinson H, *et al*. WHO's budgetary allocations and burden of disease: a comparative analysis. *Lancet* 2008;372:1563–9.
37 Ariës MJH, Joosten H, Wegdam HHJ, *et al*. Fracture treatment by bonesetters in central Ghana: patients explain their choices and experiences. *Trop Med Int Health* 2007;12:564–74.
38 Geleto A, Chojenta C, Musa A, *et al*. Barriers to access and utilization of emergency obstetric care at health facilities in sub-Saharan Africa: a systematic review of literature. *Syst Rev* 2018;7:183.
39 Sorenson SB. Gender disparities in injury mortality: consistent, persistent, and larger than you'd think. *Am J Public Health* 2011;101(Suppl 1):S353–8.
40 Mactaggart I, Limburg H, Bastawrous A, *et al*. Rapid assessment of avoidable blindness: looking back, looking forward. *Br J Ophthalmol* 2019;103:1549–52.
41 World Health Organisation. *SEX-RAR guide: the rapid assessment and response guide on psychoactive substance use and sexual risk behaviour*. Geneva, 2002.
42 Beran D, Yudkin JS, de Courten M. Assessing health systems for type 1 diabetes in sub-Saharan Africa: developing a 'Rapid Assessment Protocol for Insulin Access'. *BMC Health Serv Res* 2006;6:17.
43 REDLAC. *Methodology rapid assessment for humanitarian assistance*. Panama, 2006.
44 Bates CJ, Singer M, Needle R, *et al*. The rare model of rapid HIV risk assessment. *J Health Care Poor Underserved* 2007;18:16–33.
45 Holdsworth LM, Safaeinili N, Winget M, *et al*. Adapting rapid assessment procedures for implementation research using a team-based approach to analysis: a case example of patient quality and safety interventions in the ICU. *Implement Sci* 2020;15:12.
46 Palinkas LA, Zatzick D. Rapid assessment procedure informed clinical ethnography (RAPICE) in pragmatic clinical trials of mental health services implementation: methods and applied case study. *Adm Policy Ment Health* 2019;46:255–70.
47 World Health Organisation. *A guide to rapid assessment of human resources for health*. Geneva, 2004.
48 Moher D, Liberati A, Tetzlaff J, *et al*. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009;339:b2535.

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49 Whitaker J, Denning M, O'Donohoe N, *et al*. Assessing trauma care health systems in low- and middle-income countries, a protocol for a systematic literature review and narrative synthesis. *Syst Rev* 2019;8:157.
50 EndNote [program].. *EndNote X9 version*. Philadelphia, PA: Clarivate Analytics, 2013.
51 Godin K, Stapleton J, Kirkpatrick SI, *et al*. Applying systematic review search methods to the grey literature: a case study examining guidelines for school-based breakfast programs in Canada. *Syst Rev* 2015;4:138.
52 World bank country and lending groups. Available: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups [Accessed 15 Sep 2020].
53 Ouzzani M, Hammady H, Fedorowicz Z, *et al*. Rayyan-a web and mobile app for systematic reviews. *Syst Rev* 2016;5:210.
54 Balk EM, Chung M, Hadar N. *AHRQ methods for effective health care. Accuracy of data extraction of non-English language trials with Google translate*. Rockville, MD: Agency for Healthcare Research and Quality (US), 2012.
55 Bishop-Williams KE, Sargeant JM, Berrang-Ford L, *et al*. A protocol for a systematic literature review: comparing the impact of seasonal and meteorological parameters on acute respiratory infections in Indigenous and non-Indigenous peoples. *Syst Rev* 2017;6:19.
56 Jackson JL, Kuriyama A, Anton A, *et al*. The accuracy of Google translate for Abstracting data from Non-English-Language trials for systematic reviews. *Ann Intern Med* 2019;171:677–9.
57 Taylor MJ, McNicholas C, Nicolay C, *et al*. Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. *BMJ Qual Saf* 2014;23:290–8.
58 Snilstveit B, Oliver S, Vojtkova M. Narrative approaches to systematic review and synthesis of evidence for international development policy and practice. *J Dev Effect* 2012;4:409–29.
59 Campbell M, Katikireddi SV, Sowden A, *et al*. Improving conduct and reporting of narrative synthesis of quantitative data (ICONS-Quant): protocol for a mixed methods study to develop a reporting guideline. *BMJ Open* 2018;8:e020064.
60 Donabedian A. The quality of care. How can it be assessed? *JAMA* 1988;260:1743–8.
61 Creswell JW, Plano Clark VL. *Designing and conducting mixed methods research*, 2018.
62 Glasgow RE, Chambers D, robust D. Developing robust, sustainable, implementation systems using rigorous, rapid and relevant science. *Clin Transl Sci* 2012;5:48–55.
63 Glasgow RE. What does it mean to be pragmatic? pragmatic methods, measures, and models to facilitate research translation. *Health Educ Behav* 2013;40:257–65.
64 Blair KJ, Paladino L, Shaw PL, *et al*. Surgical and trauma care in low- and middle-income countries: a review of capacity assessments. *J Surg Res* 2017;210:139–51.
65 Hardcastle TC, Steyn E, Boffard K, *et al*. Guideline for the assessment of trauma centres for South Africa. *S Afr Med J* 2011;101:189–94.
66 Stewart BT, Gyedu A, Quansah R, *et al*. District-level Hospital trauma care audit filters: Delphi technique for defining context-appropriate indicators for quality improvement initiative evaluation in developing countries. *Injury* 2016;47:211–9.
67 Suwaratchai P, Sithisarankul P, Sriratanban J, *et al*. Utilize the modified Delphi technique to develop trauma care indicators. *J Med Assoc Thai* 2008;91:99–103.
68 Stelfox HT, Joshipura M, Chadbunchachai W, *et al*. Trauma quality improvement in low and middle income countries of the Asia-Pacific region: a mixed methods study. *World J Surg* 2012;36:1978–92.
69 LaGrone LN, Fuhs AK, Egoavil EH, *et al*. Mixed-Methods assessment of trauma and acute care surgical quality improvement programs in Peru. *World J Surg* 2017;41:963–9.
70 LaGrone LN, Romaní Pozo DA, Figueroa JF, *et al*. Status of trauma quality improvement programs in the Andean region: what Foundation do we have to build on. *Injury* 2017;48:1985–93.
71 Zetlen HL, LaGrone LN, Foianini JE, *et al*. Status of trauma quality improvement programs in the Americas: a survey of trauma care providers. *J Surg Res* 2017;220:213–22.
72 Fuangworawong P, LaGrone LN, Chadbunchachai W, *et al*. Assessment of trauma quality improvement activities at public hospitals in Thailand. *Int J Surg* 2016;33 Pt A:88–95.
73 Wesson HKH, Stevens KA, Bachani AM, *et al*. Trauma systems in Kenya: a qualitative analysis at the district level. *Qual Health Res* 2015;25:589–99.
74 Kuzma K, Lim AG, Kepha B, *et al*. The Tanzanian trauma patients' prehospital experience: a qualitative Interview-Based study. *BMJ Open* 2015;5:e006921.
75 Patel A, Vissoci JRN, Hocker M, *et al*. Qualitative evaluation of trauma delays in road traffic injury patients in Maringá, Brazil. *BMC Health Serv Res* 2017;17:804.
76 Haghparast-Bidgoli H, Khankeh H, Johansson E, *et al*. Exploring the provision of hospital trauma care for road traffic injury victims in Iran: a qualitative approach. *J Inj Violence Res* 2013;5:28–35.
77 Haghparast-Bidgoli H, Hasselberg M, Khankeh H, *et al*. Barriers and facilitators to provide effective pre-hospital trauma care for road traffic injury victims in Iran: a grounded theory approach. *BMC Emerg Med* 2010;10:20.
78 Khorasani-Zavareh D, Khankeh HR, Mohammadi R, *et al*. Post-crash management of road traffic injury victims in Iran. stakeholders' views on current barriers and potential facilitators. *BMC Emerg Med* 2009;9:8.
79 Stephens T, Mezei A, O'Hara NN, *et al*. When surgical resources are severely constrained, who receives care? Determinants of access to orthopaedic trauma surgery in Uganda. *World J Surg* 2017;41:1415–9.
80 Wesson HKH, Bachani AM, Wekesa JM, *et al*. Assessing trauma care at the district and provincial Hospital levels: a case study of hospitals in Kenya. *Injury* 2013;44(Suppl 4):S75–80.
81 Jagnoor J, Lukaszyk C, Christou A, *et al*. Where to from here? A quality improvement project investigating burns treatment and rehabilitation practices in India. *BMC Res Notes* 2018;11:224–24.
82 Bruni AKK, Bailey K, Rambaran N. A qualitative assessment of trauma care and Georgetown public hospital Corporation in Guyana. *West Indian Med J* 2017;66:202–7.
83 Tachfouti N, Bhatti JA, Nejjari C, *et al*. Emergency trauma care for severe injuries in a Moroccan region: conformance to French and world Health organization standards. *J Healthc Qual* 2011;33:30–8.
84 Chokotho L, Mulwafu W, Singini I, *et al*. First responders and prehospital care for road traffic injuries in Malawi. *Prehosp Disaster Med* 2017;32:14–19.
85 Al-Attas AH, Williams CD, Pitchforth EL, *et al*. Understanding delay in accessing specialist emergency eye care in a developing country: eye trauma in Tanzania. *Ophthalmic Epidemiol* 2010;17:103–12.
86 Lombardo S, Unurbileg B, Gerelmaa J, *et al*. Trauma care in Mongolia: intact evaluation and recommendations for improvement. *World J Surg* 2018;42:2285–92.
87 Ankomah J, Stewart BT, Oppong-Nketia V, *et al*. Strategic assessment of the availability of pediatric trauma care equipment, technology and supplies in Ghana. *J Pediatr Surg* 2015;50:1922–7.
88 Arreola-Risa C, Mock C, Vega Rivera F, *et al*. Evaluating trauma care capabilities in Mexico with the world Health organization's guidelines for essential trauma care publication. *Rev Panam Salud Publica* 2006;19:94–103.
89 Aboutanos MB, Mora F, Rodas E, *et al*. Ratification of IATSIC/WHO's guidelines for essential trauma care assessment in the South American region. *World J Surg* 2010;34:2735–44.
90 Burke TF, Hines R, Ahn R, *et al*. Emergency and urgent care capacity in a resource-limited setting: an assessment of health facilities in Western Kenya. *BMJ Open* 2014;4:e006132.
91 Cerrada WVA. Evaluación de servicios de emergencia para atención al trauma en Mérida, Venezuela. *MedULA* 2017;26:1–7.
92 Chichom-Mefire A, Mbarga-Essim NT, Monono ME, *et al*. Compliance of district hospitals in the center region of Cameroon with WHO/IATSIC guidelines for the care of the injured: a cross-sectional analysis. *World J Surg* 2014;38:2525–33.
93 Son NT, Thu NH, Tu NTH, *et al*. Assessment of the status of resources for essential trauma care in Hanoi and Khanh Hoa, Vietnam. *Injury* 2007;38:1014–22.
94 Razzak JA, Baqir SM, Khan UR, *et al*. Emergency and trauma care in Pakistan: a cross-sectional study of healthcare levels. *Emerg Med J* 2015;32:207–13.
95 Shah MT, Bhattarai S, Lamichhane N, *et al*. Assessment of the availability of technology for trauma care in Nepal. *Injury* 2015;46:1712–9.
96 Shah MT, Joshipura M, Singleton J, *et al*. Assessment of the availability of technology for trauma care in India. *World J Surg* 2015;39:363–72.
97 Hanche-Olsen TP, Alemu L, Viste A, *et al*. Trauma care in Africa: a status report from Botswana, guided by the World Health Organization's "Guidelines for Essential Trauma Care". *World J Surg* 2012;36:2371–83.
98 Rosales-Mayor E, Miranda JJ, Lema C, *et al*. Recursos Y capacidades de servicios de emergencia para atención de lesiones POR traumas en Perú. *Cadernos de Saúde Pública* 2011;27:1837–46.

BMJ Glob Health: first published as 10.1136/bmjgh-2020-004324 on 11 May 2021. Downloaded from http://gh.bmj.com/ on May 18, 2021 at University of Birmingham. Protected by copyright.

99 Nakahara S, Saint S, Sann S, *et al*. Evaluation of trauma care resources in health centers and referral hospitals in Cambodia. *World J Surg* 2009;33:874–85.
100 Mock C, Nguyen S, Quansah R, *et al*. Evaluation of trauma care capabilities in four countries using the WHO-IATSIC guidelines for essential trauma care. *World J Surg* 2006;30:946–56.
101 Stewart BT, Quansah R, Gyedu A, *et al*. Strategic assessment of trauma care capacity in Ghana. *World J Surg* 2015;39:2428–40.
102 Stewart BT, Quansah R, Gyedu A, *et al*. Serial assessment of trauma care capacity in Ghana in 2004 and 2014. *JAMA Surg* 2016;151:164–71.
103 Tabiri S, Nicks BA, Dykstra R, *et al*. Assessing trauma care capabilities of the health centers in northern Ghana. *World J Surg* 2015;39:2422–7.
104 Uthkarsh PS, Gururaj G, Reddy SS, *et al*. Assessment and availability of trauma care services in a district hospital of South India; a field observational study. *Bull Emerg Trauma* 2016;4:93–100.
105 Dewberry L, McCullough C, Goss J, *et al*. Trauma capacity in the central plateau department of Haiti. *J Surg Res* 2014;192:34–40.
106 McCullough C, DeGennaro V, Bagley JK, *et al*. A national trauma capacity assessment of Haiti. *J Surg Res* 2016;201:126–33.
107 Norman ID, Aikins M, Binka FN, *et al*. Hospital all-risk emergency preparedness in Ghana. *Ghana Med J* 2012;46:34–42.
108 Clarke DL, Aldous C, Thomson SR. Assessing the gap between the acute trauma workload and the capacity of a single rural health district in South Africa. what are the implications for systems planning? *Eur J Trauma Emerg Surg* 2014;40:303–8.
109 Blair KJ, Boeck MA, Gallardo Barrientos JL, *et al*. Assessment of surgical and trauma capacity in Potosí, Bolivia. *Ann Glob Health* 2017;83:262–73.
110 Chokotho L, Jacobsen KH, Burgess D, *et al*. A review of existing trauma and musculoskeletal impairment (TMSI) care capacity in East, central, and southern Africa. *Injury* 2016;47:1990–5.
111 Mowafi H, Hariri M, Alnahhas H, *et al*. Results of a nationwide capacity survey of hospitals providing trauma care in War-Affected Syria. *JAMA Surg* 2016;151:815–22.
112 Jat AA, Khan MR, Zafar H, *et al*. Peer review audit of trauma deaths in a developing country. *Asian J Surg* 2004;27:58–64.
113 Mock CN, Adzotor KE, Conklin E, *et al*. Trauma outcomes in the rural developing world: comparison with an urban level I trauma center. *J Trauma* 1993;35:518–23.
114 Roy N, Kizhakke Veetil D, Khajanchi MU, *et al*. Learning from 2523 trauma deaths in India- opportunities to prevent in-hospital deaths. *BMC Health Serv Res* 2017;17:142.
115 Hardcastle TC, Reeds MG, Muckart DJJ. Utilisation of a level 1 trauma centre in KwaZulu-Natal: appropriateness of referral determines trauma patient access. *World J Surg* 2013;37:1544–9.
116 Costa CDdaS, Scarpelini S. Evaluation of the quality of trauma care service through the study of deaths in a tertiary hospital. *Rev Col Bras Cir* 2012;39:249–54.
117 Ifesanya OA, Ifesanya UJ. Orthopaedic care in a southwestern Nigeria secondary level Hospital: are patients' needs being Met? *Afr J Med Med Sci* 2012;41:153–9.
118 Ozgüç H, Kaya E, Yünük O, *et al* Outcome of major trauma in a Turkish university hospital: did integrated approach make a difference? *Eur J Emerg Med* 2000;7:183–8.
119 Bigdeli M, Khorasani-Zavareh D, Mohammadi R. Pre-hospital care time intervals among victims of road traffic injuries in Iran. A cross-sectional study. *BMC Public Health* 2010;10:406.
120 Khan A, Zafar H, Naeem SN, *et al*. Transfer delay and in-hospital mortality of trauma patients in Pakistan. *Int J Surg* 2010;8:155–8.
121 Paravar M, Hosseinpour M, Salehi S, *et al*. Pre-Hospital trauma care in road traffic accidents in kashan, Iran. *Arch Trauma Res* 2013;1:166–71.
122 Ibrahim NA, Ajani AWO, Mustafa IA, *et al*. Road traffic injury in Lagos, Nigeria: assessing prehospital care. *Prehosp Disaster Med* 2017;32:424–30.
123 Haider AH, Hashmi ZG, Gupta S, *et al*. Benchmarking of trauma care worldwide: the potential value of an international trauma data bank (ITDB). *World J Surg* 2014;38:1882–91.
124 Zafar H, Rehmani R, Raja AJ, *et al*. Registry based trauma outcome: perspective of a developing country. *Emerg Med J* 2002;19:391–4.
125 Arreola-Risa C, Mock CN, Padilla D, *et al*. Trauma care systems in urban Latin America: the priorities should be prehospital and emergency room management. *J Trauma* 1995;39:457–62.
126 Paravar M, Hosseinpour M, Mohammadzadeh M, *et al*. Prehospital care and in-hospital mortality of trauma patients in Iran. *Prehosp Disaster Med* 2014;29:473–7.
127 Matityahu A, Elliott I, Marmor M, *et al*. Time intervals in the treatment of fractured femurs as indicators of the quality of trauma systems. *Bull World Health Organ* 2014;92:40–50.
128 Bal A, Cooper M, Lee A, *et al*. The evaluation of trauma care: the comparison of 2 high-level pediatric emergency departments in the United States and turkey. *Pediatr Emerg Care* 2019;35:18.
129 Hashmi ZG, Haider AH, Zafar SN, *et al*. Hospital-based trauma quality improvement initiatives: first step toward improving trauma outcomes in the developing world. *J Trauma Acute Care Surg* 2013;75:60–8. discussion 68.
130 Chadbunchachai W, Sriwiwat S, Kulleab S, *et al*. The comparative study for quality of trauma treatment before and after the revision of trauma audit filter, Khon Kaen Hospital 1998. *J Med Assoc Thai* 2001;84:782–90.
131 Chadbunchachai W, Saranrittichai S, Sriwiwat S, *et al*. Study on performance following key performance indicators for trauma care: Khon Kaen Hospital 2000. *J Med Assoc Thai* 2003;86:1–7.
132 Spangenberg K, Mock C. Utilization of health services by the injured residents in Kumasi, Ghana. *Int J Inj Contr Saf Promot* 2006;13:194–6.
133 Nordberg E, Kimani V, Diwan V. Household survey of injuries in a Kenyan district. *East Afr Med J* 2000;77:240–4.
134 Wu Y, Zhang W, Zhang L. Non-fatal injuries treated outside a hospital in Hunan, China: results from a household interview survey. *Eur J Public Health* 2016;27:331–4.
135 El Tayeb S, Abdalla S, Van den Bergh G, *et al*. Use of healthcare services by injured people in Khartoum state, Sudan. *Int Health* 2015;7:183–9.
136 Mock C, Ofosu A, Gish O. Utilization of district health services by injured persons in a rural area of Ghana. *Int J Health Plann Manage* 2001;16:19–32.
137 Mock CN, nii-Amon-Kotei D, Maier RV. Low utilization of formal medical services by injured persons in a developing nation: health service data underestimate the importance of trauma. *J Trauma* 1997;42:504–11. discussion 11-3.
138 Petroze RT, Joharifard S, Groen RS, *et al*. Injury, disability and access to care in Rwanda: results of a nationwide cross-sectional population study. *World J Surg* 2015;39:62–9.
139 Nguyen TLH, Nguyen THT, Morita S, *et al*. Injury and pre-hospital trauma care in Hanoi, Vietnam. *Injury* 2008;39:1026–33.
140 Yeboah D, Mock C, Karikari P, *et al*. Minimizing preventable trauma deaths in a limited-resource setting: a test-case of a multidisciplinary panel review approach at the Komfo Anokye teaching hospital in Ghana. *World J Surg* 2014;38:1707–12.
141 Parra MW, Castillo RC, Rodas EB, *et al*. International trauma teleconference: evaluating trauma care and facilitating quality improvement. *Telemed J E Health* 2013;19:699–703.
142 Tansley G, Schuurman N, Amram O, *et al*. Spatial access to emergency services in low- and middle-income countries: a GIS-based analysis. *PLoS One* 2015;10:e0141113.
143 Stewart BT, Gyedu A, Tansley G, *et al*. Orthopaedic trauma care capacity assessment and strategic planning in Ghana: mapping a way forward. *J Bone Joint Surg Am* 2016;98:e104.
144 Channa R, Jaffrani HA, Khan AJ, *et al*. Transport time to trauma facilities in karachi: an exploratory study. *Int J Emerg Med* 2008;1:201–4.
145 Petroze RT, Mehtsun W, Nzayisenga A, *et al*. Ratio of cesarean sections to total procedures as a marker of district hospital trauma capacity. *World J Surg* 2012;36:2074–9.
146 Joseph K, Trehan A, Cherian M. Assessment of acute burn management in 32 low- and middle-income countries. *World J Surg* 2016;40:791–800.
147 Kesinger MR, Puyana JC, Rubiano AM. Improving trauma care in low- and middle-income countries by implementing a standardized trauma protocol. *World J Surg* 2014;38:1869–74.
148 Hanche-Olsen TP, Alemu L, Viste A, *et al*. Evaluation of training program for surgical trauma teams in Botswana. *World J Surg* 2015;39:658–68.
149 Balikuddembe JK, Ardalan A, Khorasani-Zavareh D, *et al*. Factors affecting the exposure, vulnerability and emergency medical service capacity for victims of road traffic incidents in Kampala metropolitan area: a Delphi study. *BMC Emerg Med* 2017;17:1.
150 Scott JW, Nyinawankusi Jeanne D'Arc, Enumah S, *et al*. Improving prehospital trauma care in Rwanda through continuous quality improvement: an interrupted time series analysis. *Injury* 2017;48:1376–81.
151 Nagata T, Takamori A, Kimura Y, *et al*. Trauma center accessibility for road traffic injuries in Hanoi, Vietnam. *J Trauma Manag Outcomes* 2011;5:11.

BMJ Glob Health: first published as 10.1136/bmjgh-2020-004324 on 11 May 2021. Downloaded from http://gh.bmj.com/ on May 18, 2021 at University of Birmingham. Protected by copyright.

152 Son NT, Mock C. Improvements in trauma care capabilities in Vietnam through use of the WHO-IATSIC guidelines for essential trauma care. *Int J Inj Contr Saf Promot* 2006;13:125–7.
153 Ouma PO, Maina J, Thuranira PN, *et al*. Access to emergency hospital care provided by the public sector in sub-Saharan Africa in 2015: a geocoded inventory and spatial analysis. *Lancet Glob Health* 2018;6:e342–50.
154 Sethi D, Aljunid S, Saperi SB, *et al*. Comparison of the effectiveness of trauma services provided by secondary and tertiary hospitals in Malaysia. *Ann Emerg Med* 2007;49:52–61.
155 Zafarghandi M-R, Modaghegh M-HS, Roudsari BS. Preventable trauma death in Tehran: an estimate of trauma care quality in teaching hospitals. *J Trauma* 2003;55:459–65.
156 Zargar M, Modaghegh MH, Rezaishiraz H. Urban injuries in Tehran: demography of trauma patients and evaluation of trauma care. *Injury* 2001;32:613–7.
157 Wong EG, Gupta S, Deckelbaum DL, *et al*. The International assessment of capacity for trauma (intact): an index for trauma capacity in low-income countries. *J Surg Res* 2014;190:522–7.
158 Wong EG, Gupta S, Deckelbaum DL, *et al*. Prioritizing injury care: a review of trauma capacity in low and middle-income countries. *J Surg Res* 2015;193:217–22.
159 Lashoher A, Schneider EB, Juillard C, *et al*. Implementation of the world Health organization trauma care checklist program in 11 centers across multiple economic strata: effect on care process measures. *World J Surg* 2017;41:954–62.
160 Vanderschuren M, McKune D. Emergency care facility access in rural areas within the golden hour?: Western Cape case study. *Int J Health Geogr* 2015;14:5.
161 Murlidhar V, Roy N. Measuring trauma outcomes in India: an analysis based on TRISS methodology in a Mumbai university hospital. *Injury* 2004;35:386–90.
162 Muñoz JHM, Ortiz AFR, Ramos KYS, *et al*. Mortalidad Prevenible en trauma: un estudio de Reuniones de Análisis de Mortalidad en un Hospital Universitario en Colombia. *Panamerica J Trauma Crit Care Emer Surg* 2014;3:59–67.
163 Choi SJ, Oh MY, Kim NR, *et al*. Comparison of trauma care systems in Asian countries: a systematic literature review. *Emerg Med Australas* 2017;29:697–711.
164 Saleh HM, Elsabagh AE, Elewa MG, *et al*. Admission delays' magnitude of traumatized patients in the emergency department of a hospital in Egypt: a cross-sectional study. *Eur J Trauma Emerg Surg* 2018;44:225–30.
165 Mock CLJ, Goosen J, Joshipura M, *et al*. *Guidelines for essential trauma care*. Geneva, Switzerland: World Health Organization, 2004.
166 World Health Organization. *Essential trauma care project, checklists for surveys of trauma care capabilities*, 2004.
167 Sethi DHS, McGee K, Peden M. *Guidelines for conducting community surveys on injuries and violence*. World Health Organisation, 2004.
168 World Health Organisation. *Guidelines for trauma quality improvement programmes*. Geneva, 2009.
169 World Health Organisation. Emergency and trauma care activities. Available: https://www.who.int/emergencycare/activities/en/ [Accessed 22 May 2020].
170 World Health Organisation. Trauma system maturity index. Available: https://www.who.int/emergencycare/trauma/essential-care/maturity-index/en/ [Accessed 22 May 2020].
171 World Health Organization. *Prehospital trauma care systems*, 2005.
172 World Health Organization. Sustainable development goal 3: health, 2015. Available: https://www.who.int/topics/sustainable-development-goals/targets/en/
173 Global Health Data Exchange. Global burden of disease results tool. Available: http://ghdx.healthdata.org/gbd-results-tool [Accessed 6 Aug 2020].
174 Kawuwa MB, Mairiga AG, Usman HA. Community perspective of maternal mortality: experience from Konduga local government area, Borno state, Nigeria. *Ann Afr Med* 2007;6:109–14.
175 Accorsi S, Somigliana E, Solomon H, *et al*. Cost-effectiveness of an ambulance-based referral system for emergency obstetrical and neonatal care in rural Ethiopia. *BMC Pregnancy Childbirth* 2017;17:220.
176 Lassi ZS, Middleton P, Bhutta ZA, *et al*. Health care seeking for maternal and newborn illnesses in low- and middle-income countries: a systematic review of observational and qualitative studies. *F1000Res* 2019;8:200–00.
177 Larkin PM, Begley CM, Devane D. Breaking from binaries - using a sequential mixed methods design. *Nurse Res* 2014;21:8–12.
178 Bhalla K, Adofo K, Mock CN, *et al*. Non-traditional data sources for injury control: an agenda for action in Ghana. *Inj Prev* 2012;18:277.
179 Juran S, Broer PN, Klug SJ, *et al*. Geospatial mapping of access to timely essential surgery in sub-Saharan Africa. *BMJ Glob Health* 2018;3:e000875–e75.
180 Geduld H, Hynes EJC, Wallis LA, *et al*. Hospital proximity does not guarantee access to emergency care. *Lancet Glob Health* 2018;6:e731.
181 Rudolfson N, Gruendl M, Nkurunziza T, *et al*. Validating the global surgery geographical accessibility indicator: differences in modeled versus patient-reported travel times. *World J Surg* 2020;44:2123–30.
182 van Duinen AJ, Adde HA, Fredin O, *et al*. Travel time and perinatal mortality after emergency caesarean sections: an evaluation of the 2-hour proximity indicator in Sierra Leone. *BMJ Glob Health* 2020;5:e003943.
183 Mould-Millman N-K, Dixon JM, Sefa N, *et al*. The state of emergency medical services (EMS) systems in Africa. *Prehosp Disaster Med* 2017;32:273–83.
184 El Sayed MJ. Measuring quality in emergency medical services: a review of clinical performance indicators. *Emerg Med Int* 2012;2012:161630.
185 Tayler-Smith K, Zachariah R, Manzi M, *et al*. An ambulance referral network improves access to emergency obstetric and neonatal care in a district of rural Burundi with high maternal mortality. *Trop Med Int Health* 2013;18:993–1001.
186 Groppi L, Somigliana E, Pisani V, *et al*. A hospital-centered approach to improve emergency obstetric care in South Sudan. *Int J Gynaecol Obstet* 2015;128:58–61.
187 Ravindran J, Parampalam SD. Revisiting the obstetric flying squad. *Med J Malaysia* 2000;55:280–2.
188 de Ramirez SS, Doll J, Carle S, *et al*. Emergency response in resource-poor settings: a review of a newly-implemented EMS system in rural Uganda. *Prehosp Disaster Med* 2014;29:311–6.
189 Adewole OA, Fadeyibi IO, Kayode MO, *et al*. Ambulance services of Lagos state, Nigeria: a six-year (2001-2006) audit. *West Afr J Med* 2012;31:3–7.
190 Slabbert JA, Smith WP. Patient transport from rural to tertiary healthcare centres in the Western Cape: is there room for improvement? *African Journal of Emergency Medicine* 2011;1:11–16.
191 Leslie HH, Sun Z, Kruk ME. Association between infrastructure and observed quality of care in 4 healthcare services: a cross-sectional study of 4,300 facilities in 8 countries. *PLoS Med* 2017;14:e1002464.
192 Wassihun B, Zeleke S. Compassionate and respectful maternity care during facility based child birth and women's intent to use maternity service in Bahir Dar, Ethiopia. *BMC Pregnancy Childbirth* 2018;18:294–94.
193 Orimolade EA AO, Oginni LM, Asuquo JE. Reasons why trauma patients Request for discharge against medical advice in Wesley guild Hospital Ilesha. *East Central Afr J Surg* 2014;18.
194 Latifi R, Ziemba M, Leppäniemi A, *et al*. Trauma system evaluation in developing countries: applicability of American College of Surgeons/Committee on trauma (ACS/COT) basic criteria. *World J Surg* 2014;38:1898–904.
195 GlobalSurg Collaborative. Mortality of emergency abdominal surgery in high-, middle- and low-income countries. *Br J Surg* 2016;103:971–88.
196 Biccard BM, Madiba TE, Kluyts H-L, *et al*. Perioperative patient outcomes in the African surgical outcomes study: a 7-day prospective observational cohort study. *Lancet* 2018;391:1589–98.
197 Wright NJ, Global PaedSurg Research Collaboration. Management and outcomes of gastrointestinal congenital anomalies in low, middle and high income countries: protocol for a multicentre, international, prospective cohort study. *BMJ Open* 2019;9:e030452.
198 Ndabarora E, Chipps JA, Uys L. Systematic review of health data quality management and best practices at community and district levels in LMIC. *Information Development* 2014;30:103–20.
199 Hung YW, Hoxha K, Irwin BR, *et al*. Using routine health information data for research in low- and middle-income countries: a systematic review. *BMC Health Serv Res* 2020;20:790.
200 Howitt P, Darzi A, Yang G-Z, *et al*. Technologies for global health. *The Lancet* 2012;380:507–35.
201 Franzen SRP, Chandler C, Lang T. Health research capacity development in low and middle income countries: reality or rhetoric? A systematic meta-narrative review of the qualitative literature. *BMJ Open* 2017;7:e012332.
202 White A, Thomas DSK, Ezeanochie N, *et al*. Health worker mHealth utilization: a systematic review. *Comput Inform Nurs* 2016;34:206–13.

BMJ Glob Health: first published as 10.1136/bmjgh-2020-004324 on 11 May 2021. Downloaded from http://gh.bmj.com/ on May 18, 2021 at University of Birmingham. Protected by copyright.

203 Vesel L, Manu A, Lohela TJ, *et al*. Quality of newborn care: a health facility assessment in rural Ghana using survey, vignette and surveillance data. *BMJ Open* 2013;3:e002326.
204 Villar Uribe M, Alonge OO, Bishai DM, *et al*. Can task-shifting work at scale?: comparing clinical knowledge of non-physician clinicians to physicians in Nigeria. *BMC Health Serv Res* 2018;18:308.
205 Leonard KL, Masatu MC. The use of direct clinician observation and vignettes for health services quality evaluation in developing countries. *Soc Sci Med* 2005;61:1944–51.
206 Peabody JW, Luck J, Glassman P, *et al*. Comparison of vignettes, standardized patients, and chart abstraction: a prospective validation study of 3 methods for measuring quality. *JAMA* 2000;283:1715–22.
207 Gidengil CA, Linder JA, Beach S, *et al*. Using clinical Vignettes to assess quality of care for acute respiratory infections. *Inquiry* 2016;53. doi:10.1177/0046958016636531. [Epub ahead of print: 20 Apr 2016].
208 Christian CS, Gerdtham U-G, Hompashe D, *et al*. Measuring quality gaps in TB screening in South Africa using standardised patient analysis. *Int J Environ Res Public Health* 2018;15:729.
209 de Savigny D, Adam T. *Systems thinking for health systems strengthening. alliance for health policy and systems research*. Geneva: World Health Organisation, 2009.
210 de Savigny D, Blanchet K, Adam T. *Applied systems thinking for health systems research : a methodological handbook*. McGraw-Hill Education, 2017.
211 Peters DH. The application of systems thinking in health: why use systems thinking? *Health Res Policy Syst* 2014;12:51.
212 Aaronson E, Mort E, Soghoian S. Mapping the process of emergency care at a teaching hospital in Ghana. *Healthc* 2017;5:214–20.
213 Forrester JA, Koritsanszky LA, Amenu D, *et al*. Developing process maps as a tool for a surgical infection prevention quality improvement initiative in resource-constrained settings. *J Am Coll Surg* 2018;226:1103–16.
214 Varghese J, Kutty VR, Paina L, *et al*. Advancing the application of systems thinking in health: understanding the growing complexity governing immunization services in Kerala, India. *Health Res Policy Syst* 2014;12:47.
215 Waqa G, Moodie M, Snowdon W, *et al*. Exploring the dynamics of food-related policymaking processes and evidence use in Fiji using systems thinking. *Health Res Policy Syst* 2017;15:74.
216 McLean E, Dube A, Saul J, *et al*. Implementing electronic data capture at a well-established health and demographic surveillance site in rural Northern Malawi. *Glob Health Action* 2017;10:1367162.
217 Walther B, Hossin S, Townend J, *et al*. Comparison of electronic data capture (EDC) with the standard data capture method for clinical trial data. *PLoS One* 2011;6:e25348.
218 Thriemer K, Ley B, Ame SM, *et al*. Replacing paper data collection forms with electronic data entry in the field: findings from a study of community-acquired bloodstream infections in Pemba, Zanzibar. *BMC Res Notes* 2012;5:113.
219 Yu P, de Courten M, Pan E, *et al*. The development and evaluation of a PDA-based method for public health surveillance data collection in developing countries. *Int J Med Inform* 2009;78:532–42.
220 Sutton J, Austin Z. Qualitative research: data collection, analysis, and management. *Can J Hosp Pharm* 2015;68:226–31.
221 ESSENCE on Health Research. *Research-costing practices: towards bridging the gaps in research funding in low- and middle-income countries*, 2012.
222 Petroze RT, Nzayisenga A, Rusanganwa V, *et al*. Comprehensive national analysis of emergency and essential surgical capacity in Rwanda. *Br J Surg* 2012;99:436–43.
223 World Health Organization. *Service availability and readiness assessment (SARA) reference manual*. Geneva: World Health Organisation, 2013.
224 Sharif-Alhoseini M, Eghbali A, Rahimi-Movaghar V, *et al*. Situation analysis of trauma based on Arizona trauma center standards in university hospitals of Tehran, Iran. *Chin J Traumatol* 2009;12:279–84.
225 Deshmukh VU, Ketkar MN, Bharucha EK. Analysis of trauma outcome using the TRISS method at a tertiary care centre in Pune. *Indian J Surg* 2012;74:440–4.
226 Mpirimbanyi C, Abahuje E, Hirwa AD, *et al*. Defining the three delays in referral of surgical emergencies from district hospitals to university teaching hospital of Kigali, Rwanda. *World J Surg* 2019;43:1871–9.

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