Serial Assessment of Trauma Care Capacity in Ghana in 2004 and 2014

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IMPORTANCE Trauma care capacity assessments in developing countries have generated evidence to support advocacy, detailed baseline capabilities, and informed targeted interventions. However, serial assessments to determine the effect of capacity improvements or changes over time have rarely been performed.

OBJECTIVE To compare the availability of trauma care resources in Ghana between 2004 and 2014 to assess the effects of a decade of change in the trauma care landscape and derive recommendations for improvements.

DESIGN, SETTING, AND PARTICIPANTS Capacity assessments were performed using direct inspection and structured interviews derived from the World Health Organization’s Guidelines for Essential Trauma Care. In Ghana, 10 hospitals in 2004 and 32 hospitals in 2014 were purposively sampled to represent those most likely to care for injuries. Clinical staff, administrators, logistic/procurement officers, and technicians/biomedical engineers who interacted, directly or indirectly, with trauma care resources were interviewed at each hospital.

MAIN OUTCOMES AND MEASURES Availability of items for trauma care was rated from 0 (complete absence) to 3 (fully available). Factors contributing to deficiency in 2014 were determined for items rated lower than 3. Each item rated lower than 3 at a specific hospital was defined as a hospital-item deficiency. Scores for total number of hospital-item deficiencies were derived for each contributing factor.

RESULTS There were significant improvements in mean ratings for trauma care resources: district-level (smaller) hospitals had a mean rating of 0.8 for all items in 2004 vs 1.3 in 2014 (P = .002); regional (larger) hospitals had a mean rating of 1.1 in 2004 vs 1.4 in 2014 (P = .01). However, a number of critical deficiencies remain (eg, chest tubes, diagnostics, and orthopedic and neurosurgical care; mean ratings ≤2). Leading contributing factors were item absence (503 hospital-item deficiencies), lack of training (335 hospital-item deficiencies), and stockout of consumables (137 hospital-item deficiencies).

CONCLUSIONS AND RELEVANCE There has been significant improvement in trauma care capacity during the past decade in Ghana; however, critical deficiencies remain and require urgent redress to avert preventable death and disability. Serial capacity assessment is a valuable tool for monitoring efforts to strengthen trauma care systems, identifying what has been successful, and highlighting needs.
Trauma has become increasingly recognized as a leading cause of death and disability. To benchmark capabilities, trauma care capacity assessments in low- and middle-income countries (LMICs) have been performed. Additionally, these assessments have generated evidence to support advocacy and identified specific deficits to inform targeted interventions.4

Despite more than 20 assessments, only 2 countries have compared repeated assessments with baseline capacity to determine the effect of trauma care advocacy or interventions over time.4,6,8 Serial assessment after 3 years of surgical capacity expansions in Sierra Leone demonstrated significant improvements at nearly all of the 10 hospitals reassessed.4,5 In Hanoi, Vietnam, initial assessment of trauma care occurred in 2002. After identifying deficiencies in training and physical resources, targeted interventions were implemented. One year later, 9 of 13 items at district-level hospitals and 7 of 13 items at city hospitals were more often available and used than before the interventions.8 Serial capacity assessments are useful for quantifying the effect of health systems, strengthening efforts in LMICs, and informing the way forward.9,10

In 2004, a systematic assessment of trauma care capacity was performed in Ghana using the World Health Organization’s Guidelines for Essential Trauma Care.3,11 Since then, Ghana witnessed the birth and growth of a national ambulance service, implementation and maturation of the National Health Insurance Scheme, creation and dissolution of a trauma care continuing education course, formation of an emergency medicine training program, and rapid urbanization with concomitant increases in road injury.12-16 The summative effect of these exposures on national trauma care capacity is unknown.

This study aimed to compare the availability of trauma care services and the resources necessary to provide them in district-level and regional hospitals in Ghana between 2004 and 2014. By doing so, the effects of a decade of change in Ghana’s trauma care landscape can be assessed and potential interventions defined.

Methods

Setting

Ghana is a heavily indebted, lower-middle-income country in West Africa with a population of nearly 26 million people.17 From 2004 to 2014, life expectancy at birth increased from 57 to 61 years. This gain came in part from improved health care development evidenced by a tripling of government health expenditure per capita and creation of the National Health Insurance Scheme, which covers emergency care.17,18 However, the government health expenditure per capita as a percentage of gross domestic product has decreased from 6.1% to 4.5%. Ghana has also witnessed a dramatic increase in motor vehicle ownership, heralding the potential for a greater incidence of road traffic injuries (Table 1).19

Sampling

For both assessments, district-level hospitals were sampled to represent those most likely to care for injuries, the diversity of trauma care development, and local socioeconomics. At least 1 district-level hospital in each region was selected by meeting the following criteria:

- In a populous area, near heavily trafficked roads likely to produce traffic injuries; or
- Identified by the respective regional health directorate as caring for a higher injury volume than others within the region; or
- Designated as a trauma hospital; and
- Outside 1 hour’s transport to a regional or tertiary hospital.

In 2004, 10 hospitals were purposively sampled to represent regional and district-level hospitals in the southern regions (7 of the 10 regions). In 2014, all regional hospitals (except 1 that declined participation) and 30 district-level hospitals were sampled. To appositely compare hospitals from both studies, only the 32 district-level and regional hospitals representing the southern regions from the 2014 assessment were analyzed.

The 2004 study was approved by the Ghana Health Service. The 2014 study was approved by the Kwame Nkrumah University of Science and Technology Committee for Human Research and Publication Ethics and the University of Washington Institutional Review Board. In addition to ethical approval, approvals were obtained from the Ministry of Health and the Ghana Health Service. Informed consent was obtained from the leadership at each hospital prior to assessment. All data were anonymously recorded.

Data Collection

The World Health Organization Guidelines for Essential Trauma Care list 260 items of personnel and physical resources essential (ie, most cost-effective, universally applicable; eg, basic airway equipment) or desirable (ie, value-added, less cost-effective; eg, computed tomography) at different levels within a health care system. The assessments mutually examined 28 items from both groups; these items were used for the comparison. A technology item was defined as any electronic medical equipment (eg, mechanical ventilator, hemoglobin analyzer, radiography).

For both assessments, the following staff were asked to complete their respective part of the survey depending on context: surgeons, anesthetists, medical officers, professionals,

### Table 1. Ghana’s Development Indicators in 2004 and 2014

<table>
<thead>
<tr>
<th>Development Indicator</th>
<th>2004</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population, No.</td>
<td>20 840 000</td>
<td>25 900 000</td>
</tr>
<tr>
<td>Urban population, %</td>
<td>47</td>
<td>53</td>
</tr>
<tr>
<td>Life expectancy at birth, y</td>
<td>57</td>
<td>61</td>
</tr>
<tr>
<td>GDP per capita, $</td>
<td>426</td>
<td>1850</td>
</tr>
<tr>
<td>Government health expenditure per capita $</td>
<td>26</td>
<td>83</td>
</tr>
<tr>
<td>GDP, %</td>
<td>6.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Out-of-pocket expenditure on health, $</td>
<td>64</td>
<td>67</td>
</tr>
<tr>
<td>Registered motor vehicles/1000 population, No.</td>
<td>2.9</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Abbreviation: GDP, gross domestic product.
technicians, and/or in-charge nurses from the casualty, theater, critical care, wards, laboratory, radiology, physiotherapy, procurement, accounts, and engineering departments. Item availability was rated as the following: 0, absent but should be present; 1, inadequate, available to fewer than half of those who need it; 2, partially adequate, available to more than half but not to most who need it; or 3, adequate, present, readily available to almost everyone in need, and used when needed.

To further the usefulness of the 2014 reassessment, factors contributing to item ratings of 2 or lower were systematically assessed as the following: never been present; present but broken and awaiting repairs; present and staff able to use it, except at night or on the weekend; no staff member trained in using the available item; available but lacks reagents or supplies; necessary equipment or supplies out of stock or insufficient in number; available, but only after prepayment that prevents many from receiving the service or item; and/or other, with explanation.

Factors were not mutually exclusive, except for the category of never been present, which ruled out any other contributing factor. Direct inspection of items was performed to corroborate ratings and troubleshoot reason(s) for unavailability. Direct inspection included determining whether the item was present or absent, examining it for useful availability, and evaluating why it was not available at times if rated lower than 3.

**Statistical Analysis**

Data from 2004 have been published and were extracted for comparison.11,20 For the 2014 assessment, data were collected on paper forms and transcribed to Microsoft Excel (Microsoft Corp). Item availability ratings were described using Stata version 13 statistical software (StataCorp LP). Given that 8 of the 10 hospitals assessed in 2004 were reassessed in 2014, the Wilcoxon signed rank test was used to compare item availability ratings between the 2 assessments. Lastly, the number of hospitals that reported a specific factor contributing to each deficient item was calculated; each item rated lower than 3 at a specific hospital was defined as a hospital-item deficiency. Scores for total number of hospital-item deficiencies were derived for each of the major contributing factors to identify potential targets for interventions.

**Results**

**District-Level Hospitals**

In district-level hospitals, resuscitation and the requisite equipment and supplies were more dependably available in 2014 than in 2004. Most notable were basic and advanced airway equipment (mean rating increased from 1 in 2004 to 2 and 3, respectively in 2014), oxygen supply (rating increased from 1 to 3), pulse oximetry (rating increased from 0 to 3), and blood transfusion capabilities (rating increased from 1 to 2). The availability of chest tubes, a low-cost item, was lower in 2014 (mean rating of 0) than in 2004 (mean rating of 1) (Table 2).

Diagnostic services were not markedly different in 2014 compared with 2004. Determination of blood electrolytes and stationary radiography availability were better than at the initial assessment but had mean ratings less than 3 (Figure 1).

General surgical capabilities were more consistently available (mean rating increased from 1 to 2); however, there were no improvements in the availability of skin grafting or basic orthopedic or neurosurgical operative capacity (ratings <2) (Table 2).

Overall, there was strong evidence for improvement in item availability at district-level hospitals in 2014 (mean rating of 1.3) compared with 2004 (mean rating of 0.8) (P = .002) (Table 2).

**Regional Hospitals**

Availability of resuscitation items at regional hospitals also markedly improved from 2004 and in a pattern similar to that of district-level hospitals. Although substantially improved from 2004, pulse oximetry, mechanical ventilation, and electronic cardiac monitoring remain deficient (mean ratings <3) (Table 2).

Mean ratings for laboratory and imaging diagnostics exactly mirrored district-level hospitals’ ratings and were relatively unchanged from 2004, except for portable radiography availability, which was lower in 2014 (mean rating decreased from 2 to 0) (Figure 1).

Definitive care was more often available in regional hospitals than district hospitals and in 2014 compared with 2004. General surgical capabilities were dependably available (mean rating of 3), although skin grafting and internal fixation for fractures were rarely available (mean rating of 1). Importantly, intracranial pressure monitoring, neurosurgical operative capacity, and spinal fixation had no improvement or had a lower rating (mean rating of 0 in 2014) (Table 2).

As with district-level hospitals, regional hospitals had significantly improved item availability ratings in 2014 (mean rating of 1.4) compared with 2004 (mean rating of 1.1) (P = .01) (Table 2).

**Factors Contributing to Deficiencies in 2014**

Assessment of the factors contributing to specific resource deficiencies helps to identify which inputs (eg, training, financing mechanisms, stock management practices) likely contributed to improved availability and which factors remain to be confronted. The 3 most frequently reported causes of deficiencies were item absence (ie, never having been present at the facility; 503 hospital-item deficiencies), lack of training to use items that were present (335 hospital-item deficiencies), and stockout of consumables (137 hospital-item deficiencies) (Figure 2). If an item had been present at a facility before (ie, absence not a contributing factor), lack of training was the most commonly reported factor contributing to item deficiency.

Items that were deficient but with improved availability in 2014 compared with 2004 were more often broken, out of stock, or insufficient in quantity than items that did not have improved availability. Conversely, items that were deficient and with equivalent or lower availability in 2014 compared with
2004 were more often absent or not used because of a lack of training compared with items with improved availability.

Discussion

This study aimed to compare the availability of trauma care services and the resources necessary to provide them in Ghana between 2004 and 2014 and generate recommendations for potential interventions. While trauma care capacity was significantly better in 2014 at both district-level and regional hospitals, critical deficiencies remain (eg, training for basic procedures, technology items, and definitive care). Item absence and lack of training were the most common factors contributing to deficiency. Notably, items that did not have improved availability in 2014 compared with 2004 were more often not used owing to a lack of training compared with items that had improved availability. Without a systemwide approach to trauma care capacity improvements, reversal of the gains made and ongoing deficiencies will continue to result in preventable traumatic death and disability.

Table 2. Comparison of Availability of Trauma Care Services and Resources Necessary to Provide Them in 2004 and 2014 in Ghana

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Availability Rating, Mean²</th>
<th>District-Level Hospitals</th>
<th>Regional Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitals assessed, No.</td>
<td></td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Airway</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Basic equipment³</td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Oxygen supply</td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Chest tubes</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pulse oximetry</td>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Bag valve mask</td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical ventilator</td>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Circulation</td>
<td></td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Urinary catheter</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Blood transfusion capabilities</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronic cardiac monitoring</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Laboratory diagnostics</td>
<td></td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Hemoglobin determination</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arterial blood gas, lactate</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Imaging diagnostics</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Stationary radiography</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Portable radiography</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FAST scan</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Computed tomography</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Angiography</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>General surgery</td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Basic general surgery¹</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Skin grafting</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Skin or skeletal traction</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>External fixation</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Internal fixation</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Image intensification</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>ICP monitoring</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Basic neurosurgery³</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Spinal fixation</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Assessment mean⁰</td>
<td></td>
<td>0.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Abbreviations: FAST, focused assessment with sonography for trauma; ICP, intracranial pressure; NA, not available.

² Rating scheme was as follows: 0, absent; 1, inadequate, available to fewer than half of those who need it; 2, partially adequate, available to more than half but not to most who need it; and 3, adequate, present, readily available to almost everyone in need, and used when needed.
³ Oral and nasal airways or suction pump.
⁴ Endotracheal tubes or laryngoscope.
⁵ Wound debridement, 1% total body surface area burn excision, digital amputation, or surgical airway.
⁶ Neck exploration, exploratory laparotomy, or major amputation.
⁷ Burr hole or treatment of open depressed skull fracture.
⁸ Wilcoxon signed rank test was used to compare item availability ratings between the 2 assessments and within each hospital level. For district-level hospitals in 2014 vs 2004, \( P = .002 \); for regional hospitals in 2014 vs 2004, \( P = .01 \).
In 2003, Ghana passed the National Health Insurance Act to provide essential care to the majority of its citizens. Initially, the National Health Insurance Scheme resulted in improved access to care, better availability of consumables, and increased operating budgets.\textsuperscript{13,18,21} Notwithstanding early success, total timely reimbursement rates are now low owing to increasing reliance on a narrow tax base, a large informal sec-

**Figure 1. Changes in Availability of Trauma Care Services and the Resources Necessary to Provide Them Between 2004 and 2014 in Ghana**

- Basic airway equipment
- Advanced airway equipment
- Oxygen supply
- Chest tubes
- Pulse oximetry
- Bag valve mask
- Mechanical ventilator
- Urinary catheter
- Blood transfusion capabilities
- Electronic cardiac monitoring\textsuperscript{a}
- Hemoglobin determination
- Electrolyte determination\textsuperscript{a}
- Arterial blood gas, lactate\textsuperscript{a}
- Stationary radiography
- Portable radiography
- FAST scan
- Computed tomography\textsuperscript{a}
- Basic general surgery
- Major general surgery
- Skin grafting
- Skin or skeletal traction
- External fixation\textsuperscript{a}
- Internal fixation\textsuperscript{a}
- Image intensification\textsuperscript{a}
- Basic neurosurgery

**Figure 2. Factors Contributing to Hospital-Item Deficiencies for Services and Resources for Trauma Care in 2014 Compared With 2004 in Ghana**

- Absence
- Broken
- Personnel shortage
- Lack of training
- Insufficient quantity
- Stockouts
- User fees

FAST indicates focused assessment with sonography for trauma.

\textsuperscript{a} Mean item availability rating was 0 in both assessments at district-level and/or regional hospitals.

in the course was significant hindering hospitals' ability to afford essential care items, in-service trainings, or repairs of broken technology.\textsuperscript{23,24} Concerted and sustained political effort in redressing the national insurance reimbursement scheme is needed to avoid ongoing, critical essential resource deficiencies for trauma care as well as other fundamental health care services.\textsuperscript{25}

Significant gains in service availability were identified for resources that required improvements primarily in training (eg, advanced airway management, basic and major surgery, basic fracture management). This may have been due in part to a homegrown trauma care continuing education course that ran for 15 years in Ghana. Despite established success, the Advanced Trauma Life Support course is often prohibitively expensive and inappropriate for the severe resource limitations commonly encountered in LMICs.\textsuperscript{26,27} Recognizing the need for a context-appropriate course, faculty at the Kwame Nkrumah University of Science and Technology developed a continuing education course specifically for rural district- and regional hospitals in 1996.\textsuperscript{14} An annual 40-hour program that encompassed essential management of the injured patient for the general practitioner working with severe resource limitations was developed. In an assessment of the courses, pretest and posttest scores documented good retention of the program's content.\textsuperscript{14} Follow-up assessments after 6 months and 2 years demonstrated that participants were significantly more comfortable with trauma management principles and procedures covered by the course. With help from the Ministry of Health, district health services shouldered course expenses (individual participant cost was $135).\textsuperscript{14} Unfortunately, the course dissolved in 2011 owing to lack of funding and support. Given improvements documented by the training program and the recurrent or residual deficiencies in essential trauma care training, reinventing the trauma care continuing education course is a potentially important priority, particularly for improving definitive care capacity at district-level and regional hospitals. This also provides an instructive
lesson for other LMICs by demonstrating the significant gains that can be made with regularly held, low-cost trauma care continuing education courses.

Blood transfusion capabilities were more often available than items requiring less advanced inputs (eg, basic airway supplies, chest tubes) in both assessments. This relatively complex service is afforded by dedicated vertical program funding for human immunodeficiency virus and maternal health. Although relatively successful for disease-specific interventions and providing some broader benefits, vertical programs may channel resources away from other pressing public health dilemmas, like injury control.28,29 However, dependable availability of these high-resource services demonstrates that it is possible to provide essential services when funding and political will align.25,30 Investment in trauma care not only will reduce the injury burden but also represents an opportunity for synergistically improving many aspects of health care systems (eg, prehospital and diagnostic services; emergency, essential surgical, and rehabilitative care).29,31

Higher-cost technology not supported by vertical programs continues to be rarely available (eg, mechanical ventilation, blood electrolyte or arterial blood gas determination, radiography). Low availability of such equipment has been found to be the result of long breakage, software faults, and being mal-adapted to the environment of rural hospitals in LMICs.5,32 Although technology has the capacity to markedly improve health care service delivery in LMICs, it must come in parallel with the requisite development in infrastructure (eg, affordable and consistent electricity, network capabilities), biomedical engineering capacity, and technical support to avoid suboptimal use of costly equipment.32–34 Once items are made available and staff are trained to use them, ensuring that technology items remain functional becomes particularly important.

Basic neurosurgical capacity remains critically deficient at regional hospitals not only in Ghana but in many LMICs.31,35,36 Compliance with basic resource-appropriate standards of head injury care and capacity to accurately assess intracranial pressure, perform trepanation, and fix open depressed skull fractures can be lifesaving interventions, particularly when referral is not a viable option.35,37,38 Given that head injuries are among the leading causes of traumatic death and disability, improving access to essential neurosurgical and resuscitation capabilities is imperative to prevent a large number of secondary brain injuries and avoidable deaths.35,39

This study had several limitations that should be considered when drawing conclusions from its results. First, the rating scheme used (0-3) was somewhat subjective. Ratings could be biased either higher (ie, if staff wanted to show that their hospital was better for job security or other reasons) or lower (ie, if staff wanted to advocate for more funding and/or resources). To strengthen response validity, respondents from multiple departments who interacted with the same item (eg, radiography: emergency department physicians, emergency department nurses, surgeons, nurse anesthetists, radiography technicians, biomedical engineers) were asked to rate its availability and responses were triangulated. Further, direct observation was performed to corroborate ratings. Nonetheless, the same scheme was used in both assessments and has been validated internationally.3,20,32 Second, the 2004 assessment did not include 3 northern regions or any tertiary hospital. The capacity of these facilities is an important component of the trauma care system in Ghana. Third, pediatric-specific trauma care items were more often deficient than adult-sized items in 2014.24 The 2004 assessment did not specifically evaluate these items, disabling a potentially useful comparison. Last, we assessed trauma care services and resources. These constitute assessments of structure, which may or may not translate into improvements in the process or outcomes of care. However, improvements in trauma care structure have been shown to be positively correlated with improvements in process and patient outcome; therefore, clinically significant improvements could be expected.40,41 Despite these limitations, this study has the strengths of being an extensive multihospital comparison done using the same tool, performed in the same regions and hospitals, and managed by the same team. These results provide a reliable and particularly useful serial assessment of trauma care capacity. As such, they allow reasonable conclusions to be drawn about ways to improve trauma care capacity in Ghana and other LMICs.

Conclusions

Serial assessments of trauma care capacity in Ghana demonstrated significant improvements in both district-level and regional hospitals. For example, resuscitation equipment and supplies, diagnostic capacity, and surgical care services were more often available in 2014 than in 2004. However, serious deficiencies have recurred or remain, namely those related to continued item absence or insufficient training as well as stockouts and/or technology breakage. Specifically, for items that improved during the decade, remaining deficiencies were more often related to breakage and stockouts than items that did not improve, which were most often due to item absence or lack of training. These deficiencies must be overcome so that timely essential trauma care can be provided to the large and increasing number of injured persons in Ghana as well as other LMICs.42 By doing so, unnecessary death and disability might be prevented. To make strides in trauma care capacity development, maintaining funding and support for a continuing education course for district-level and regional hospital staff is needed. Next, dedicated funding for trauma care is required, particularly as the burden of injury from urbanization and motorization grows.19 This should begin with ensuring timely national health insurance reimbursements so that hospitals can reliably purchase essential trauma care items. Lastly, it should be reinforced to national and regional policy makers that funding for trauma care could be effectively leveraged to synergistically improve numerous facets of deficient health systems (eg, prehospital and diagnostic services; emergency, surgical, and rehabilitative care). Because surgical and trauma care capacity assessments are performed to plan interventions, serial assessment is a valuable tool for monitoring and evaluating health care development strategies in the setting of rapidly changing disease burden in LMICs.1,43
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Surveillance and Data Capture to Assess Trauma Care Capacity in Low- and Middle-Income Countries

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We commend Stewart et al on their article regarding their longitudinal capacity assessment of the progress in trauma service availability during the last decade in Ghana and their recognition of the need for expanding the evidence base for trauma care capacity in low- and middle-income countries. The successes in improving in-hospital capacity such as infrastructure (eg, blood bank), equipment (eg, chest tubes, ventilator), and services (eg, skin grafting, neurosurgery) are part of broader needed efforts for capacity development of a complex, multicomponent, interconnected, and evolving trauma care delivery system. Remaining gaps in process evaluation (eg, prevention, prehospital triage, mobile emergency services, definitive hospital care, workforce distribution, long-term rehabilitation, transfer protocols and criteria, communication, and workflow) as well as injury and outcome surveillance present ongoing opportunities for collaboration and building to overcome present barriers in the delivery of trauma care. These summative factors are necessary components for accurate and reliable appraisal of a country’s trauma care capacity. Moreover, the implementation of a formal injury surveillance mechanism would enable the collection of reliable injury data for problem assessment and determination of whether advances have been made regarding quality and process improvement. Establishing monitoring mechanisms that provide country-specific injury and outcome data will enable the accurate characterization of persistent deficits in trauma care capacity that may then more effectively inform policy making. Therefore, adoption of a systems-based approach and a broadening of the context-specific knowledge base are essential to trauma care capacity development. In short, we need timely, accurate, and available data on the occurrence of injuries and related deaths; once these data have been collected and outcomes have been reviewed, steps can be made toward applied data—targeted, sustainable, and cost-effective strengthening of trauma care services in already resource-poor settings.

A recent study demonstrating a largely unchanged prevalence of prehospital deaths (76%) in Ghana compared with a decade earlier (80%) seems to underscore the conceivable impact that prioritization of strategic interventions at the level of prehospital triage and transport could have. As other sectors such as maternal and child health recognize the need for such monitoring and evaluation, even as part of the Millennium Development Goal Acceleration Framework, hopefully lessons learned can be transferred and applied to Ghana’s trauma care system.

ARTICLE INFORMATION
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