SURGICAL INFECTIONS
Volume 15, Number 4, 2014

DOI: 10.1089/sur.2013.146

Infectious Outcomes Assessment for Health System Strengthening in Low-Resource Settings: The Novel Use of a Trauma Registry in Rwanda

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Abstract

Background: More than 90% of injury deaths occur in low-income countries where a shortage of personnel, infrastructure, and materials challenge health system strengthening efforts. Trauma registries developed regionally have been used previously for injury surveillance in resource-limited settings, but scant outcomes data exist.
Methods: A 31-item, two-page registry form was developed for use in Rwanda, East Africa. Data were collected over a one-year period from April 2011 to April 2012 at two university referral hospitals. Inpatient 30-d follow up data were abstracted from patient charts, ward reports, and operating room logs. Complications tracked included surgical site infection (SSI), pneumonia, urinary tract infection (UTI), decubitus ulcers, transfusion, cardiac arrest, respiratory failure, and blood thromboses. Univariate analysis with chi-square and the Fisher exact test was performed to determine the association between complications and hospital stay and complications and mortality. Multivariable logistic regression was used to control for age, gender, hospital, mechanism of injury (penetrating versus blunt), and Glasgow Coma scale score (GCS).
Results: A total of 2,227 patients were recorded prospectively. One thousand five hundred nineteen patients were admitted for inpatient care (69%) with a 4% (n = 67) 30-d mortality. One hundred thirteen patients developed a hospital-acquired infection (88 SSI, 15 UTI, 12 pneumonia). For admitted patients, 25% (n = 387) were still in-hospital at 30-d. Whereas the development of any complication was associated with an increased mortality ($p < 0.0001$, unadjusted OR 3.2, 95% CI 1.8–5.7), there was no association between the development of an infection and mortality ($p = 0.6$). Hospital-acquired infection was associated with an increased length of stay ($p < 0.0001$, adjusted odds ratio (OR) 7.3, 95% confidence interval (CI) 4.7–11.2). Surgical site infection and UTI were individually associated with an increased length of stay.
Conclusions: The development of hospital-acquired infections is associated with an increased hospital stay in the trauma population in Rwanda. This has important implications in improving a health system already strained by limited infrastructure, personnel, and finances.

More than 90% of injury deaths occur in low-income countries, amounting to more annual deaths than human immunodeficiency virus/acquired immune deficiency syndrome, malaria, and tuberculosis combined [1,2]. The African region has nearly twice the disability burden of the Americas and Europe, perhaps related to the limited availability of emergency services, and lack of prompt resuscitation, and surgical management of non-fatal injuries [3]. The disproportionate injury burden in resource-limited settings coincides with a shortage of personnel, infrastructure, and resources that challenge health system strengthening efforts. Whereas they carry nearly a quarter of the global disease burden, countries in sub-Saharan Africa have only 3% of the world's health workforce and spend less than 1% of the world's healthcare dollars [4].

Over 70% of World Health Organization member countries have no data on surgical conditions, and even fewer have data on safety or outcomes; these data limitations are more prominent in low- and middle-income countries (LMIC) [5]. Hospital-based trauma registries developed regionally have

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been shown to be useful mechanisms for injury surveillance in some resource-limited settings [6–10]. A prospective, minimal data set trauma registry was established in Uganda in 1997 as an integral step in the initiation of an Injury Control Center [6]. The development of trauma registries has been described further in countries such as Tanzania, Ethiopia, Malawi, and Haiti.

Whereas these registries have been extremely useful in creating an overview of trauma epidemiology, trauma registries in LMIC have yet to be used to track in-patient complications and patient outcomes. We hypothesize that extending trauma registry data collection to include specific outcomes assessment can provide information to assess treatment and resource allocation and to establish targets for hospital-level systems improvement. Our study demonstrates the use of a trauma registry in the primary trauma referral hospitals of a low-income country to track the development of hospital-acquired infections.

Hypothesis

Implementation of a trauma registry that tracks the development of infectious complications in a resource-limited setting can serve an important role in health system strengthening.

Setting

Rwanda is a densely populated, low-income country in sub-Saharan Africa with a population nearing 11 million, more than 80% of which is rural [11]. Following the political unrest, civil war, and genocide of the 1990s, Rwanda had some of the worst health indicators in the world [12]. Since that time, the country has prioritized programs within the health sector as being key to sustainable and equitable economic and social development; Rwanda is the only sub-Saharan African country on target to meet the 2015 Millennium Development Goal (MDG) deadline for most or all of the MDG indicators [13]. Many of these improvements have occurred in community health and through the provision of government health insurance [14]. There is still a severe shortage of physicians and hospital-based resources for acute care. Rwanda has only 5.5 doctors, 0.15 general surgeons, and 0.09 orthopedic surgeons per 100,000 persons [15].

A collaborative trauma registry was established in March 2011 through the National University of Rwanda (NUR) at the two university referral centers in Rwanda to collect data on the injured patient population. Rwanda has more than forty district hospitals, each serving a population of about 250,000 and staffed by general practitioners. Because few emergency or surgical services are provided at the district hospitals, injured patients are often sent to the two university hospitals. The Centre Hospitalier Universitaire Kigali (CHUK) is a 520-bed hospital in the capital of Kigali. The Centre Hospitalier Universitaire Butare (CHUB) is a 430-bed hospital located in the university town of Butare, about two hours south of Kigali. Both hospitals are public and serve as training sites for NUR health professional students.

Materials and Methods

A 31-item, two-page registry form was adapted from regional trauma registries for use in Rwanda. Data were collected over a one-year period from April 2011 to April 2012 at the two university referral hospitals. Of note, trauma registry data collection did not begin at CHUB until July 2011. All injured patients who were transferred from a district hospital for evaluation of their injury, died in the emergency department as a result of their injury, or were admitted to the hospital for treatment of their injury were included in the study. Patients treated in an outpatient fashion for minor injuries were excluded. Patient demographics, pre-hospital care, initial physiology, early interventions, and disposition were recorded in the emergency department. Inpatient 30-d follow up data were abstracted from patient charts, ward reports, and operating room logs. Complications were determined based upon the doctor's diagnosis in the chart, laboratory or definitive diagnostic evidence, or clinical suspicion combined with antibiotic treatment. Complications tracked included surgical site infection (SSI), pneumonia, urinary tract infection (UTI), decubitus ulcers, transfusion, cardiac arrest, respiratory failure, unplanned intubations, and blood thromboses.

A trained data manager entered all data into a searchable, password-protected Microsoft Access database (Microsoft Corp, Redmond, WA); all data extracted for statistical analysis were de-identified. Data were analyzed using SAS software,

TABLE 1. CHARACTERISTICS OF REGISTRY PATIENTS (N = 2227)

	Number (%)
Age, y (n = 2203)	
Mean + SD	30 ± 20
Median, IQR	27, 16–41
Sex (n = 2,227)	
Male	1667 (75)
Female	560 (25)
Hospital (n = 2,227)	
CHUK (Kigali)	1417 (64)
CHUB (Butare)	810 (36)
Mechanism of Injury (n = 2,200)	
Road traffic accident	1052 (48)
Fall	612 (28)
Blunt force	305 (14)
Burn	102 (5)
Stabbing/cutting	76 (3)
Animal	17 (1)
Gunshot	9 (< 1)
Landmine/grenade	8 (< 1)
Other	19 (1)
Disposition from Accident and Emergency (n = 2203)	
Home	468 (21)
Referred	86 (4)
Died	130 (6)
Admitted	1519 (69)
Direct to operating theater	395 (18)
General ward	838 (38)
High Care Unit	246 (11)
''Intensive'' Care Unit	40 (2)
Physiologic parameters (n = variable)	
Mean SBP + SD, mmHg (n = 1,731)	120 ± 19
Mean RR + SD, bpm (n = 1,311)	22 ± 5
Mean GCS + SD (n = 2,186)	14 ± 3

CHUK = Centre Hospitalier Universitaire Kigali; CHUB = Centre Hospitalier Universitaire Butare; SBP = systolic blood pressure; RR = respiratory rate; GCS = Glasgow Coma Scale score; IQR = interquartile range.

Table 2. Inpatient Complications in Patients with a 30-Day Inpatient Mortality (n = 67)

Complication	Number (%)	p value	OR (95% CI), unadjusted
Any complication	16 (24)	< 0.0001	3.2 (1.8– 5.7)
Any Hospital-acquired infection	4 (6)	0.6	0.8 (0.3– 2.2)
Surgical site infection (SSI)	1 (2)	0.2	0.2 (0.0– 1.7)
Urinary tract infection (UTI)	0 (0)	1	n/a
Pneumonia	3 (5)	0.01	7.5 (2.0–28.4)

version 9.3 (SAS Institute, Cary, NC). Univariate analysis was performed to determine the association between complications and hospital stay, and complications and mortality using simple logistic regression and the Wald chi-square test to estimate odds ratios and 95% confidence intervals. The Fisher exact test was used for rare outcomes. The development of any complication, any hospital-acquired infection, surgical site infections, pneumonias, and urinary tract infections were analyzed separately. Multivariable logistic regression was used to control for age, gender, hospital, mechanism of injury (penetrating versus blunt), and Glasgow Coma Scale score (GCS) in outcomes with sufficient sample size to support multivariable regression. We conducted a subset univariate analysis with chi-square or the Fisher exact test to determine the relationship between complications and hospital stay, and complications and mortality in the most severely injured patients, those with an initial GCS of 3–8 points.

Results

Two thousand two hundred twenty seven patients were recorded prospectively during the study period. Patients were predominantly male (3:1) with a mean age of 30 y. The hospital in Kigali contributed nearly twice as many patients to the study cohort, and road traffic accidents accounted for nearly one-half of all injuries. Table 1 summarizes the demographics for all patients entered into the registry for the year. Glasgow Coma Scale score (GCS) was the best recorded physiologic parameter that could be used as a marker of injury severity, with inconsistent recording of blood pressure and respiratory rate. Emergency department mortality was 6% (n = 130) for the full cohort and 44% (n = 92) for the cohort of patients with an initial GCS of 3–8 points (n = 209).

One thousand five hundred nineteen patients were admitted for inpatient care (69%) with a 4% (n = 67) 30-d mortality. In total, 113 patients developed a hospital-acquired infection (88 SSI, 15 UTI, 12 pneumonia, including two patients with more than one infection). For admitted patients, 25% (n = 387) were still in-hospital at 30 d. While the development of any complication was associated with an increased mortality (p < 0.0001, unadjusted OR 3.2, 95% CI 1.8–5.7), there was no association between the development of an infection and mortality (p = 0.6). Three patients with pneumonia died within 30 d, which was statistically different from patients who developed a pneumonia and survived (p = 0.01). Table 2 details the association between mortality and inpatient complications.

However, hospital-acquired infection was associated with an increased length of stay (p < 0.0001, adjusted OR 7.3, 95% CI 4.7–11.2). SSI and UTI were associated individually with an increased length of stay. Table 3 details the association between patients who were still in the hospital at 30 d and the development of complications.

Just 39% (n = 82) of patients presenting with an initial GCS of 3–8 points were admitted to the hospital, with 18% (n = 15) developing any complication and 11% (n = 9) developing a hospital-acquired infection (two SSI, three pneumonia, and five UTI, with one patient developing two infections).

Overall inpatient mortality was 23% (n = 19), with no statistically significant associations with the development of complications suggested by univariate analysis. Twenty two percent of patients (n = 18) were still in the hospital at 30 d. The association between the development of an infection and at least a 30-d length of stay was statistically significant with a p value of 0.02 (OR 5.8, 95% CI 1.4–24.5).

Discussion

Hospital-based trauma registries play an important role in informing the care of the injured patient by describing injury patterns and severity. This information can be useful in expanding injury surveillance programs and hopefully implementing population-based prevention programs in low-resource settings. Although many injuries can be prevented, the presence of injury is ubiquitous in society, and attention must also focus on hospital-based interventions. By analyzing factors such as hospital length of stay and in-hospital complications, particularly infectious complications, health systems can identify targets for improvement, including hospital infrastructure, resources, and staffing.

Our study utilized a prospective trauma registry in the small sub-Saharan African nation of Rwanda to evaluate the role of in-hospital infectious complications on length of stay

Table 3. Inpatient Complications in Patients Still in Hospital at 30 Days (n = 387)

Complication	Number (%)	p value	OR (95% CI), unadjusted	OR (95% CI), adjusted*
Any complication	83 (22)	< 0.0001	4.6 (3.2– 6.5)	5.3 (3.6– 7.8)
Any hospital-acquired infection	71 (18)	< 0.0001	5.8 (3.9– 8.7)	7.3 (4.7–11.2)
Surgical site infection (SSI)	54 (14)	< 0.0001	5.2 (3.4– 8.2)	6.1 (3.8– 9.8)
Urinary tract infection (UTI)	14 (4)	< 0.0001	42.5 (5.6–323.9)	N/A
Pneumonia	5 (1)	0.2	2.1 (0.7– 6.7)	N/A

*Only outcomes with sufficient sample size were subjected to multivariable analysis, controlling for age, gender, hospital, mechanism of injury, and GCS.

N/A = not applicable.

and mortality. Not surprisingly, the development of any in-hospital complication was associated with increased mortality ($p < 0.0001$) as well as increased length of stay ($p < 0.0001$). Only the development of pneumonia showed a statistically significant association with mortality ($p = 0.01$), although these results may be difficult to interpret with only 12 recorded occurrences of the outcome. The data did show a strongly significant increase in length of stay associated with the development of hospital-acquired infections, with SSIs and UTIs being individually associated with an increased length of stay ($p < 0.0001$). When adjusted for age, gender, hospital, GCS, and injury mechanism, the development of a hospital-acquired infection increased the odds of a patient still being in the hospital at 30 d by seven-fold (OR 7.3, 95% CI 4.7–11.2). Not surprisingly, severely injured patients with an initial GCS of 3–8 points had the highest overall mortality in the study cohort (44%). For those patients who did survive to admission, the development of an infection was associated with an increased length of stay ($p = 0.02$), but these subset results are limited by the small sample size.

Our study does not attempt to suggest causality in the association. However, regardless of whether the hospital-acquired infections cause or are the result of prolonged inpatient stays, these extended lengths of stay could have important implications for the patients and their families as well as the health system, including increased cost and potential long-term complications. Furthermore, hospital overcrowding at the referral hospitals may lead to delayed transfer of new patients, as many of the district hospitals are not equipped to manage traumatic injuries. A 2010 survey of every government hospital in Rwanda found that open fracture care was one of the most common reasons for transfer of a surgical patient from the district hospitals to the referral hospitals and is definitely considered by practitioners in the district hospitals and the referral hospitals as a bottleneck in the referral process [15].

To our knowledge, utilizing a trauma registry in a low-resource setting to track infectious outcomes has yet to be described. This is perhaps not surprising as funding limitations, personnel turnover, limited quality control, and poor charting plagues most of the existing trauma registries in sub-Saharan Africa. A study in Malawi evaluating the efficacy of physiologic predictors for trauma by comparing retrospective chart review to a prospective minimal dataset trauma registry showed severe discrepancies in the quality of chart documentation—many patients did not have vital signs recorded, for example, and researchers had difficulty determining cause of injury from retrospective chart review [16]. The trauma registry in Rwanda is not without these limitations, including the poor quality of chart documentation (which can often be in multiple languages), a scarcity of personnel with time to prioritize documentation or data collection, and limited resources for diagnostic and laboratory evaluation of suspected infections. One of the authors (RTP) provided in-country oversight and quality control of the registry and follow up process for the full study year through April 2012. However, the trauma registry at CHUB was not implemented until three months after the start of this study, which may introduce a selection bias. Although we attempted to track outcomes such as deep vein thromboses, pulmonary emboli, and myocardial infarctions, these diagnoses were documented rarely as there is minimal objective patient monitoring or diagnostic capacity. Inpatient units at both hospitals are predominantly designed with open wards of up to 50–60 individuals, which can be staffed by as few as two to three nurses. The Accident and Emergency Department at CHUK is overcrowded, with patients often waiting several days for an inpatient bed. Interestingly, the overall inpatient infection rate in the study cohort was only 7%, which is lower than infection rates in many resource-rich countries and might not be expected given the open ward design of the Rwandan hospitals. This may indicate under-reporting of infection or a less acute patient population. Our study does not take into account specific infection control practices, nurse staffing, patterns of prophylactic antibiotic usage, or other treatment factors such as surgical intervention. These are just a few of the unique factors that may contribute to the development of hospital-acquired infections.

Yet, despite these limitations, the support of trauma registries in LMIC and the expansion to track inpatient outcomes and complications may be particularly useful as hospitals often have limited data apart from mortality statistics to monitor the effect of their treatment. Identifying opportunities to potentially decrease length of stay by decreasing post-trauma infections is beneficial not just to the patient, but also in providing targets to improve the overall health system efficiency.

Conclusions

The development of hospital-acquired infections is associated with an increased hospital stay in the trauma population in Rwanda. This has substantial implications in improving a health system already strained by limited resources, and renders post-trauma infection an important outcomes measure.

Ethical Approval

Institutional approval to conduct this study was obtained from the University of Virginia HSR IRB and the Ethics Committee at the Centre Hospitalier Universitaire Kigali.

Acknowledgments

The authors acknowledge the work of the trauma registry coordinator, Mr. Viateur Muhirwa, and the trauma registry data manager, Ms. Assumpta Muzayire, and the rest of the trauma registry team in Kigali and Butare for their outstanding work.

Author Disclosure Statement

Support for the Rwanda Injury Registry (local staff stipends, training, and registry printing) comes from a Fogarty International Clinical Research Fellowship, NIH and International Clinical Research Fellows Program at Vanderbilt University, USA (R24 TW007988) from February 2011–August 2012.

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