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Electronic Medical Records For Trauma Surveillance In South Africa: The Case Of Khayelitsha Hospital

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Abstract

ELECTRONIC MEDICAL RECORDS FOR TRAUMA SURVEILLANCE IN SOUTH AFRICA: THE CASE OF KHAYELITSHA HOPITAL. Emmanuel C. Ohuabunwa, Karen J. Jubanyik. Department of Emergency Medicine, Yale University School of Medicine, New Haven, CT

Electronic Medical Records (EMRs) have shown benefit for clinical, organizational, and societal outcomes(1). In South Africa, the desire for effective record keeping will continue to rise with increasing trauma and infectious disease rates. Recognizing this, the Western Cape government in 1999 signed a tender to rollout Clinicom EMR, an online storage system for paper records, to all hospitals within the province(2).

In 2012, Khayelitsha Hospital (KH) was opened with the Clinicom EMR installed. In 2013, KH received the ministerial award for clinical excellence as a result of the effective EMR rollout. Due to a high incidence of violence around Khayelitsha, and the need for effective trauma surveillance for efficient resource allocation, the authors sought to calculate the Emergency Center (EC) trauma rate for KH. Retrospective review of both paper charts and the Clinicom EMR from July 2012 to May 2013 was performed.

The Clinicom EMR yielded a mean monthly EC trauma visit of 280 patients, mean EC census of 3537 patients and a mean trauma rate of 8%. The latter was much lower than the nationwide estimate of 33%. For the month of July, 66 additional cases were found on the paper registry but not on the EMR. Furthermore for the months of January to May 2013, scanned copies of patient records were unavailable on the EMR online database.

The discrepancy between the paper records and the EMR suggest potential difficulties with the implementation of the Clinicom EMR that were overlooked by the award committee, and call into question the 8% trauma rate calculated. The results highlight the need for further evaluation of the functioning of the Clinicom EMR system to identify difficulties in implementation and correct them before the system is utilized in hospitals across South Africa.

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Introduction

TRAUMATIC INJURIES IN LOW-TO-MIDDLE INCOME COUNTRIES (LMICs)

Traumatic injuries are defined as injuries caused by an extrinsic source, usually occurring suddenly with high severity, and necessitating immediate medical attention(3). They may result from sports activities, motor vehicle collisions, or natural disasters; can vary from intentional to unintentional origins(3); and are commonly divided into blunt, penetrating and burn mechanisms. According to WHO estimates, traumatic injuries account for 9% of deaths and 12% of the burden of diseases worldwide (4), translating to almost 5 million deaths annually and surpassing the mortality caused by HIV, malaria, and TB combined (5,6). In 2013 an estimated 973 million people suffered injuries that required services of a healthcare professional and for 4.8 million people, these injuries were fatal (7). In terms of major causes of injury deaths, road traffic injuries were by far the most popular, accounting for 29.1% of deaths, followed by self-harm (17.6%)(7). Falls and interpersonal violence rounded out the most popular causes, accounting for 11.6% and 8.5% respectively (7).

Although the global burden of disease secondary to road traffic injuries has decreased between 1990 and 2013, the effect has been mainly evident in higher income countries (7). Low and middle income countries (LMICs) continue to suffer from high injury mortality and disability-adjusted life year (DALY) rates (7), which will remain the case unless preventive efforts are instituted and health care systems are strengthened to meet the growing challenges. (4-6). As LMICs continue to develop economically, the number of automobiles have increased and this has been associated with more road-traffic related crashes, injuries and deaths(8). The annual cost of injury, especially those

resulting from road traffic injuries amounts to approximately $500 billion, far exceeding the total global expenditures in developmental assistance. This does not include the cost of hospitalizations, emergency department visits and injuries and permanent disability(8). People with life-threatening but salvageable injuries are six times more likely to die in a low-income setting (36% mortality) than in a high-income setting (6% mortality)(9). Furthermore, much of the improvement in patient outcomes in higher-income countries has been attributed to improvements in the trauma care service infrastructure, highlighting the importance of such development in hospital systems in LMICs (9). Although there are multiple avenues to strengthen trauma care infrastructure, when looking at hospital systems, promising data have shown the benefit of mobile health technology development in accurately documenting injury severity, with the resulting effective triage, leading to better patient outcomes. (9-11).

SOUTH AFRICA AND ITS INJURY BURDEN

South Africa is a middle income country with 52 million people, residing in 9 provinces, speaking 11 official languages and contributing to one of the largest Gross Domestic Products (GDP) in Africa, estimated at US $218 billion dollars(2). Although officially possessing a 23% unemployment rate, approximately 50% of its population lived below the poverty datum line and 10.7% lived on less than US $1 per day in 2013(2,12).

The South African population is plagued by a quadruple burden of disease: HIV/AIDS, chronic disease, injuries, and maternal/ child mortality (4,13). Like many other rapidly developing countries, the rates of injury morbidity and mortality have increased with urbanization in the past decade(14). According to WHO data for the year

2000, of the estimated 59,935 injury deaths, 46% were from homicides, 26% from road traffic accidents while 9.1% were self-inflicted (4). Comparing this data to 2012 statistics published in the Lancet, there is a mild decrease in the number of injury deaths to approximately 50,779(15) but the quadruple burden of disease persists (15). The decline in injuries was partly attributed to a reduction in political turmoil after the apartheid era and a decline in firearm-related homicides after the Fire Arms Control Act of year 2000(15). Nevertheless, the death toll relative to injuries is still a cause for concern and sadly is not restricted to adult males either. In the same year, they occurred in 14 and 11.7 per 100 000 in boys and girls under the age of five, respectively, which was more than double the average rates in other LMICs(16). The intimate partner homicide against females of 8.8 per 100,000, age-standardized homicide rate of 64.9 per 100,000(16) and overall murder rate of 31.9 per 100,000 (almost double the African continent average of 17.4), moved South Africa to the 14th highest in the world in rates of violence(14).

Aside from homicides, South Africa has among the highest burdens of morbidity and mortality from road traffic injuries. Road traffic age-specific mortality rates were approximately double the global rate for both sexes, with rates as high as 2.5 times the global rate for adult women aged 30-44(4). Looking at long-term morbidity, injuries were responsible for an estimated 2.3 million disability adjusted life years (DALYs), with the male burden three times that of the female(4). Overall, intentional and unintentional injuries were second to HIV/AIDS in all-cause DALYs in South Africa for the year 2000, responsible for 14.3% of the 16.2 million total DALYs (4). Although these values have decreased slightly based on statistics from the year 2012, the persistently high numbers necessitate further efforts to curb this trend (15).

Some proposed reasons for the high rates of injuries and deaths include the preponderance of poorly designed informal settlements that are without proper roads, streetlights or maintained pathways. These settlements are relegated to the poorer citizens and are almost absent of state police patrol(17). Other reasons include rapid societal change, income inequality, high unemployment, and gang violence (4). Combined with the legacy of apartheid, the poor treatment of residents of these settlements has left a deep mistrust of law enforcement, leading to a high incidence of vigilantism. Referred to colloquially as "community assaults", the vigilantes use traditional whips called sjambaks, to beat other members of the community who are caught committing crimes. These often lead to extensive soft-tissue trauma and sometimes crush syndrome(17).

KHAYELITSHA TOWNSHIP AND ITS INJURY BURDEN

With a population of around 400,000 squeezed into a 43.5 km^2 area, Khayelitsha is the largest and fastest growing township in South Africa (18-21). In the Xhosa language, Khayelitsha means "new home" and for the 55% of its population relegated to informal dwellings, it hardly lives up to its name (18). Situated in the Western Cape, Khayelitsha's population is comprised of 99% Black Africans, and 0.6% of mixed ancestry. Approximately 74% of households earn US $ 320 per month; less than 7% of its residents are older than 50 years and; greater than 40% of its residents are younger than 19 years (18). Estimates from 2007 reveal a high incidence of TB and HIV, and most of the population is served by ten small primary health clinics around the township (22,23). Due to unemployment rates that are considerably higher than the national average, many of the residents rely on government-sponsored health care service delivery(20).

Like the rest of South Africa, community assaults represent an important cause of interpersonal morbidity and mortality in Khayelitsha (17). The extensive injury from the beatings, combined with the tendency for the victims to hide for hours after the assault before seeking medical attention, increases the risk of serious morbidity and mortality for these patients (17). However, many other significant causes of traumatic injuries are present at Khayelitsha. According to the Institute of Development Studies crime statistics for 2007 and 08, Khayelitsha ranked among the top areas for murder, rape, and aggravated robbery [22]. In the same year, it overtook Nyanga, as the "murder capital" of South Africa(24) with a total of 430 murders. Khayelitsha was the site of 1510 reported cases of serious assault and 2,168 cases of aggravated robbery, both said to be grossly underreported(17,21). Estimates place rates of murder and rape at over two and a half times the South African average of 41 per 100,000 and over twenty times the average in Western Europe(25). Violence is especially high among male youth with homicide rates as high as 451 per 100,000 in the 15-24 age group(4). Sadly, violence against children is also common with mortality rates for the under 5 year age group of 27 per 1,000 live births in 2012(18). The high incidence of traumatic injuries in Khayelitsha was the subject of a 2013 BBC documentary featuring the efforts of various frontline physicians, juxtaposed against the intensity of the gang violence in the township(26). Another documentary, titled "U-Carmen eKhayelitsha" zoomed in on the violence, while taking into account the social fabric of Khayelitsha township (25).

OVERVIEW OF THE SOUTH AFRICAN HEALTH SYSTEM

The South African health care system, like that of many other countries, is divided into private and public sectors. The private sector comprises the 20% of the

population who can afford medical insurance, are usually well-off and account for 60% of the total healthcare spending(2). The public sector on the other hand, comprises 80% of the population, who are mainly without insurance, and therefore dependent on government-sponsored initiatives (2). The public sector services are delivered across the three levels of government: national, provincial and local. The National Department of Health (NDoH) makes the legislation, policy, norms and standards of health; the nine provincial departments of health plan, budget and deliver the health services to their respective provinces (13,27,28) and the local governments deliver municipal services as related to community healthcare(2).

The public sector uses both primary health centers and hospital facilities to provide care to approximately 80% of the South African population(29). For a patient to access the hospital system, a healthcare worker from any of the over 1550 primary health clinics distributed across South Africa must first refer him/her, except in emergency situations(29). The primary health clinics are usually open 8 hours per day and mostly run by nurses. They offer services related to vaccination, family planning, treatment of infectious diseases and management of chronic conditions. The hospital system, as found in higher income countries, has in-patient, out-patient and emergency care capabilities. The 388 hospitals in South Africa are divided into three categories: district (64%), regional (32%) and tertiary hospitals (4%) (29). For many South Africans, especially those residing in rural areas, district hospitals are the only type to which they have access (29). They are usually between 30 and 200 beds, open 24 hours/day, and offer access to generalists from a range of disciplines including emergency medicine, family and internal medicine, obstetrics, psychiatry, rehabilitation, surgery, pediatrics and geriatrics. Patients

are referred to regional hospitals from district hospitals as appropriate(29). Because patients can bypass primary health clinics in emergency situations and are restricted from accessing higher levels of care without first going through the lowest rung, district hospitals play an important role in trauma surveillance in South Africa.

TRIAGE SEVERITY SCORING SYSTEM USED IN SOUTH AFRICA

In 2006, the South African Triage Score (SATS) emerged as the accepted method of triage (30-32). The SATS is calculated based on a combination of patient physiological parameters, found in the Triage Early Warning Score (TEWS), and patient clinical discriminators. Patients are assigned one of five color codes: red, orange, yellow, green and blue, with red requiring immediate attention, orange requiring very urgent care, yellow requiring urgent care, green requiring routine care and blue requiring no care at all as the patient is deceased (31), (see appendix A and B for examples of the TEWS and SATS scorecards reprinted with permission). The discriminators include the mechanism of injury, presentation of injury, patient pain level and the senior health care professional's discretion (31). These codes are necessary for effective triage in the Emergency Center.

In their evaluation of the SATS, Rosedale et al found that it under- triaged 4.4% of patients and over-triaged 4.3% of the patients(33), values that were well within the American College of Surgeons Committee of Trauma (ACSCOT) guidelines(33). Under-triage in this case, refers to when a patient is incorrectly given a lower severity code, increasing likelihood for poorer outcomes (33). Many other studies have shown the utility of the SATS both in reducing patient waiting times in the EC and as an acceptable predictor of patient outcomes especially in low resource areas (30,34).

STATE OF E-HEALTH IN SOUTH AFRICA

In regards to health care technology, The NDoH coordinates the national e-Health agenda through both the Directorate of Information Communication Technology and the National Health Information System of South Africa (NHIS/SA)(27,28), while at the provincial level, the respective Departments of Health are responsible for coordinating individual health information systems and telemedicine (2). Plans to strengthen health information systems in South Africa began in 1994. By 1997, the NDoH published the white papers for the Transformation of the Health System, which advocated for the development of a comprehensive national health information system(13). However, in 2009, the Bill and Melinda Gates Foundation delineated the 5 stages of eHealth maturity (reprinted below) in their landscape analysis of health information systems (13), and it became evident that South Africa was only in stage 3. Below are the stages:

> "Stage 1 - paper-based systems for collecting district health indicators,
>
> Stage 2 - optimization of paper systems through simplifying indicators and reducing duplication,
>
> Stage 3 - migration of traditional district health information systems to electronic storage and reporting,
>
> Stage 4 - introduction of operational ICT systems as a source of data for HIS,
>
> Stage 5 - a fully comprehensive and integrated national HIS."

The realization that SA was only in stage 3, spurred the NDoH to embark on a journey to further strengthen its Health Information System infrastructure. The NDoH's first order of action in 2010 was to release a ten- point plan that established an electronic health record for South Africa, implemented in phases by March 2012(27). However, because funding for eHealth implementation was the responsibility of the provincial and municipal governments, large variations were evident in the financial investment on eHealth from province to province(13). In a 2009 audit, Gauteng, Limpopo and KwaZulu-Natal had the largest annual budgets with: R188.3m, R178.6m and R105m respectively(1 US dollar= approximately 10 Rands)(13). The Western Cape was in the middle of the pack in terms of resources while North West, Northern Cape and Free State with R15m, R20.4m and R32m respectively rounded up the bottom 3 provinces(13). The audit also revealed that these investments were uncoordinated and therefore yielded very limited benefits. In their 2012 eHealth strategy, the NDoH released yet another plan to develop a National electronic Health Record System in order to effectively manage the National health insurance scheme while providing information for monitoring, evaluating and managing the performance of the national healthcare system(13). Their efforts showed a strong recognition of the importance of EMRs and the desire to tap into this area of infrastructural development.

EMR DEFINITION AND BENEFITS

An EMR is ‘‘a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports’’(1,35,36). In

high-income countries, the popularity of EMRs has soared because of its many benefits (36,37), which can be divided into three major spheres: clinical, organizational and societal outcomes and are further exemplified by three tools: Clinical decision support (CDS), Computerized Physician Order Entry (CPOE) systems, and Health Information exchange systems (HIE)(1).

EMRs affect clinical outcomes by improving the quality of care and reducing medical errors thereby increasing ‘‘safety, effectiveness, and efficiency.’” (1) In a widely cited study, experts found that the institution of a CPOE system was associated with a 55% reduction in serious medication errors in the hospital setting. A follow-up study by the same team found that by adding a CDS system to a CPOE system, medication errors were reduced by as much as 86% (1). Looking at the efficiency component, a study performed by Nies et al evaluated the effects of a CDS system on redundant blood tests in a cardiovascular surgery department. They found that point-of-care computerized reminders of previous blood tests significantly reduced the incidence of unnecessary tests. Furthermore, in the outpatient setting, Tierney et al found a 14.3% reduction in the number of diagnostic tests ordered per visit and a 12.9% reduction in diagnostic test costs per visit when using an EHR with CDS and CPOE components (1). Looking at the effectiveness component, a study by Kucher et al found a 19% increase in the use of anticoagulation prophylaxis when using computer alerts, leading to a 41% reduction in the risk of deep venous thrombosis or pulmonary embolism at 90 days after discharge(1).

EMRs affect organizational outcomes by increasing revenue, averting costs from redundant tests and medications, and decreasing legal vulnerability of hospitals. The increased revenue aspect results from improved charge capture, decreased billing errors

and increased cash flow (1). EMRs also increase the accounts receivable turnover, which is defined as the amount of time it takes for payers to fulfill their financial obligations to the hospital. By increasing this value, EMRs enhance revenue generation (1). Wang et al in 2003 produced one of the most cited studies on the cost-effectiveness of EMR installation. They created a cost-benefit model for a hospital that implemented an EMR system and showed a net benefit of $86,400 per provider by year five (38). Of this amount, a reduction in drug benefit expenditures made up the largest proportion of the benefits at 33% of the total gain. A few other highlights include: reduced radiology utilization (17%), reduced billing errors (15%), and increased charge capture (15%)(38).

Last but not least, EMRs affect societal outcomes by facilitating research, and promoting population health, making it easier to monitor diseases, and in the long-run, increasing job satisfaction among physicians (1,39,40). In developing countries they have been used for infectious disease monitoring and tracking important prognostic factors for patients with HIV/AIDS, such as viral load, CD4 counts, and clinical stage of infection (41,42). In addition, they have helped to facilitate follow-up in patients with chronic diseases such as TB, hypertension and diabetes (43).

TYPES OF EMR SYSTEMS

EMRs come in two major forms: open-source and proprietary. Open-source systems are characterized as having source codes that are freely available to developers to examine and modify to fit their needs (41,44,45). Proprietary systems, on the other hand, are usually controlled by private companies which tend to not share their source codes to other developers. As one would expect, open-source systems have gained popularity in low to middle income countries because they are much cheaper than their proprietary

counterparts, do not have licensing fees, and offer more customizability for consumers (39,44,46,47). Some estimates put the cost of open source systems at 40 times less than that of their proprietary counterparts (44). Over 114 LMICs are working on national electronic health systems, according to a WHO survey with open-source approaches gaining the most traction (44,45). In 2004, for example, the Mexican Government began adopting World Vista across 40 large hospitals serving 30 million patients within the health system operated by the Instituto Mexicano del Seguro Social (IMSS), the largest social insurance organization in Latin America(44). In Thailand, the department of health, determined to decrease costs after the implementation of a universal health coverage scheme, developed a hospital operating system (OS) that was deployed in 95 rural hospitals and 402 health centers(44). In Kenya, Rwanda, Mozambique and many other resource-constrained African countries, the Open Medical Record System (openMRS) has gained traction also for its ease of use and financial favorability(44).

However, open-source systems are not without limitations. A 2012 study by Millard et al evaluated the efficacy of various open source systems to determine their utility in areas with limited internet connection. Six systems were identified (iSante, PHIS, Dream-Sant Egidio, OpenMRS, WorldVista, OSCAR) and various clinicians and technical coordinators were surveyed about their experiences(46). They found that none of the systems met "minimum requirements for effective implementation in a primary care resource-limited setting", especially lacking in the area of safe medication prescribing. The authors therefore proposed moving beyond the predominantly disease-specific EMR development to a more universal open source platform that can facilitate use in the hospital setting as opposed to primary care clinics (41,46). Another area of

concern is in the privacy of patient records, for which there is equivocal evidence in support of proprietary systems (41,45,48). On the one hand, expensive, private companies control proprietary systems and therefore devote many resources to protecting patient data and auditing systems for unauthorized entry(44). These commercial companies portray open-source systems as more prone to bugs and security breaches(44). However, there is the argument that open source systems are actually more secure since the freely available source codes allow each institution to independently assess for potential security breaches, making patches to potential breaches much easier and code quality improvement more efficient(44,45). Many countries balance the cost consideration with the privacy consideration in determining what type of system to employ(45).

EMR PENETRATION IN SOUTH AFRICA BY PROVINCE

Table 1 shows the various EMRs that dominate the markets of the nine provinces in South Africa. What it does not show is that only a third of South Africa's provincial hospitals have some form of functional EMR and these systems are not interoperable(13,48). One of the goals of the health departments, as published in its 2012 eHealth strategy document, was to fully integrate these systems to facilitate communication and achieve the full benefits of EMRs (48). In line with this vision, the DoH of the Western Cape province revealed a plan to deploy the Clinicom system, one of the EMRs listed in Table 1, in all hospitals in the province (2,28,48). The Clinicom Enterprise Content Management (Clinicom) is a proprietary system, (49) controlled by Datacentrix, a private provider of “high performing and secure ICT solutions”(50). Unlike a full EMR, Clinicom functions as an online database for storage of scanned paper records, thereby decreasing the need for physical documentation and paper-based files

(36,50,51). It uses an indexing model that allows authorized users to quickly find patient folders online using both the patient name and a unique patient identification number(50). Furthermore, all standard patient forms are barcoded to make indexing of patient information easier and faster(50).

Table 1: Patient Management/ Hospital Information Systems deployed in public sector facilities in South Africa as of 2012

PROVINCE	PATIENT MANAGEMENT/ HOSPITAL INFORMATION SYSTEM IN USE
Western Cape	Clinicom; Delta 9; PHCIS; JAC Pharmacy
Free State	Meditech; PADS
Gauteng	Medicom; Soarian MedSuite; PharmAssit; PAAB
KwaZulu- Natal	Medicom; Meditech; PALS; Pro-Clin; ReMed
Mpumalanga	PAAB
North West	PAAB
Northern Cape	Nootroclin
Eastern Cape	Delta 9
Limpopo	Medicom

The Western Cape Department of Health was especially impressed by the potential of this system and prior to 2012 deployed in to a handful of hospitals, all of

which were in various stages of the conversion process from a completely paper-based system(48). This made studying the efficacy of the Clinicom system very challenging. However, in 2012, Khayelitsha Hospital (KH), a state of the art facility that employed the Clinicom system from the beginning, was commissioned by the DoH. The high burden of disease and incidence of trauma plaguing the nearly 1.5 million people in the neighboring townships motivated the construction of Khayelitsha Hospital (KH), a 240-bed hospital, boasting a 30% larger accident and emergency unit than that of a standard district hospital (52). The total design and construction cost for the hospital, including the ambulance station situated on the premises, came to R632 million - R556 million for infrastructure, R60 million for health technology and R16 million for organizational development and quality assurance (52). Although specific trauma burden for KH have not been calculated (4,25), with the new record system in place and its touted accuracy and efficiency, calculating this value would no longer be difficult, thereby allowing for better resource allocation in the Khayelitsha township. This was especially reinforced when Khayelitsha Hospital received the ministerial award for excellence in patient care 2013(36,51). The Clinicom ECM implementation was one of the reasons for its selection and had been described as a "resounding success" (50). Patient file retrieval times had been cut down to zero since physicians could now retrieve files electronically and the system had helped cut down patient waiting times as information was now more readily available(50).

STATEMENT OF PURPOSE, HYPOTHESIS AND AIMS OF THESIS

Trauma surveillance data in South Africa is sparse and despite efforts to build a trauma registry, as at the time of the conduction of this study in 2013, these efforts were

in the beginning phases (6,12,37,53). Even in Cape Town, which possesses some of the most prolific and academically productive trauma units in South Africa, it has been difficult to accomplish effective trauma surveillance partly due to lacking reliable medical record infrastructure(6). The Department of Health of the Western Cape has made plans to tackle to this and many other healthcare problems by providing the Clinicom EMR to bolster the medical record infrastructure, facilitate cross-communication among hospitals and aide disease surveillance efforts(2).

Nationwide estimates of trauma case load in the Emergency Center range from 17.8% to 33% of all visits (12,53). However, these data are not specific to the Western Cape population. With trauma surveillance data important for policy decisions on resource allocation, the aim was to find a representative hospital in the Western Cape with a reliable EMR system to facilitate calculation of its trauma case load. Khayelitsha Hospital was selected for trauma surveillance for the following reasons. First, Khayelitsha Hospital was a brand new hospital situated around a low-income township with a reputation for high rates of community assaults, violence, mortality, and objective evidence of frequent referrals of trauma patients to higher-level hospitals (6). Therefore, surveillance data would be important for policy decisions in relation to trauma system strengthening. Secondly, as explained in the prior sections, being a district hospital, KH is the gateway to all traumas both because of its proximity to the township and its designation as the lowest rung of the hospital hierarchy without which patients cannot be referred to higher level hospitals. Thirdly, KH employed the Clinicom system from the beginning, a move that by 2013 had been touted as both a resounding success and a

critical factor for KH winning the ministerial award for clinical excellence in 2013(50,51).

The overall goal of the study was to evaluate the completeness of patient records in the EC and use data from the Clinicom EMR to calculate the trauma rate at Khayelitsha Hospital. Considering the very high rates of violence and injury in the Khayelitsha Township and its reputation as the one time “murder capital” of South Africa, we hypothesized that trauma rates at KH would be greater than or equal to the 33% nationwide estimates.

Methods

SETTING: BRIEF DESCRIPTION OF THE EC AT KH

The EC at KH has five sections and patients are assigned to each section based on triage severity designations. From lowest to highest, the designations are: Green room, asthma room, trolley room, Resus room and Peds. These correspond respectively to the severity codes: Green, Yellow, Orange, and Red. The Peds region is reserved for children below age 12 who do not require immediate resuscitation

FLOW OF PATIENT CHARTS THROUGH THE EC

For each patient presenting to the EC, a new episode folder is created with the unique identification number of the patient. Basic demographic information and chief complaint of the patient are recorded in the Clinicom daily registry by clerks, while the triage nurse assesses the patient and assigns a severity code using vital signs and other criteria specified by the South African Triage Scale (SATS).

Based on the SATS code, patients are sent to each of the five designated areas of the EC. Once the patient arrives there, the patient's basic demographic information and chief complaint is recorded for a second time. This time, however it is recorded on the paper registry for that section of the EC as opposed to the overall Clinicom daily registry. Therefore, the daily tally of patients in each of the paper registries should match the tally in the Clinicom daily registry. When healthcare professionals see a patient, hand-written notes and any other records are barcoded and placed in the patient's folder. At the end of the day, clerks pick up these folders and transfer them to the medical records department where they are scanned into the online database, available for future visits.

It is important to note that the Clinicom daily registry is separate from the Clinicom online database. The daily registry is an online version of the paper registries found in each section of the EC. Like the respective paper registries, it presents a daily record in column-format of each patient's demographic information, chief complaint, triage severity score, and a notification of whether a traumatic injury is found on initial survey. An illustrative example can be seen in Figure 1. The Clinicom Online database, on the other hand, is the online repository of each patient's medical information. It includes data from all patient visits, scanned copies of physician and nursing notes, radiological images, test results and medications dispensed. An illustrative sample of a physician's note retrieved from an online source is found in Figure 2 below.

Overall, for each patient visit, there are three pieces of evidence: a short summary of the patient's visit in one of the five paper registries, the same information available online in the Clinicom daily registry, and an online episode folder with scanned copies of all the notes, labs and images from the patient's visit.

Figure 1: Illustrative sample of patient registry copied from the Excel spreadsheet with identifying patient information removed.

1	Age	sex	date of arrival	time arrival	transport by	Time of triage	SATS code	temperature recorded	Type of Trauma	chief complaint
2	36	M	7/1/2012	n/a	WALK-IN	4:00	red	N/A	PENETRATING	GSW
3	26	F	7/1/2012	8:00	WALK-IN	8:15	orange	yes	blunt	fall
4	0	F	7/1/2012	n/a	WALK-IN	20:48	red	n/a	PENETRATING	laceration, head injury
5	27	M	7/1/2012	20:30	ambulance	20:30	yellow	yes	PENETRATING	stab
6	34	M	7/1/2012	4:20	WALK-IN	4:20	n/a	n/a	PENETRATING	laceration to the mouth
7	23	M	7/1/2012	n/a	ambulance	18:35	RED	yes	BLUNT	head injury+ LOC
8	39	M	7/1/2012	n/a	WALK-IN	9:20	RED	yes	PENETRATING	Stabbed on R fingers, dizziness
9	30	M	7/1/2012	23:00	WALK-IN		N/A		PENETRATING	multiple facial body lacerations
10	46	F	7/1/2012	1:50	WALK-IN	N/A	yellow	n/A	BLUNT	painful r side of hip
11	38	M	7/1/2012	1:00	WALK-IN	1:00	n/a	n/a	PENETRATING	stab (abdomen and arm)
12	36	M	7/1/2012	4:40	WALK-IN	4:30	N/A	N/A	BLUNT	BLUNT TRAUMA
13	25	M	7/1/2012	1:55	WALK-IN	N/A	N/A	N/A	PENETRATING	STAB (RIGHT FLANK AND NECK)
14	32	M	7/1/2012	n/a	WALK-IN		N/A			n/a
15	41	F	7/1/2012	n/a	WALK-IN	2:00	YELLOW	yes	PENETRATING	STAB (RIGHT EYE)
16	18	M	7/1/2012	n/a	AMBULANCE		RED	yes	PENETRATING	MULTIPLE STAB WOUNDS
17	29	M	7/1/2012	n/a	WALK-IN	2:35	N/A	N/A	PENETRATING	STAB BACK
18	27	M	7/1/2012	2:15	AMBULANCE		RED	yes	PENETRATING	GUN SHOT WOUND (GSW)
19	60	M	7/1/2012	n/a	AMBULANCE	2:07:00	RED	yes	PENETRATING	MULTIPLE STAB WOUNDS

Figure 2: Illustrative copy of a scanned physician note akin to that found at KH. Retrieved from website http://www.rajah2004.com/W%20LIBERTY%201.JPG. Date accessed Dec 27, 2014

PATIENT ELIGIBILITY

The records of all patients regardless of age, presenting to the EC of Khayelitsha hospital from July 2012 to May 2013 and who were given a trauma designation on the Clinicom daily registry were included. Trauma is defined as any injury to living tissue caused by an extrinsic agent and is divided into three major categories: blunt, penetrating and burn injuries.

DATA COLLECTION AND MANAGEMENT

Patient information was collected by the primary author through chart abstraction using one of the computers in the EC at KH. Paper registries, which are stored in a cubicle at the center of the EC were retrieved and returned to the same location after use. All paper registries in the cubicle were searched thoroughly by the principal investigator for the necessary variables needed in the study. Patient information was typed into a password-protected master Excel spreadsheet. Only the principal investigator had access to these documents. All data was stripped of patient identifying information.

OVERVIEW OF DESIGN

To get a sense of the trauma case load in the EC at KH as compared to the nationwide estimates of 33% of EC visits, a retrospective chart review of the paper registries, the online Clinicom daily registry (henceforth referred to as "the registry") and the Clinicom online database (henceforth referred to as" the database") was conducted in two phases, see figure 3 for timeline. The major aim of phase 1 was to gain a general sense of the trauma case load as recorded by the registries while the aim of phase 2 was to gain a general sense of the completeness of the scanned copies of patient records onto the database.

For phase 1, identification numbers for all patients visiting the EC from the months of July 2012 to May 2013 and designated as trauma on the registry were typed into the master Excel spreadsheet. For each of the months, the total number of patients visiting the EC was also recorded to aide in the calculation of the monthly trauma rate. This process was repeated 3 times to ensure data accuracy. Since KH opened in April 2012, the first three months (April, May, and June) were excluded from the study to

allow for staff acclimation to the new system. Furthermore, since the data collection occurred in June 2013, the month of June was also excluded. Using a random number generator with the months of July 2012 to May 2013 assigned equal probabilities, the month of July 2012 was selected. Attempts were made to attain paper registries for all five sections of the EC for the month of July 2012 through a thorough search of the cubicle in which registries were haphazardly organized. There were only registries for the months of May 2012, June 2012 and July 2012 in the cubicle and these were all incomplete. Nevertheless, the paper registry that was found for the month of July 2012 was compared to the Clinicom online registry for that month to ensure concordance between registries.

For phase 2, a random number generator was used again to select a month between July 2012 and May 2013 for further analysis of chart completeness. The month of Jan 2013 was initially selected and the identification numbers for all trauma patients visiting the EC during that month were typed into the database. However, on the database, there was no record of any of the patient's visits for that month. Using the random generator again, the month of March 2013 was selected and again, there were no scanned copies of trauma patient records for that month. Using the random number generator a third time, the month of July 2012 was selected, this time the identification numbers yielded evidence of the patient's visit for the month of July. Using this sample, the initial variables gleaned from the registry were cross-checked with those on the database for concordance. These variables include: patient age, sex, time of arrival, time of triage, temperature, mode of transport and triage severity code. Furthermore, since all patients were seen by both a physician and nurse with these notes are supposed to be

scanned into the online database, the presence of scanned copies of both physician and nursing notes were confirmed on the database.

Since the principal investigator noticed a pattern of missing scanned records for the months of January and March, efforts were made to confirm that this was not the case for the remaining 9 months. A random sample of 20 patient records from each of the remaining months was taken. For example, for the month of August 2012, a random sample of 20 patient ID numbers from the registry was retrieved. Next, each of these identification numbers was typed into the database to confirm that records for each patient's visit was stored in the online database.

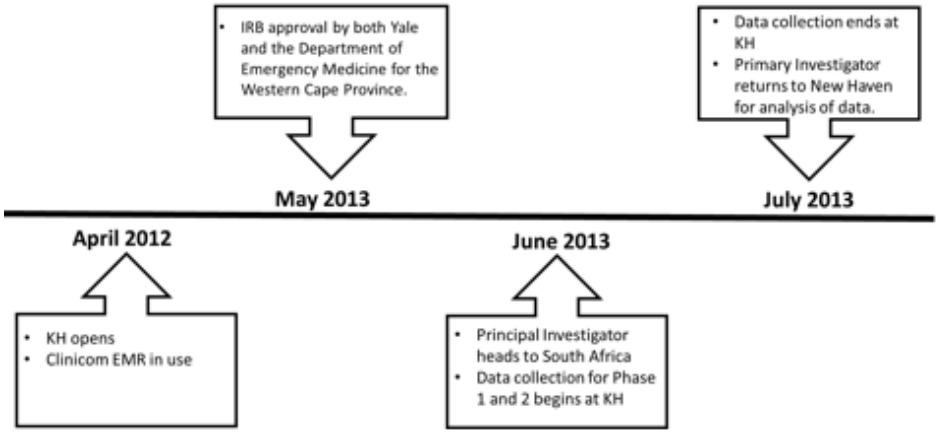
STATISTICAL ANALYSIS

All data was collected using Microsoft Excel 2010. Analysis including descriptive statistics and charts were performed using Microsoft Excel 2013.

APPROVAL

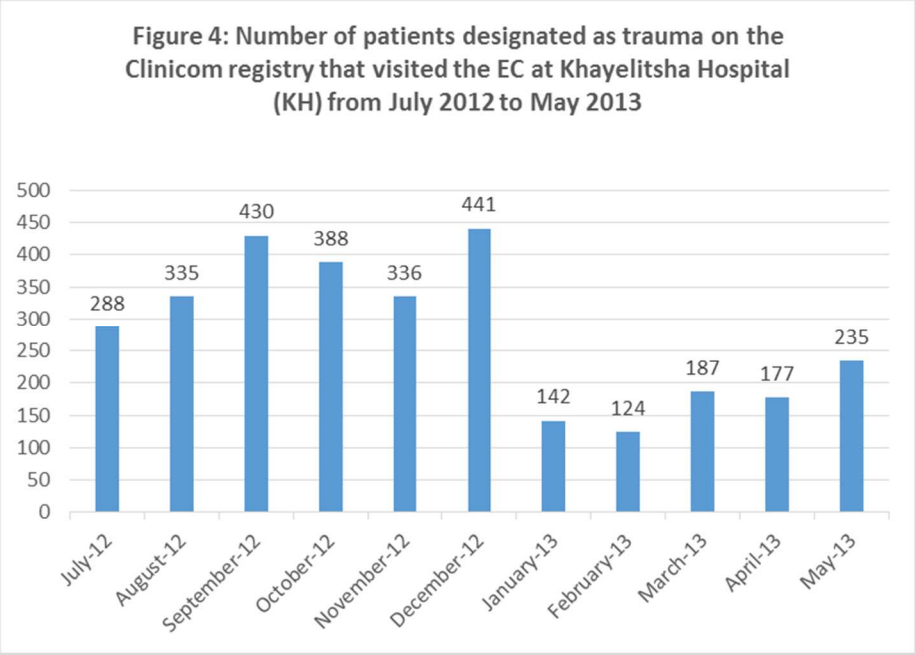
All methods described above were performed by the principal investigator (ECO). Approval for the study was granted by the Yale School of Medicine, the Western Cape Department of Emergency Medicine and Khayelitsha District Hospital. HIC Protocol #: 1304011877

Figure 3: **Timeline of data collection for the present study at Khayelitsha Hospital (KH)**



Results

The total number of patients visiting the EC and designated as trauma on the Clinicom online registry for each of the months from July 2012 to May 2013 is shown in Figure 4. The graph shows an increasing number from the months of July 2012 to December 2012, followed by a sharp drop in January 2013 that persists until the end point in May 2013.



For each of these months the total number of EC patient visits was calculated using the census on the online registry. Based on Table 2, the trauma rate also follows the same pattern of increasing from 8% in July to 11% in December, followed by a sharp decline that persists from Jan to May 2013.

Table 2: Number of patients visiting the EC at KH and designated as trauma on the Clinicom registry from July 2012 to May 2013 with associated trauma rate calculation

Months	Number of patients designated as trauma on Clinicom online registry for each of the months	Total number of patients visiting the EC for the month from Clinicom online registry	Trauma rate (Column b/c)
Jul-12	288	3488	8%
Aug-12	335	3624	9%
Sep-12	430	3548	12%
Oct-12	388	3675	11%
Nov-12	336	3482	10%
Dec-12	441	3837	11%
Jan-13	142	3485	4%
Feb-13	124	3287	4%
Mar-13	187	3936	5%
Apr-13	177	3299	5%
May-13	235	3247	7%
Average	**280**	**3537**	**8%**

The month of July 2012 was randomly selected for comparison between the online registry and the paper registry. As shown in Table 3, there were 66 extra unique trauma patient visits that were found on the paper registry but not in the online registry. These 66 patient IDs in addition to the 288 found on the Clinicom daily registry yielded a total of 354 trauma cases. The total number of patients visiting the EC as calculated from the online registry for July was 3488, yielding a trauma case load of 10% (354/3488). It is important to note that only one of the five paper registries for the month of July was found and it corresponded to that of the "Trolley area", where patients triaged as "orange" are treated. Furthermore, paper registries were stored, unordered, in a cubicle at the center of the ED and only parts of those from May, June and July 2012 were found.

Table 3: Calculating the trauma case load for the month of July 2012 using the paper registries and comparing this value with that of the Clinicom online registry	
Number of patients designated as trauma on Clinicom online Registry	288
Number of patients designated as trauma on the paper registries	354
number of cases by which there was a discrepancy	66
Total number of patients visiting the EC in the month of July	3488
Trauma case load calculation for the month of July	354/3488
Calculated Percent	10%
Estimated nationwide trauma case load for comparison	33%

In phase 2 of the study, patient identification numbers were typed into the online database for each of the months from July to May 2013. This was done to assess the availability and completeness of the scanned copies of the patient's record in the online database. Based on the data from table 4, we find that from the month of January to May, none of these patient records were available on the database. This is not the case for the months of July to December 2012. As explained in the methods section, the month of January was initially selected and all 142 patient ID numbers were typed into online database. None of these yielded any scanned records of the patient's visit. The same was true for the month of March. Finally, the month of July was selected and all 354 records were found in the online database. Noticing a trend, twenty randomly selected patient ID numbers from the remaining months were typed into the online database, revealing the pattern in the third column of table 4.

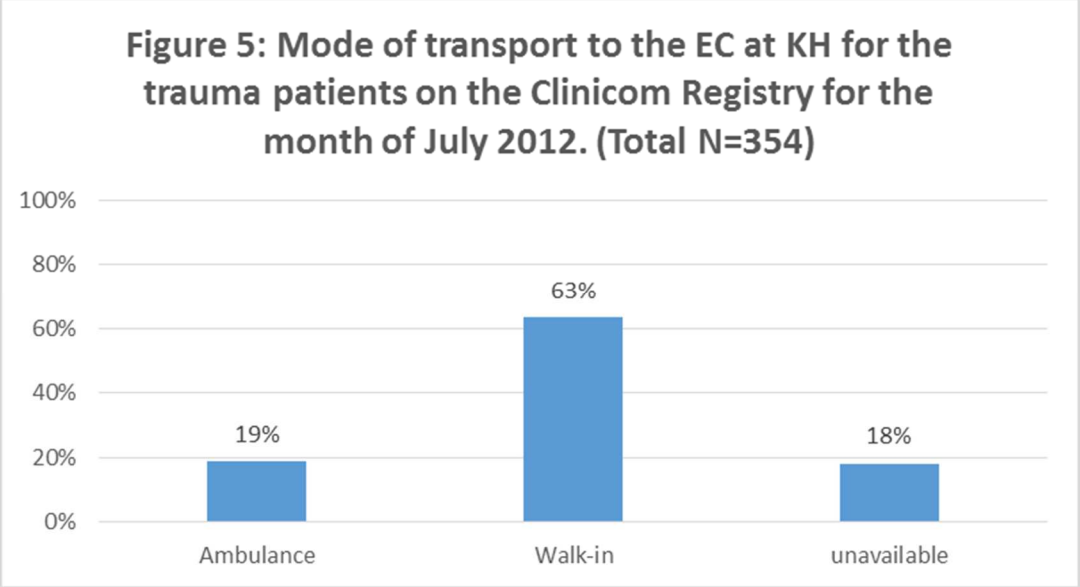
Table 4: Number of trauma patient records from the Clinicom registry that have been scanned into the Clinicom online database for each month.

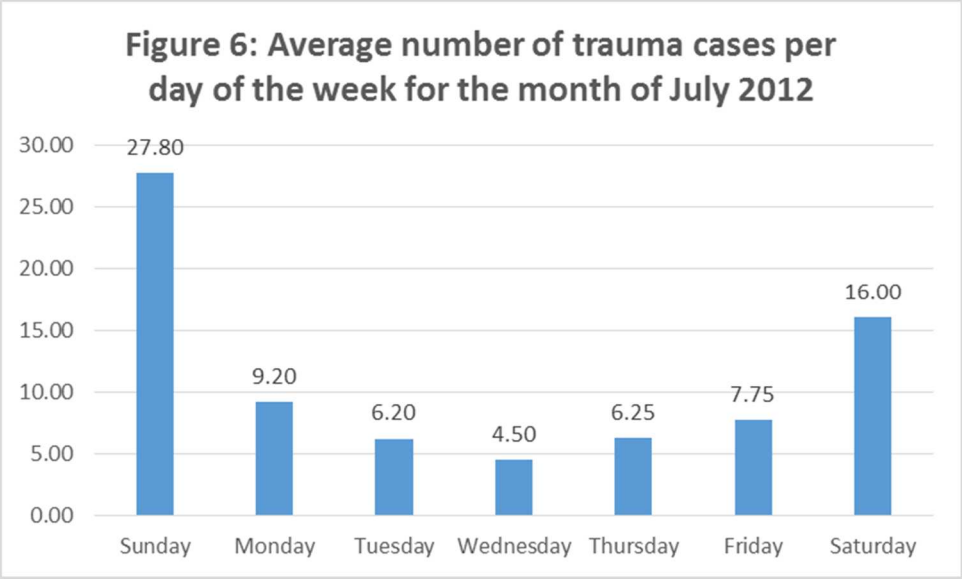
Month	Number of patient ID numbers typed onto the online database	Number of patient ID numbers with some scanned record of patient visit on online database for the respective date
Jul-12	354	354
Aug-12	20	20
Sep-12	20	20
Oct-12	20	20
Nov-12	20	20
Dec-12	20	20
Jan-13	142	0
Feb-13	20	0
Mar-13	187	0
Apr-13	20	0
May-13	20	0

Note: the months of Jan, march and then July were sequentially selected using an Excel randomizer for further analysis. Because the ID numbers for Jan and march did not yeild any online scanned records for their respective months, the month of July was selected. For the rest of the months, 20 patient ID numbers were randomly selected to ensure availability of scanned records

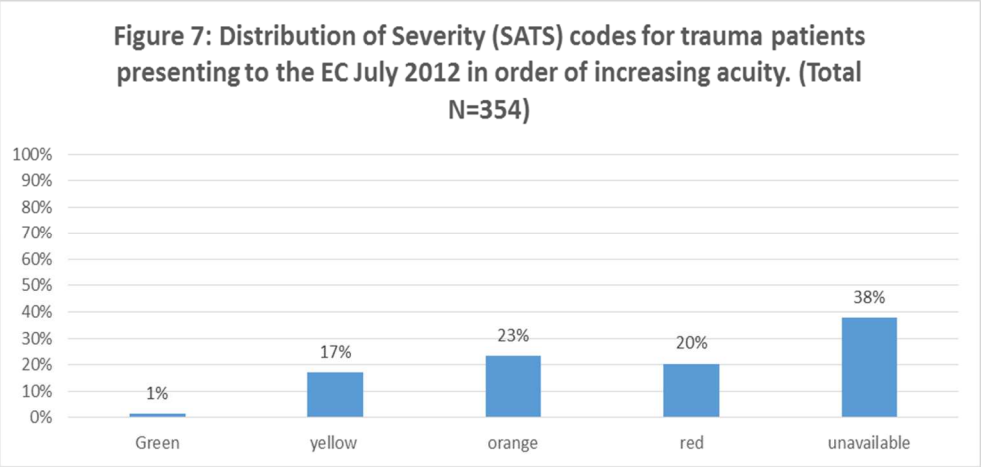
Looking specifically at the 354 trauma patients presenting to the EC in the month of July 2012, patients were relatively young, with an average age of 27.9 and most of these patients were male as seen in table 5. A minority of patients were brought in with an ambulance (figure 5) with most patients presenting as walk-ins. Most of these patients were brought in to the EC on Saturdays and Sundays, with Wednesdays having the least number of trauma visits during that month as seen in figure 6.

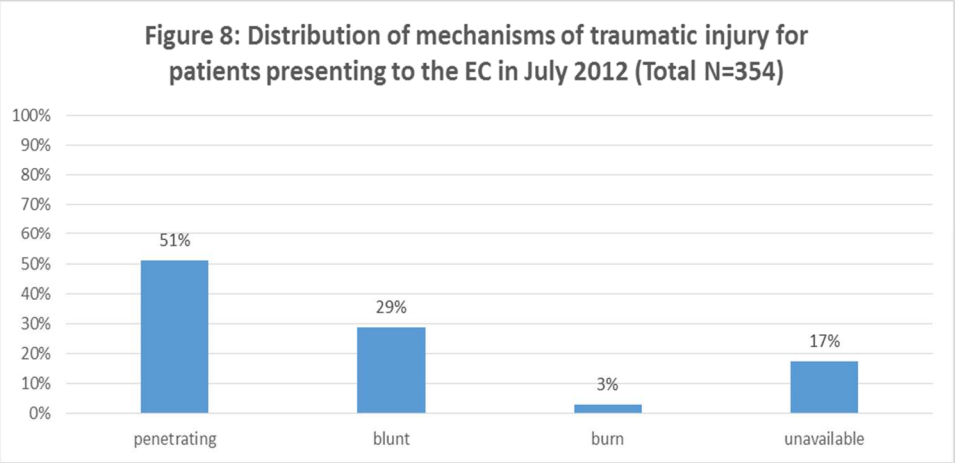
Table 5: Data from the Clinicom registry for the trauma patients presenting to the EC for the month of July 2012 (Total N= 354)	
Category	**Number (%)**
Sex	
Female	89 (25%)
Male	265(75%)
Time of triage recorded?	
Yes	85(24%)
No	269(76%)
Patient vital signs recorded	
Yes	176(50%)
No	176 (50%)

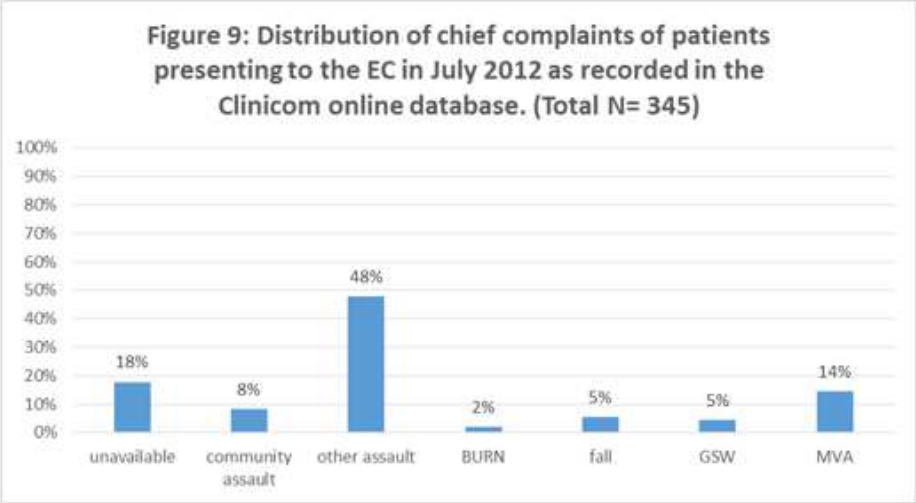




Trauma patients with higher severity codes (red, orange, and yellow) were almost evenly distributed in this population with almost no low acuity patients as shown in figure 7. In terms of injury mechanisms, penetrating injuries were the most common with 51% (118) followed by blunt and burn injuries as seen in figure 8. In terms of chief complaints, non-community assaults were most common with 48% (169) of visits while motor vehicle accidents were responsible for 14%, and community assaults for 8%. Gunshot wounds, falls and burns were less common in this population (figure 9).







Abbreviations: GSW= Gun Shot Wound. MVA= Motor Vehicle Accident

Finally, in the above figures, one sees evidence of incomplete filling of patient data both in the registry and the database with 76 % (269) of charts lacking recorded time of arrival or triage, 18% (64) lacking a mode of transport for patients, 38% (134) lacking patient severity codes, 50% (176) lacking temperature recordings, 17% (61) without a mechanism of injury and 18% (63) of charts without a chief complaint.

Discussion

The results confirm certain expected characteristics of trauma patients visiting the EC. The young average age (28) and predominance of males (75%) is in line with the findings in other studies looking at EC trauma visits in South Africa (4,6,11). A study by Nicol et al looking at patients in Groote Schuur Hospital, a neighboring but higher level center, found that most trauma patients were male and below the age of forty (4,6). The results also show a much higher census during the weekend than during the weekdays. This could be related to the decreased availability of clinics during the weekend, leaving patients with the EC as their only option, a phenomenon that has been shown in multiple studies in higher income countries (54-56). With the high incidence of multi-drug resistant tuberculosis and patients living with untreated HIV/AIDs in South Africa, even minor traumatic injuries have a high potential for complications(57). Furthermore, since most South Africans are paid on Fridays, their newfound funds combined with availability of alcohol, and relaxed road safety regulation, could increase likelihood for injuries to occur (4,6) and potentially explain the high incidence of visits to the EC.

In terms of the patient transport to the EC, despite the fleet of 11 ambulances and 110 ambulance staff members dedicated to the Khayelitsha community and surrounding areas(23), the majority (63%) of trauma patients arrived at the EC using private forms of transportation. One potential cause is the lacking trauma infrastructure in the Khayelitsha Township to allow ambulance access to the sites of traumatic injuries. A 2014 New England Journal of Medicine paper examining the South African injury burden highlighted the importance of varying levels of infrastructure for primary, secondary and tertiary prevention of injury-related disability and mortality(57). On the first level is the

primary prevention of injuries through preventative measures such as speed limit enforcement, restrictions on drinking and driving, regulations on types of vehicles on roads and gun control. On the second level are measures to decrease the severity of injury such as laws to enforce the use of seat belts while driving and helmets while riding a motorcycle. On the third are systems to improve care post injury, such as improved ambulance service, first responder access to patients and emergency care(57). The informal settlements in Khayelitsha with less than optimal roads to and from the Township, and the high incidence of violence could deter ambulance access to injured patients. More studies are needed to explore this issue to help guide policy makers towards adequate resource deployment.

Looking at the severity of injuries, the percentage of high acuity patients visiting the EC was relatively consistent with expectations. Although a large proportion of trauma patients were of high acuity, one would have expected a higher percentage of "red' severity scores than "orange" especially considering the amount of violence in Khayelitsha and its one time reputation as the murder capital of South Africa. The lower proportion of red severity patients could result from pre-mature death due to transport by family members as opposed to trained ambulance staff. Supporting this is the finding that patients suffering assaults, especially community assaults take much longer to arrive in the EC. This, combined with the scarcity of ambulance services to the area, increases likelihood of pre-hospital mortality, falsely causing the proportion of "red" severity patients to be lower than expected (17). Nevertheless, the distribution of trauma mechanisms and chief complaints further highlight the burden of non-community assaults

in Khayelitsha, and the need for infrastructural development to improve patient outcomes(58).

The results do suggest that there are potential problems with the record keeping at Khayelitsha Hospital. Contrary to expectations, the average trauma rate based on the Clinicom daily registry data from July 2012 to May 2013 was 8% (Table 2) as opposed to the hypothesized value of greater than or equal to 33%. This is especially interesting, considering the high rates of violence in the surrounding Khayelitsha Township as highlighted in the introduction. There are a few potential reasons for the lower than expected census. It could be that because KH is a relatively new hospital, most would-be patients are sent to other hospitals in the vicinity. This is supported by the evidence from figure 5 that a minority of patients were brought in by ambulance services and based on the assumption that ambulance drivers are more likely to know about newly built hospitals than the general population. However, it does not explain the high rates of trauma patient referrals to tertiary hospitals that have been documented by other studies (6). It also does not explain the sudden drop in trauma rate from December to January which persisted until May as seen in table 2.

A second potential explanation could be the lack of effective trauma systems, causing a high proportion of patients to pass away before reaching the hospital. As shown in the previous paragraph, this has been documented in patients suffering from community assaults. However, from figure 9, community assaults are not the most common cause of traumatic injuries. Furthermore, the lack of trauma systems does not completely explain why the highest proportion of trauma patient referrals to Groote Schuur Hospital, are from KH as shown in a 2014 paper by the Surgical division of the

Journal of American Medical Association (JAMA)(6). If 17.8% of the 2938 trauma referrals to Groote Schuur during a 9 month period are from Khayelitsha hospital, and if 51.1% of the patients presenting to Groote Schuur are by ambulance, then one can infer that the trauma system is at least functional in certain areas(6). Therefore, it does not completely explain the lower than expected rate.

A third and more plausible reason based on data from this study relates to potential inefficiencies in record keeping on the Clinicom EMR. On the one hand, it is possible that the mechanism of patient's injuries are not correctly classified as trauma on the Clinicom EMR, so that a higher percentage of the 3537 patients visiting the EC per month are actually trauma-related. This would necessitate better training of clerks or triage nurses to better stratify patients. It is also possible that patient data are not recorded consistently. In this case, a more generalized education of various stakeholders in the hospital system on the importance of consistent record-keeping is warranted.

From the data, it is evident that both scenarios are at play at KH. The haphazardly organized paper registries in the cubicle, and resulting difficulty in finding all the registries despite multiple attempts, hampered the efforts of the principal investigator to properly quantify the discrepancies between the paper registry and the Clinicom daily registry. Despite this, 66 cases were found for the month of July and this corresponded to patients classified as "orange" severity. One could potentially infer that a greater proportion of trauma patients would have been found if the "red" patient severity registry was available, considering that these patients present with more severe conditions and that the most common reason for presentation to the EC is assault. Furthermore, even

more cases would have been found if the other three registries were available, or ideally, if the total patient count was accurately reflected on the Clinicom online registry.

The percentage of records with missing data on the Clinicom online registry is also a cause for concern. As explained in the introduction, the South African Triage score is calculated using important variables as seen in Appendix A and B. These variables include the patient's vital signs, mechanism of injury, and level of alertness. Especially for an emergency center that depends on efficient triage to increase a patient's likelihood of survival, missing variables like this could increase patient morbidity and mortality. Furthermore, the unavailability of patient records in the online database from January to May 2013, as seen in table 4 is also concerning. It shows that the online database is potentially not fulfilling its main function. Considering that the initial investment in health technology amounted to 60 million Rands ($6.9 million based on the 2012 exchange rate), the returns based on this study do not justify such a hefty investment(52). Further studies are required to better quantify the full extent of this discrepancy and figure out solutions to them.

Nevertheless, the Clinicom EMR, when functioning optimally is an important first step in the right direction because it sidesteps an important barrier to electronic record implementation. Many studies have shown that healthcare professionals serve as a major barrier to implementation of Electronic Medical Record systems (1,35,36). For healthcare professionals, EMR use negatively impacts patient-centeredness as clinicians are forced to spend a greater percentage of their time during a visit, facing a computer as opposed to the patient. EMR use also increases the health professionals' workload since they now have to type notes as opposed to hand-write their notes, which as many would argue, dis

incentivizes brevity in note-writing(35). Especially in the EC, where fast-pace and quick decision-making are extremely important, having to type notes on an electronic system after a slew of patients can be daunting, when compared to hand-writing notes(36). A 2012 survey showed that Emergency Center physicians were three times as likely as primary care physicians to negatively perceive the impact of EMRs on their interactions with patients(59). Further studies highlight the importance of a culture change of healthcare professionals as a larger impediment to EMR adoption than the upfront investment costs of EMRs, especially in areas where cheaper open-source options are available(36). Therefore, by retaining paper records for creation of content, while organizing this content in a central repository that is available to health professionals, the Clinicom EMR presents an important value proposition—making the transition to a full electronic medical record system less abrupt. In the short-run, this is a welcome option. In the long-run, however, a full EMR system is warranted.

So what can be done in the short-term? If the problem is that healthcare professionals are not consistently filling out patient data, then KH needs to increase supervision/ audits of the patient records to ensure that important data are filled out correctly. Especially in the Emergency Center, charts without triage codes or chief complaints make it difficult for providers to give quality care, while also exposing the hospital to litigation. An audit system with repercussions for missing notes would be a step in the right direction to ensure notes are adequately filled out in a timely fashion (43). For data with pre-defined ranges, some studies have shown the efficacy of automatic alerts for data that is out of the range (1,43). For other systems with stronger capabilities, the system prevents a provider from moving to the next page until critical

information is filled out (1,43). Although not currently part of the Clinicom EMR armamentarium, adding these capabilities could potentially help remedy the issue of incompletely filled out charts at KH.

A second potential area of need is resource capacity, which can be divided into human and material resources. This paragraph will delve into material resources while the next will look at human resources. In the Clinicom daily registry, it is possible that patient temperatures are not filled out because thermometers are not readily available in the Emergency Center. This is not an uncommon omission in the South African patient records and points to a wider problem across the country(60). An analysis by the Medical Protection Society of South Africa in 2011 showed that patient temperature, pulse rate, description of awareness level and negative clinical findings were the most commonly omitted variables in a large sample of patient records(60). Especially in the fast-paced EC, material resources as simple as thermometers are important for calculating patient severity scores, which are necessary for effective patient triage.

One could posit that the material resource problems at Khayelitsha hospital are not restricted to the Emergency Center. Another potential site for a bottleneck to be present is the medical records department. For a system like the Clinicom EMR that depends on paper copies of records scanned onto the online database, a low scanner-to-worker ratio could lead to longer waiting times for workers and therefore limit their ability to scan folders in a timely manner. Furthermore, throughout the hospital, the limited amount of broadband internet and slower download speeds as is seen throughout South Africa would make interconnectivity among departments and hospitals difficult(2,48). This is especially true in the Western Cape. Although the Clinicom

system has been installed in three of its hospitals, they are still not linked to each other because of limited bandwidth (18). Furthermore, despite having the largest telecommunications market in Africa, valued at about $25 billion, broadband penetration in South Africa is low and bandwidth is expensive(2), making efforts to remedy this critical. The South African government has made strides towards solving this problem by arranging for the procurement of the South African Research Network (SANReN) to improve broadband connectivity(2). The hope is that initiatives like this will help strengthen the material resource capacity and improve the capabilities of EMR systems across the country.

Human resource problems also abound at Khayelitsha Hospital and could contribute to the difficulties with the Clinicom EMR found in this study. Statistics from 2011 about the City of Cape Town showed unemployment rates of 38%, with the highest rates among black Africans(19). Considering that 99% of the population of Khayelitsha is black African, one would expect that the opening of KH would help decrease this level of unemployment. In many ways it has but there is still work to be done. As of Jan 2012, there were 56 positions that were not yet filled at KH(23). One could posit that this would lead to workers having to perform tasks for which they do not possess adequate training, leading to burnout and high turnover rates for workers. Those with lower skill levels who are easier to replace would especially be affected, leading to both frictional and structural unemployment. Frictional unemployment refers to workers who are actively searching for jobs and have the skills to accomplish their work. Structural unemployment, on the other hand, results when workers do not possess the skills for a job and usually results from technological innovations. For lower-skilled tasks such as those involved in

scanning patient files in the medical records department, a high worker turnover would lead to high levels of frictional unemployment. Such turnover leads to productivity loss and wasted resources as managers constantly have to train new employees(61). This is not sustainable and if present at KH, efforts should be made to increase worker retention thereby decreasing resource utilization.

A larger problem in the area of human resources results from the introduction of new technology and the structural unemployment that has ensued for higher-skilled jobs at KH. Many studies have highlighted the difficulties associated with hospitals employing workers who are not computer literate including medical practitioners and the overall unavailability of data information specialists (2,61). This level of structural unemployment is prevalent in Africa and has caused various countries to implement training programs to develop pipelines for information technology capacity-building (61,62). The Rwandan government as of 2010 was working on partnerships with the Google Summer of Code to provide grants supporting mentored projects for students trained in computer science(62). There were also efforts to integrate these types of training at the University level, thereby increasing its availability while minimizing potential redundancies(62). The South African government is also making strides in this area by introducing stronger training initiatives in the area of information technology(2). Places of learning like the Mareka Institute should in the long run help to remedy some of the human resources needs at KDH(2).

Overall, it is evident there was some difficulty with the implementation of the Clinicom EMR system at KH. The Clinicom EMR was not adequately utilized, some of the paper registries were missing at the time of the study and those records that were

available on the online database were either incompletely filled out or missing whole sections. Aside from the above, there are other reasons preventing hospitals from implementing full EMRs in South Africa and they include the medico-legal requirements by the South African Government to have 'hardcopy' documentation of patient records (36), the cultural difficulties to the clinician when his/her decision-making is available for everyone to see and judge, difficultly managing life and death situations in the EC while at the same time battling with a system that is relatively new, and the typical challenges associated with any new technology, such as the acquisition of typing skills and a minimal comfort level with technology(35,36). In the short-term, therefore, efforts should be made towards optimizing the current system. This should involve increasing resources, manpower, supervision, and training (35,62).

In the long term, a complete conversion to a full EMR system that involves direct input of doctors' and nurses' notes into the computer will be the most ideal solution. This will allow the hospitals to attain the full benefits of EMRs as detailed in the introduction. For an efficient EMR system to be implemented, there must be important pieces in the toolkit, including the development of a system that has adaptable, interoperable, and scalable software while fostering relationships in the community to provide ''technical, financial, and training support''(40). The implementation of such a system would require a bottom up approach involving buy-in from all levels of stakeholders, and ensure that the initial delays and decreased productivity do not serve as deterrents to full implementation(63). This approach stresses the equal role of technical considerations and socio-cultural factors in influencing the success of EMR implementation(63). Furthermore, to minimize stakeholder resistance, as would be expected when trying to

cause change in a large bureaucratic system such as a hospital, researchers emphasize the use of pilot projects as opposed to major overhauls. This is predicated on the belief that it is much easier to garner support when one provides evidence of quick wins, which would usually result when one focuses on small pilot projects (64).

As expected, a full EMR is a larger undertaking, and requires a large investment to implement and maintain. Some solutions are available to help with funding. Governments like the US have provided incentives for ‘‘meaningful use’’ of this technology to healthcare facilities. The South African government can do the same, providing subsidies for hospitals that use the system and penalties for those that do not. Furthermore, there are cheaper and more malleable options for EMRs, such as open source versions, which would be much more feasible in a low-resource environment.

Limitations

For any new technology, there is always a lag time for adjustment. This is another one of the pitfalls for the EMRs. The time can vary according to institution, with some institutions taking up to two years of dedicated effort to achieve full use(35). It could be that KH needs a few years for all the systems to come into place and fully realize the benefits of the installed records system. Further research should look at how efficient the system is in the coming years. Additionally, this study had only a small sample. Though KH is a large and fairly representative hospital of those in South Africa installing EMRs, this study only looked at the effects on one department in one large hospital. Future studies should look at more hospitals to determine whether there are common issues and solutions.

Finally, as both the registry and the online database were incomplete, it was difficult to establish a gold standard for the trauma load at KH. It is possible that some of the encounters on Clinicom were incorrectly coded as non-trauma, thereby underestimating the trauma load. Further studies are required, using a system that works, to help with the original aim of trauma surveillance in South Africa.

Conclusion

The desire for EMRs in LMICs will continue to rise with increasing rates of trauma and infectious diseases. With this increased pressure, hospitals and governments have a few options. They can choose to adopt a system like Clinicom EMR as was done in Khayelitsha Hospital. However, the results from this study suggest that there might be potential pitfalls with the implementation of this system at KH. Hospitals looking to employ the Clinicom EMR should ensure that their budgets account for the difficulties encountered in this study, including adequate training and supervision of workers and increased investment in necessary resources. In the long run, efforts should be made to transition into a full EMR system so that hospitals can reap the full benefits of a truly electronic system.

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Appendix

Appendix A: The Triage Early Warning Score. RR, respiratory rate; HR, heart rate; SBP, systolic blood pressure; AVPU, alert, voice, pain, unresponsive. Sun JH, Twomey M, Tran J, et al. Emerg Med J (2011). doi:10.1136/emermed-2011-200619

ADULT TRIAGE SCORE							© South African Triage Group 2008	
	3	2	1	0	1	2	3	
Mobility				Walking	With Help	Stretcher/ Immobile		Mobility
RR		less than 9		9-14	15-20	21-29	more than 29	RR
HR		less than 41	41-50	51-100	101-110	111-129	more than 129	HR
SBP	less than 71	71–80	81-100	101-199		more than 199		SBP
Temp		Cold OR Under 35		35-38.4		Hot OR Over 38.4		Temp
AVPU		Confused		Alert	Reacts to Voice	Reacts to Pain	Unresponsive	AVPU
Trauma				No	Yes			Trauma
over 12 years / taller than 150cm								

Appendix B: Wallis PA, Gottschalk SB, Wood D, et al. The Cape Triage Score—a triage system for South Africa. S Afr Med J. 2006 Jan;96(1):53-6.

Colour	Red	Orange	Yellow	Green	Blue
TEWS	**7 or more**	**5 - 6**	**3 - 4**	**0 - 2**	**Dead**
Target time to treat	Immediate	Less than 10 min	Less than 60 min	Less than 240 min	
Mechanism of injury		High energy transfer			
Presentation		Shortness of breath – acute		All other patients	Dead
		Coughing blood			
		Chest pain			
		Haemorrhage – uncontrolled	Haemorrhage – controlled		
	Seizure – current	Seizure – post ictal			
		Focal neurology – acute			
		Level of consciousness reduced			
		Psychosis/aggression			
		Threatened limb			
		Dislocation – other joint	Dislocation – finger or toe		
		Fracture – compound	Fracture – closed		
	Burn – face/ inhalation	Burn over 20%	Burn – other		
		Burn – electrical			
		Burn – circumferential			
		Burn – chemical			
		Poisoning/overdose	Abdominal pain		
	Hypoglycaemia - glucose less than 3	Diabetic – glucose over 11 & ketonuria	Diabetic – glucose over 17 (no ketonuria)		
		Vomiting – fresh blood	Vomiting – persistent		
		Pregnancy and abdominal trauma or pain	Pregnancy and trauma		
			Pregnancy and PV bleed		
Pain		Severe	Moderate	Mild	
	Senior health care professional's discretion				

Fig. 2. The CTG discriminator list (adult version).