

RESEARCH ARTICLE

Injuries in Bolivia: Initial Trauma Registry Results from Five Hospitals in Santa Cruz de la Sierra

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RESUMEN

Título: Trauma en Bolivia: Resultados iniciales del registro de trauma de cinco hospitales en Santa Cruz de la Sierra

Objetivo: Trauma es una de las causas principales de muerte en el mundo. Muchos entornos con recursos limitados, como Bolivia, no tienen datos sobre los mecanismos y resultados de lesiones traumáticas, lo que restringe las iniciativas específicas de prevención y mejora en la calidad. Revisamos los resultados iniciales de cinco registros de trauma hospitalarios en Santa Cruz de la Sierra para explorar las características de las lesiones en esta región de Bolivia.

Materiales y métodos: Desde octubre del 2015 hasta mayo del 2016, el personal del departamento de urgencias (DU) recopiló información sobre los pacientes traumatizados, incluyendo datos demográficos personales y de las lesiones, datos pre-hospitalarios y su disposición del hospital, con la transferencia posterior a una plataforma virtual.

Resultados: El registro capturó N = 3,220 pacientes, de los cuales el 64% eran hombres de 21 años (RIC 6, 37). El transporte hospitalario se realizó a través de un automóvil privado

(37%), taxi (23%), o ambulancia (15%), y muchos se presentaron el día de la lesión (74%) y dentro de las primeras cuatro horas (52%). La mayoría de las lesiones ocurrieron en el hogar (38%) o en la calle (29%), fueron contusos (64%), y se debieron a caídas (43%), incidentes de tránsito (13%), o mordeduras de perros (8%). Las lesiones clasificables (N = 2,874) más comunes incluyeron contusiones de cabeza/cara/extremidades (43%), fracturas de extremidades (12%), lesiones penetrantes de brazos/manos (3%), y lesiones por mordedura a la cara (3%). Los pacientes fueron dados de alta habitualmente desde el servicio de urgencias a domicilio (62%) o fueron admitidos (16%), y se reportaron seis fatalidades (0.19%).

Conclusiones: Estos datos sugieren que los pacientes con trauma que acuden a los hospitales del registro no son hospitalizados con frecuencia, y muchas lesiones se pueden prevenir. Una representación más completa del trauma dentro de la ciudad requiere una mejor calidad de los datos, la expansión del programa, y la inclusión de fuentes de datos complementarios. Los resultados servirán para informar al área de planificación de los recursos y de estrategias preventivas del sistema de salud, permitiendo intervenciones basadas en la evidencia que reducen la morbilidad y la mortalidad por trauma en Bolivia.

Importancia clínica: Estos resultados califican la carga por trauma en esta región boliviana, y sirven como la base para intervenciones en el futuro para mejorar los resultados de los pacientes lesionados, y reducir su morbilidad y la mortalidad.

Datos masivos: Bolivia, Carga de enfermedad, Fortalecimiento del sistema de salud, Mejora de la calidad, Mundo en desarrollo, Prevención de lesiones, Salud pública, Registro de trauma.

ABSTRACT

Aim: Trauma is a leading cause of global deaths. Many resource-limited settings, like Bolivia, lack data on injury mechanisms and outcomes, restricting targeted initiatives for prevention and quality improvement. We reviewed initial results from five hospital-based trauma registries in Santa Cruz de la Sierra to explore injury characteristics in this Bolivian region.

Materials and methods: From October 2015 until May 2016 emergency department (ED) staff gathered trauma patient information, including personal and injury demographics, prehospital facts, and hospital disposition, with subsequent transfer into an online platform.

Results: The registry captured N = 3,220 patients, of which 64% were male aged 21 years (IQR 6, 37). Hospital transport occurred via private car (37%), taxi (23%), or ambulance (15%), with many presenting on the day of injury (74%) within four hours (52%). Most injuries occurred at home (38%) or in the street (29%), were blunt (64%), and resulted from falls (43%), road traffic incidents (13%), or dog bites (8%). Common classifiable injuries (N = 2,874) included head/face/extremity contusions (43%), extremity fractures (12%), arm/hand penetrating injuries

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Conclusion: These data suggest trauma patients at registry hospitals frequently are not hospitalized and many injuries are preventable. A more complete trauma representation within the city requires data quality improvement, program expansion, and supplementary data source inclusion. Results will inform health system resource planning and preventative strategies, enabling evidence-based interventions that reduce injury morbidity and mortality in Bolivia.

Clinical significance: These results qualify the injury burden in this Bolivian region, serving as the basis for future interventions to improve injured patient outcomes, and reduce morbidity and mortality.

Keywords: Big data, Bolivia, Burden of disease, Developing world, Health system strengthening, Injury prevention, Public health, Quality improvement, Trauma registry.

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INTRODUCTION

Trauma is a leading cause of global deaths. Nine-hundred seventy-three million injuries required health facility care in 2013, with 4.8 million resulting in death according to the 2013 Global Burden of Disease (GBD) study. This accounts for an alarming 10.1% of the GBD,¹ with an estimated 90% of these deaths occurring in low- and middle-income countries (LMICs).² Trauma registries are an evidence-based method for injury data collection and assessment, enabling the analysis of trends and their associations with patient outcomes. Information gathered can be used to determine resource allocation, monitor interventions, and develop prevention practices, among other uses.³

However, many resource-limited settings, such as the Plurinational State of Bolivia, lack specific data on injury mechanisms, severities, and outcomes. This deficit severely limits the ability to develop targeted initiatives for trauma prevention and improvements in the quality of care delivered. Despite registry data advances in high-income countries (HICs), LMICs face barriers to obtaining reliable, prospective injury statistics, with a 2013 review finding only 50 registries across 21 LMICs documented in the literature.⁴ Yet data have repeatedly proven critical to developing successful initiatives, such as those at Khon Kaen Hospital in Thailand, where targeted quality improvement interventions in trauma patient care led to a 50% reduction in mortality.⁵

Using five hospital-based trauma registries in Santa Cruz de la Sierra, this study sought to evaluate initial results and explore inter-hospital differences in patient

demographics, injury characteristics, and outcomes in this region of Bolivia. We hypothesized that trauma is a significant cause of morbidity and mortality in this population, and patient characteristics would differ by the hospital due to geographic location and populations served. This information will serve as the initial step to clarifying the quality, quantity, and distribution of injuries in the city of Santa Cruz de la Sierra, providing essential information to health officials on high-yield targets for prevention campaigns and quality improvement initiatives.

MATERIALS AND METHODS

The study took place from October 2015 until May 2016 in the emergency departments (EDs) of five hospitals in Santa Cruz de la Sierra, Bolivia. Institutional Review Board approval was obtained through Northwestern University. The Secretary of Health and Social Policy for the Autonomous Department of Santa Cruz and directors at each of the participating hospitals provided local endorsement due to the absence of formal ethical research boards.

Study Location and Site Selection

Bolivia is a lower-middle income country located in the heart of South America with a population of 10.9 million people.⁶ The nation is divided into nine departments and 337 municipalities,⁷ with the largest department being Santa Cruz and its capital city of Santa Cruz de la Sierra. Two-point-seven million residents reside in this easternmost, low elevation region known as the country's agro-industrial production center, 82% of whom live in urban environments.^{8,9} In the 1960s the city was designed using traditional, early 20th-century European style with a central plaza and colonial grid layout surrounded by rings connected via radial streets (Fig. 1).¹⁰ The initial proposal stopped at four rings, but with rapid, largely unrestricted and unplanned urbanization since the 1970s, the city has grown to its current state of 12 rings with approximately one to three kilometers between each. In 1995 the city was divided into 12 urban districts, with four additional districts added in 2004 for future growth.^{9,11}

Four formal subsectors comprise the Bolivian healthcare system: public, private, social security, and traditional medicine. The public component is divided into three levels of care. The first level includes health posts and health centers, while the second consists of basic hospitals providing pediatric, gynecologic and obstetric, general medical, anesthetic, dental, and surgical care, analogous to district hospitals in other locations. Third level facilities are general hospitals or specialized institutes that provide a complete range of services or

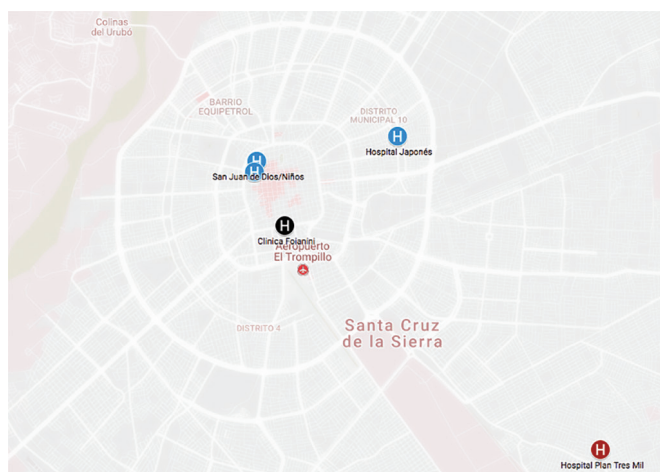


Fig. 1: Map of Participating Hospitals, Santa Cruz de la Sierra, Bolivia¹⁰

Icons: Blue-Third level hospital; Red-Second level hospital; Black-Private hospital

expert care within a given specialty.^{12,13} These institutions are currently managed under a decentralized system, with departmental health services supervising third level facilities, while first and second level centers are overseen by the municipality,¹⁴ laying the groundwork for potential coordination conflicts between levels of care. As of 2016, the department of Santa Cruz had the second highest number of healthcare facilities (N = 687) after La Paz, and the most hospital beds (N = 6,459). Despite Santa Cruz having the most people per healthcare establishment (N = 4,481), they fell to sixth for individuals per hospital (second and third level facilities) at 30,785 people per facility.¹⁵

In collaboration with local health officials and hospital personnel, five hospitals were selected for the initial trauma registry program, based on the common belief that these facilities collectively receive the majority of trauma patients in the city (Table 1). Three of the hospitals are centrally located within or at the first ring, while Hospital Universitario Japonés is situated in the east at the third ring, and Hospital Municipal Plan Tres Mil is located near the sixth ring (Fig. 1).

Trauma Registry Program Implementation

The selected trauma registry model was developed by the Panamerican Trauma Society (PTS) and has been

described in detail elsewhere.¹⁶ Ongoing data collection form revisions were completed as suggestions or conflicts arose, to better reflect local dialects, subjects of interest, or improve ease of form use and adherence (Fig. 2). The form reflected variables in a web-based platform, which remained unchanged throughout the study. Upon entry into the electronic system, each subject was automatically assigned a unique numerical identifier. The initial registry form had 36 variables, with full name, specific injury mechanism, address, respiratory rate and qualifier, Glasgow coma score (GCS) and qualifier, and injury(ies) with body part(s) collapsed into one variable each. Of these, 29 (80.5%) were deemed the minimum necessary for registry completion (hospital, date and time of hospital arrival, age, sex, referred, city, mode of transport, date and time of injury event, location of injury event, activity when injured, primary injury mechanism, specific injury mechanism(s), heart rate, blood pressure, respiratory rate, GCS, alert, voice, pain, unresponsive (AVPU) score, use of alcohol, injury(ies) and body part(s), number of serious injuries, ED disposition, date and time of ED disposition, hospital disposition, date and time of hospital discharge, final diagnoses).

Multiple stakeholder meetings took place with hospital and ED directors, local site champions, and health department officials, to ensure the development of a culturally relevant, setting appropriate, sustainable trauma registry program. This conversation was informed by lessons learned from the pilot trauma registry at Clínica Foianini.¹⁶ All of these efforts culminated in the creation of a departmental policy instructing mutual participation of the selected hospitals in the trauma registry program. Subsequent meetings and training sessions were held at each participating site with select staff responsible for trauma registry implementation. Facility visits also included logistical planning for trauma registry tasks to optimize success within each hospital's unique layout and standard operating procedures. Stakeholders at each site participated in focused qualitative interviews investigating overall hospital function and standard trauma patient management, and quantitative assessments with validated surgical capacity measurement tools (unpublished data). The project lead maintained direct, frequent contact with

Table 1: Trauma registry participating hospitals

Hospital	Type/Level	Beds ^a	Patient population	No. records N = 3,220; N (%)
Clinica Foianini	Private	50	All ages, male/female	831 (25.8)
Hospital Municipal Plan Tres Mil	Public/Second	146	All ages, male/female	189 (5.8)
Hospital Universitario Japonés	Public/Third	200	All ages, male/female	585 (18.2)
Hospital de Niños	Public/Third	120	Up to 12 years old, male/female	712 (22.1)
Hospital San Juan de Dios	Public/Third	244	13 years and older, male/female, excluding pregnant patients	903 (28.0)

^aBed capacity at the time of data collection



Hospital: _____

Formulario del Registro de Trauma de la Sociedad Panamericana de Trauma - Bolivia

Datos Demográficos - Nombre: _____
 Apellido paterno: _____ Apellido materno: _____
 EE 1 No. de historia clínica: _____ EE 2 Fecha de llegada: ____/____/____ (dd/mm/aa) EE 3 Hora de llegada: ____:____ (24h)
 EE 4 Referido/Transferido: ☐ Sí ☐ No ☐ No especificado EE 5 Edad: _____ Años ☐ Meses EE 6 Sexo: ☐ M ☐ F
 EE 7.1 Dirección: _____ EE 7.2 País: _____
 EE 7.3 Provincia/Estado: _____ EE 7.4 Cantón/Municipio: _____ EE 7.5 Ciudad: _____

Pre-Hospitalario

EE 8 Modo de transporte:
☐ Ambulancia terrestre ☐ Auto particular ☐ Transporte en tres ruedas ☐ Transporte público
☐ Ambulancia avión ☐ Bicicleta ☐ Taxi ☐ A pie/caminando
☐ Ambulancia helicóptero ☐ Motocicleta ☐ Policía ☐ Otro

Evento de Lesión

EE 9.1 Fecha del evento: ____/____/____ (dd/mm/aa) EE 9.2 Hora del evento: ____:____ (24h)
 EE 9.3 Lugar del evento
☐ Área administrativa pública ☐ Áreas industriales/construcción ☐ Granja (excluye el hogar) ☐ Laguna, lago, río embalse, pozo
☐ Área comercial/servicio ☐ Calle, carreteras, camino ☐ Hogar (incluye jardín /salida)
☐ Área de servicio médico ☐ Vía / Estación de tren ☐ Institución residencial ☐ Desconocido
☐ Área atlética o de deportes ☐ Escuela, otras instituciones ☐ Tierra abierta, playa, bosque, desierto ☐ Otro
 EE 9.4 Actividad
☐ Deportes ☐ Educación ☐ Tiempo libre/ juego ☐ Trabajo (incluye viaje de trabajo) ☐ Viaje no definido ☐ Desconocido ☐ Otro

Evento de Lesión

Mecanismo primario: ☐ Penetrante ☐ Contuso ☐ Quemadura ☐ Otro

EE 10.1 Lesión de tránsito <input type="checkbox"/> Sí <input type="checkbox"/> No especificado EE 10.4 Grado quemadura <input type="checkbox"/> Primer grado <input type="checkbox"/> Segundo grado <input type="checkbox"/> Tercer grado <input type="checkbox"/> No especificado EE 10.6 Caídas <input type="checkbox"/> Sí <input type="checkbox"/> No especificado EE 10.8 Violencia doméstica <input type="checkbox"/> Sospecha de violencia <input type="checkbox"/> Abuso físico <input type="checkbox"/> Abuso psicológico <input type="checkbox"/> Abuso sexual	EE 10.2 Lesiones arma de fuego <input type="checkbox"/> Pistola / Revolver <input type="checkbox"/> Rifle, escopeta o arma larga <input type="checkbox"/> Arma de fuego no especificada <input type="checkbox"/> Otro EE 10.5 Envenenamiento <input type="checkbox"/> Drogas <input type="checkbox"/> Pesticidas <input type="checkbox"/> Exposición a gases y vapores <input type="checkbox"/> Otras sustancias químicas <input type="checkbox"/> Mordedura / contacto serpiente EE 10.7 Otros mecanismos/intento aparente <input type="checkbox"/> Colgado <input type="checkbox"/> Ahogamiento y sumersión <input type="checkbox"/> Explosión <input type="checkbox"/> Esfuerzo Excesivo <input type="checkbox"/> Fuerzas Naturales <input type="checkbox"/> Golpe por objeto contundente <input type="checkbox"/> Otra fuerza mecánica inanimadas <input type="checkbox"/> Contacto traumático maquinaria/herramientas <input type="checkbox"/> Contusión/aplastamiento/sofocación/obstrucción de vía aérea	EE 10.3 Lesiones arma blanca <input type="checkbox"/> Apuñalado <input type="checkbox"/> Corte/laceraciones <input type="checkbox"/> No especificada <input type="checkbox"/> Mordedura/contacto reptil <input type="checkbox"/> Mordedura/contacto escorpión <input type="checkbox"/> Mordedura/contacto de araña <input type="checkbox"/> No especificado <input type="checkbox"/> Otro <input type="checkbox"/> No especificado <input type="checkbox"/> Mordedura de perro <input type="checkbox"/> Mordedura de otro animal <input type="checkbox"/> Asalto/Homicidio/Intencional <input type="checkbox"/> Auto lesión intencional <input type="checkbox"/> Intento de suicidio <input type="checkbox"/> No Intencional (Accidental) <input type="checkbox"/> Intervención legal por la policía	EE 10.4 Quemadura <input type="checkbox"/> Fuego directo <input type="checkbox"/> Fricción <input type="checkbox"/> Aire caliente/gases <input type="checkbox"/> Sólidos calientes <input type="checkbox"/> Líquidos calientes <input type="checkbox"/> Rayos <input type="checkbox"/> Radiación <input type="checkbox"/> Quemadura por escaldadura <input type="checkbox"/> Quemadura química <input type="checkbox"/> Eléc. voltaje alto <input type="checkbox"/> Eléc. voltaje bajo <input type="checkbox"/> Eléc. no especificado <input type="checkbox"/> Exposición a humo <input type="checkbox"/> No especificado <input type="checkbox"/> Otro
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Evaluación del Paciente en Sala de Emergencia

EE 11 Signos de vida: ☐ Sí ☐ No EE 12 Pulso: _____ EE 13 Presión arterial: _____ / _____
 EE 14 F. Respiratoria: _____ EE 15 Calificador de F. respiratoria* ☐ FR asistida ☐ FR sin asistencia
 (*Pacientes intubados)
 EE 16 Escala de coma de glasgow (ECG)
 EE 16.1 Ocular: ____/4 EE 16.2 Verbal: ____/5 EE 16.3 Motor: ____/6 EE 16.4 ECG Total: ____/15
 EE 16.5 Calificador de escala de coma de glasgow
☐ Paciente con sedación analgesia o paralizante ☐ Paciente intubado
☐ Los ojos del paciente están obstruidos ☐ ECG Válida (ninguno de lo anterior)

Fig. 2A: Trauma registry form

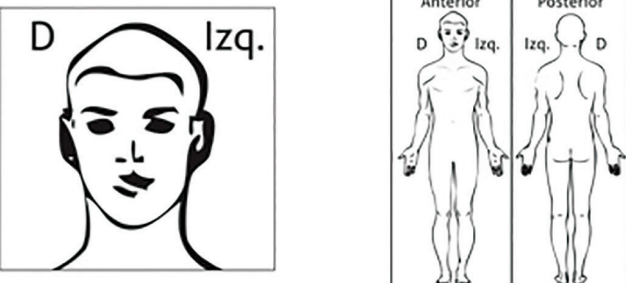
EE 16.6 Puntaje AVDI <input type="checkbox"/> Alerta <input type="checkbox"/> Estimulo verbal <input type="checkbox"/> Provocación de dolor <input type="checkbox"/> Inconsciente		EE 16.7 Sospecha de consumo de bebidas alcohólicas <input type="checkbox"/> Sí <input type="checkbox"/> No <input type="checkbox"/> No especificado	
EE 17.1 Parte del cuerpo lesionado		EE 17.2 Lesión presentada	
Anote: TODAS las lesiones presentadas en su parte del cuerpo correspondiente y datos pertinentes de la historia de enfermedad actual (ej. AMPLIA, pérdida de consciencia)			
Cabeza/Cara: _____ Oídos/Ojos: _____ Cuello: _____ Tórax: _____ Abdomen: _____ Pelvis: _____ Espalda: _____ Genitourinario: _____		Rectal: Tono <input type="checkbox"/> Normal <input type="checkbox"/> Anormal Sangre <input type="checkbox"/> Positivo <input type="checkbox"/> Negativo Vaginal: Sangre <input type="checkbox"/> Positivo <input type="checkbox"/> Negativo	
Extremidades	Pulsos	Sensorial	Motor
MMSS D			
MMSS I			
MMII D			
MMII I			
EE 18 No. de lesiones serias* (*Aquella que requiere hospitalización) <input type="checkbox"/> Ninguna <input type="checkbox"/> 1 lesión seria <input type="checkbox"/> >1 lesión seria A=abrasión L=laceration H=herida F=fractura Q=quemadura			
EE 19 AIS (Escala de Severidad de las Lesiones)			
EE 19.1 Cabeza 1 2 3 4 5 6	EE 19.2 Cara 1 2 3 4 5 6	EE 19.3 Tórax 1 2 3 4 5 6	EE 19.4 Abdomen 1 2 3 4 5 6
		EE 19.5 Extremidades 1 2 3 4 5 6	EE 19.6 Externo 1 2 3 4 5 6
Disposición del paciente de Emergencia y Hospitalización			
EE 20 Disposición/Destino del paciente de sala de emergencia <input type="checkbox"/> Domicilio <input type="checkbox"/> Fallece (Morgue) <input type="checkbox"/> Referido a otro hospital <input type="checkbox"/> Internado <input type="checkbox"/> Desconocido <input type="checkbox"/> Alta solicitada <input type="checkbox"/> Quirófano <input type="checkbox"/> Admitido a la UCI/UTI <input type="checkbox"/> Murió antes de la llegada a hospital <input type="checkbox"/> Otro			
EE 21 Fecha de disposición/Destino: ____/____/____ (dd/mm/aa)		EE 22 Hora de disposición/Destino: ____:____ (24h)	
EE 23 Disposición/Destino del paciente de hospitalización <input type="checkbox"/> Domicilio <input type="checkbox"/> Fallece (Morgue) <input type="checkbox"/> Desconocido <input type="checkbox"/> Transferido a otro hospital <input type="checkbox"/> Alta solicitada <input type="checkbox"/> Otro			
EE 24 Fecha de alta: ____/____/____ (dd/mm/aa)		EE 25 Hora de alta: ____:____ (24h)	
EE 26 Diagnóstico/s: _____			
Pacientes Referidos a otro hospital			
EE 27.1 Hospital que recibe: _____			
EE 27.2 Médico que refiere: _____			
EE 27.3 Fecha de referencia: ____/____/____ (dd/mm/aa)			
EE 27.4 Razón de referencia y comentarios adicionales: _____			
Fecha: ____/____/____ (dd/mm/aa)			
Firma y sello del responsable			

Fig. 2B: Trauma registry form

site leaders and health department officials for questions or troubleshooting throughout the study period, and performed additional training sessions as requested. Monthly to bimonthly stakeholder meetings reviewed interim results and focused on process improvement to remove any perceived barriers, and celebrate and disseminate successful practices between sites.

Data Collection, Management, and Analysis

Emergency department (ED) staff at the five participating facilities prospectively identified and recorded trauma patient information on a paper form (initially plain paper, subsequently transitioned to carbon copy) at the time of the patients' initial presentation. Inclusion criteria were patients of any age or gender who presented to the ED of a participating hospital and were deemed by the medical staff to have a traumatic injury. Mechanisms included any acute physical injury by blunt, penetrating, burn, drowning, poisoning, or other miscellaneous forces. All non-trauma patients were excluded from the study. Methods to verify the capture of eligible patients were chosen by designated site leaders, in order to most effectively function within the existing system and improve compliance. Suggested verification practices included ED registration log comparisons, discussions with on-call physicians, and retrospective analyses of registered patient diagnoses by International Classification of Disease codes. If the patient was discharged from the ED, both copies of the form stayed in the ED for subsequent collection. If the patient was admitted to the hospital, the original form stayed in the ED and the copy was placed in the patient's chart for the final data fields to be completed at the time of hospital discharge.

Designated hospital personnel subsequently transferred data from registry paper forms into a password and firewall protected online platform designed and maintained by the PTS. Abbreviated injury scale (AIS) scores and injury severity scores (ISS) were deferred because of an inability to ensure accurate calculations from a lack of data dictionaries, and a consensus between registry leaders that this step would be a significant barrier to form completion.

Data were exported from the web-based registry platform to Microsoft Excel (Microsoft Excel for Mac 2011, Version 14.4.9 Redmond, WA: Microsoft Corporation) for review and cleaning. Double patient entries were collapsed, and data for select blank fields were extrapolated from similar fields by one author (MAB) to decrease missing data. Stata Statistical Software: Release 13 (STATA 13, College Station, TX: Stata Corp LP) was used for data analysis. Per registry design, multiple specific injury mechanisms and injury type/body part could be selected

per patient, which were summed into categories and analyzed. Categorical variables were assessed using Chi-squared tests, and continuous variables were analyzed by non-parametric methods (Kruskal-Wallis).

RESULTS

Patient and Injury Demographics

From October 2015 through May 2016 a total of $N = 3,220$ patients were entered into the trauma registry. Hospital San Juan de Dios had the most trauma registry records ($N = 903$, 28%), followed by Clínica Foianini ($N = 831$, 26%), and Hospital Universitario Japonés ($N = 585$, 18%) (Table 1). Overall, 64% were male, the median age was 21 years (IQR 6, 37), and nearly all patients were from the city of Santa Cruz de la Sierra (96.7%). Hospital de Niños was an outlier, with a median age of four years (IQR 2, 7), explained by their intended patient population ($p < 0.001$). Hospital transport occurred mainly via private car (37.4%), with most patients presenting on the day of the injury (73.6%) within four hours of the inciting event (52.0%). Most patients at either Hospital Municipal Plan Tres Mil or Clínica Foianini arrived within an hour after the injury event (36.9 and 51.8%, respectively), while patients largely arrived at the additional three facilities more than four hours since being injured (30.7–34.4%, $p < 0.001$). Generally, the busiest time for hospital presentation was between 8:00 and 15:59 (44.2%), followed by 16:00 to 23:59 (37.2%). Most injuries occurred at home (38.5%) or in the street (28.8%), though these proportions differed across hospitals. Fifty-eight-point six percent of patients presenting to Hospital de Niños were injured at home, while those going to Hospital San Juan de Dios were mainly injured in the street (52.4%) ($p < 0.001$). Overall, blunt force trauma was the most common primary mechanism (64.2%). Notably, Hospital Municipal Plan Tres Mil had nearly double the proportion of penetrating trauma as the other hospitals (30.2% *vs.* 11.8–18.5%, $p < 0.001$). Over one-third of patients presenting to Hospital de Niños and Hospital Universitario Japonés were referrals (39.9% and 33.2%, respectively, $p < 0.001$). Additional patient demographic information is provided in Table 2.

The most common specific injury mechanisms ($N = 3,359$) were falls (42.6%), road traffic incidents (13.0%), and dog bites (7.6%) (Fig. 3). Clínica Foianini had the largest proportion of falls at 62.6% of all trauma cases, with a median age of 17 years (IQR 5, 40), while road traffic incidents were highest at Hospital San Juan de Dios at 21.6%. Hospital de Niños reported 23.7% of all injuries as dog bites, where the median age was 6 years (IQR 3, 17), and Hospital Municipal Plan Tres Mil had the biggest share of stabbings at 19.3% of all injured patients.

Table 2: Patient demographics

Characteristic		N = 3,220	%
Sex ^a	Male	2,065	64.1
Age (years) ^{b,c}		21	(6, 37)
Referred/transferred ^d	Yes	673	20.9
Mode of transport	Private car	1,204	37.4
	Taxi	737	22.9
	Ambulance	503	15.6
	Public transport	451	14.0
	On foot	131	4.1
	Other ^e	194	6.0
Location of injury event	Home	1,241	38.5
	Street/avenue	926	28.8
	Athletic area	184	5.7
	Commercial/administrative area	175	5.4
	Other ^f	694	21.6
Primary mechanism ^g	Blunt	2,067	64.2
	Penetrating	506	15.7
	Burn	97	3.0
Time between injury event and hospital presentation (mins) ^{b,h}		119	(42, 540)
Use of alcohol ⁱ	Yes	192	6.0
	No	1,828	56.8
	Unspecified/blank	1,200	37.3

a. Missing data 1.9%

b. Median (IQR)

c. Missing data 6.8%

d. Missing data 9.1%

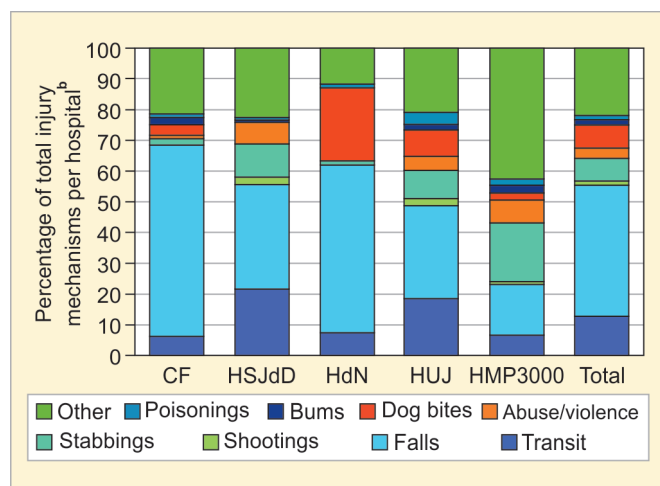
e. Bicycle, motorcycle, police, three-wheeler, other, missing data 2.7%

f. School, body of water, open space (beach, forest, desert), train station, medical service area, industrial/construction area, missing data 9.5%

g. Missing data 17.1%

h. Missing data 17.8%

i. Missing data 29.8%



a. N = 3,359 specific injury mechanisms reported in N = 3,039 (94.4%) patients; N = 181 (5.6%) patients without specific injury mechanism recorded;

b. % of total # mechanisms reported, with the possibility of multiple mechanisms per patient or no response

- Other: Aggression, drowning, hanging, traumatic contact with a machine, contusion/crush, excessive force, explosion, natural forces, suicide, accident, unspecified, other mechanical forces.

- CF: Clínica Foianini, HSJdD: Hospital San Juan de Dios, HdN: Hospital de Niños, HUJ: Hospital Universitario Japonés, HMP3000: Hospital Municipal Plan Tres Mil

Fig. 3: Specific injury mechanisms by hospital^aTable 3: Injury location/type^a

Injury	N = 2,874 ^b	%
Head contusion	383	13.3
Arm/hand contusion	303	10.5
Face contusion	289	10.1
Leg/foot contusion	270	9.4
Arm/hand fracture	231	8.0
Leg/foot fracture	113	3.9
Arm/hand penetrating	97	3.4
Face bite	89	3.1
Face excoriation/laceration	83	2.9
Arm/hand bite	69	2.4

a. Percents are of total number of injury/location types reported, with the possibility of multiple injuries per patient or blank responses

b. N=2,874 injuries in N = 2,471 (76.7%) patients; N = 749 (23.3%) patients without injuries recorded

38.5), and the largest share of total trauma cases being at Hospital Municipal Plan Tres Mil (19.3%). The most common injuries recorded (N = 2,874) included head/face or extremity contusions (43.3%), extremity fractures (12.0%), arm/hand penetrating injuries (3.4%), and facial bite wounds (3.1%) (Table 3).

Disposition from Emergency Department

The majority of patients were discharged home from the ED (62.1%), with the highest percentages at Clínica

There were N = 120 (3.6%) cases of abuse or violence documented across all five hospitals, with a 78.6% male predominance, the median age of 29.5 years (IQR 23.5,

Foianini (80.1%) and Hospital Municipal Plan Tres Mil (80.4%). Eighteen-point-two percent were admitted, either to a general ward (16.4%), intensive care unit (0.60%) or directly to the operating room (1.3%). Hospital San Juan de Dios admitted 38.0% of their trauma patients, the highest percentage. Across all five facilities, $N = 91$ patients (2.8%) were referred to another hospital, with the majority being from Hospital Universitario Japonés ($N = 66$). Seventy-nine patients (2.4%) left against medical advice, mainly from Hospital San Juan de Dios ($N = 57$) (all $p < 0.001$).

Deaths

Six deaths (0.19%) were reported over eight months, one at both Clínica Foianini and Hospital Universitario Japonés, and two at both Hospital Municipal Plan Tres Mil and Hospital San Juan de Dios. The patients' median age was 54 years (IQR 21, 61), 50% were female, and four ($N = 66.7\%$) presented with a Glasgow coma score of 15 (IQR 5, 15). Injuries and mechanisms included one stabbing and dog bite in the leg/foot, three falls, one of which was associated with suffocation/airway obstruction, an additional suffocation/airway obstruction, and one suicide by hanging with neck/spine/back injuries.

DISCUSSION

During the eight-month study period, the five hospitals enrolled in the trauma registry program in Santa Cruz de la Sierra, Bolivia saw significant numbers of injured patients, with variations between facilities in volume, demographics, injury characteristics, and disposition. Overall, a majority were discharged home from the ED, suggesting lower severity, and many injury mechanisms were preventable, emphasizing potential targets for prevention. These results provide the first data on trauma patients seen at major hospitals in this region of Bolivia.

As the largest hospital in the department, Hospital San Juan de Dios predictably registered the highest number of trauma patients, and also had the top ED disposition percentage for admissions at 38%; although the majority of patients (43.3%) were discharged home. Hospital Universitario Japonés had both high patient referral intake (33.2%) and ED referral disposition (11.3%) rates. The former was seen as related to the hospital's location towards the city's periphery, making it accessible for transfers from more rural locations (personal interview, Dr. Jose Carlos Camacho, 2015). The greater number of referrals to other facilities suggests service unavailability, such specialist evaluations. Hospital Municipal Plan Tres Mil, the only second level hospital in the registry program, had the second highest proportion of referrals at 4.8%. As mentioned previously, the Bolivian healthcare system

delegates second level facilities to provide care in basic medical disciplines, including surgery, with referrals as needed for specialists and certain predetermined diagnoses.¹³ Based on the low referral rate from the second level hospital, it would appear these facilities are generally capable of managing most trauma patients that present, enabling the delivery of timely, quality care across greater geographic distances versus relying on third level hospitals that are already functioning over capacity. All of the above highlight the critical importance that the department of health services focus on trauma system development through facility capacity designations, and recognition of trauma patient presentation patterns, to effectively allocate adequate and appropriate resources to effectively care for these patient populations.

According to local physicians, the high proportion of stabbings and violent or abusive incidents recorded at Hospital Municipal Plan Tres Mil is related to the facility's location and patient population. Plan Tres Mil (district 8) on the southeastern periphery of the city was created in the early 1980s as a response to flooding of the Río Pirai and the need to relocate 3200 families to this previously undeveloped, remote area. This community, as well as others outside the fourth ring, is known for its population congestion, inappropriate drainage, inadequate roads, and regular flooding, as well as high concentration of poverty.^{9,11} Corroborating our findings, data from the National Statistics Institute (INE) showed two districts were responsible for 60% of reported cases of violence against women in the city in the first half of 2017, one of which was Plan Tres Mil. Although prevalent alcohol use was mentioned as a risk factor,¹⁷ our data did not show this. However, 29.8% of registry entries did not provide data for whether alcohol was a factor in the injury event. This is likely explained by a lack of routine alcohol level blood testing except when requested by law enforcement, as well as a desire for physicians to not complicate patient insurance coverage should this information become public (personal interviews, local Bolivian physicians, 2015). Hospital de Niños reported a significant number of dog bites at 23.7% of their trauma cases, with the majority (71.7%) of all dog bites recorded in the registry ($N = 230$) occurring in the home. These data were anecdotally supported by commentary from physicians and an epidemiologist working in the hospital. These findings on specific, preventable injury mechanisms, which also include a significant number of falls and road traffic incidents, highlight intervention targets for local officials tasked with improving population health and safety, such as those working in departmental and municipal health services, and public safety, among others.

The registry captured fewer deaths than expected over the eight-month study period. Although no

reliable statistics exist for all trauma mechanisms for comparison, local physician estimates, media coverage, and limited INE statistics on specific injuries indicate higher trauma mortality in Santa Cruz than measured. Based on police data, the INE reported annual deaths from solely road traffic incidents ranging from 144 to 389 for 2011 to 2015 in the department of Santa Cruz,¹⁸ which likely are themselves underestimates. Explanations for our low mortality rate include the common practice of not registering patients who are dead on hospital arrival, challenges with obtaining final dispositions for admitted patients, the limited sample size of five hospitals, and patients dying at the scene of the injury or in-transit. Solutions to the above include incorporating data from the morgue and first responders into the registry, emphasizing the importance of registering all trauma patients in the registry despite arriving deceased, program expansion to additional facilities that receive trauma patients, and increased oversight of longitudinal data collection for admitted patients.

The main limitation of our study is data quality. Entry delays for the paper forms to web-based platform occurred at most facilities. Although Clínica Foianini was the initial pilot study site, they were the only site without electronic records for both April and May. This was thought to be linked to changes in personnel and data entry responsibility. The other sites were typically one month behind, except Hospital San Juan de Dios, which continued to have nearly real-time data entry. This is likely attributable to their system of registry oversight by the epidemiology department, which includes a continual supply of rotating students for form collection and data entry, serving as a potential model for other sites.

A moderate proportion of minimum necessary registry variables lacked responses, limiting the ability for exact analyses and conclusions. Percentages of missing values ranged from 0% (e.g. hospital date of arrival, hospital) to 80.8% (activity when injured). The median percent missing of all required variables was 11.2% (IQR 2.7, 28.6). This calculation does not include the AVPU score, number of serious injuries, nor the time of hospital discharge, as the electronic system was unable to export these values for analysis. Variables with more than 30% missing data were excluded from analysis (activity when injured, time of ED disposition, hospital disposition, date of discharge, final diagnoses). Those with the highest proportion of missing data still used were use of alcohol (N = 960, 29.8%), injury type/location (N = 749, 23.3%), primary injury mechanism (N = 550, 17.1%), and calculated difference between injury time and hospital presentation (N = 573, 17.8%), all of which was disclosed in table footnotes. The inclusion of these data despite

significant proportions missing was justified based on the presumed randomness of omission. Data were explored, which showed those without alcohol use responses nor primary injury mechanism indicated were younger, with the highest percentage missing at Hospital de Niños (40.7 and 44.7% respectively), with no differences by sex. Injury type/location identified Hospital San Juan de Dios as an outlier with 51.7% of patients missing data. Finally, the difference between injury time and hospital presentation was almost universally available at Hospital Municipal Plan Tres Mil (3.2% missing), without notable differences in age or sex overall. These areas are clearly problematic and require a special focus for improved data quality in the future.

The accuracy of information entered also varied, including documentation of appropriate injury mechanism(s), vital signs, and all relevant injury diagnoses, as well as complete capture of eligible trauma patients into the registry. Overall conclusions regarding patient outcomes were limited by a lack of injury severity score. Technical issues with the registry web platform prevented automatic calculation of the Revised Trauma Score, and missing variables plus technical issues with the web platform limited the calculation of the Kampala Trauma Score. The above items continue to be addressed, via a complete redesign of the web registry program, as well as improved registry quality control under the supervision of a hired administrator.

CONCLUSION

This study is the first to describe the diverse injury burden in Santa Cruz de la Sierra, Bolivia. Our results suggest trauma patients arriving at registry-enrolled hospitals frequently are not hospitalized, with many injuries stemming from preventable mechanisms. Moving toward a more complete representation of trauma within the city will include data quality improvement, registry program expansion, and supplementary data source inclusion. Results will inform health system resource planning and preventative strategies, enabling the development of evidence-based interventions that effectively address injury morbidity and mortality reduction in Bolivia.

CLINICAL SIGNIFICANCE

These results begin to quantify and qualify the local injury burden in this region of Bolivia, including between hospital differences, serving as the basis for future public health interventions. These will aim to improve injured patient outcomes through enhanced care quality and to reduce morbidity and mortality via targeted prevention strategies.

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