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ORIGINAL ARTICLE

From a Trauma Center to a Trauma System in Southwest Colombia

De un centro de trauma a un sistema de trauma en el suroccidente colombiano

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Abstract

Introduction. This study aims to evaluate the impact on mortality according to the profile of admission to a trauma center in Southwest Colombia between direct and referred patients, as a method to understand the dynamics of trauma care.

Methods. A sub-analysis of the Panamerican Trauma Society registry associated with a trauma center in Southwest Colombia was performed. Patients seen between 2012-2021 were analyzed. Patients with direct admission and those who were reffered were compared. Analyses of populations of interest such as patients with severe trauma (ISS > 15) and patients with/without brain trauma were made. The impact of referral and admission status on mortality was evaluated.

Results. A total of 10,814 patients were included. The proportion of referred patients was 54.7%. Referred versus directly admitted patients have differences regarding trauma severity and physiological compromise on admission. Referred patients have a higher risk of mortality (RR: 2.81 (95% CI 2.44-3.22). There is a high proportion of penetrating trauma due to gunshot wounds. However, it is the physiological state at the time of admission that impacts mortality.

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Conclusion. Patients referred from other institutions have a higher mortality risk, which is a a health inequity that invites the articulation of institutional actors in trauma care. A trauma center must link with partner institutions to create a trauma system that optimizes care and timeliness.

Keywords: trauma centers; prehospital care; referral and consultation; wounds and injuries; trauma severity score; advanced trauma life support care.

Resumen

Introducción. El objetivo de este estudio fue evaluar el impacto sobre la mortalidad según el perfil de ingreso a un centro de trauma del suroccidente colombiano, como método para entender las dinámicas de atención del paciente con trauma.

Métodos. Se realizó un subanálisis del registro de la Sociedad Panamericana de Trauma asociado a un centro de trauma en el suroccidente colombiano. Se analizaron los pacientes atendidos entre los años 2012 y 2021. Se compararon los pacientes con condición de ingreso directo y aquellos que ingresaron remitidos. Se hicieron análisis de poblaciones de interés como pacientes con trauma severo (ISS > 15) y pacientes con/sin trauma craneoencefálico. Se evaluó el impacto de los pacientes remitidos y su condición al ingreso sobre la mortalidad.

Resultados. Se incluyeron 10.814 pacientes. La proporción de pacientes remitidos fue del 54,7 %. Los pacientes que ingresaron remitidos presentaron diferencias respecto a la severidad del trauma y compromiso fisiológico del ingreso comparado con los pacientes con ingreso directo. Los pacientes remitidos tienen mayor riesgo de mortalidad (RR: 2,81; $IC_{95\%}$ 2,44-3,22); sin embargo, es el estado fisiológico al ingreso lo que impacta en la mortalidad.

Conclusión. Los pacientes remitidos de otras instituciones tienen un mayor riesgo de mortalidad, siendo una inequidad en salud que invita a la articulación de actores institucionales en la atención de trauma. Un centro de trauma debe relacionarse con las instituciones asociadas para crear un sistema de trauma que optimice la atención de los pacientes y la oportunidad.

Palabras Clave: centros de trauma; atención prehospitalaria; derivación y consulta; heridas y traumatismos; índices de gravedad del trauma; atención de apoyo vital avanzado en trauma.

Introduction

Trauma is a considerable cause of potentially preventable morbidity and mortality, especially in the young and adult population. The burden of trauma and disability it generates has implications for society through the loss of economic potential [1,2]. The dynamics associated with trauma are different in each population: in developed countries the main causes of trauma are traffic accidents and falls [3,4]. The trauma care response in these countries has focused on prevention and the creation of management pathways that integrate the prehospital and hospital network [5].

The organization of a multi-institutional team that coordinates trauma care efforts in a specific geographic area is called a "trauma system" [6]. The implementation of trauma systems has a positive effect in reducing mortality, with strategies of prehospital care and the organization of the intrahospital response [7,8]. These efforts should be led by a trauma center, which is an institution that has the human and technological resources to provide comprehensive care.

However, these concepts present challenges in their interpretation, applicability and possible implementation in the Latin American context. Developing countries have barriers to information on their epidemiological profile, because the clinical spectrum, severity of the trauma, management and outcomes are unknown [9]. For this reason, global surgery proposals mention that the first gap to close is recognizing the epidemiological

profile of the region [10]. To date there is experience in the creation of trauma registries in Honduras, Ecuador, Brazil, Bolivia, and Colombia. It is noteworthy that these experiences have in common a significant proportion of traumatized patients due to physical assaults secondary to violence [11–15]. To date there is experience in the creation of trauma registries in Honduras, Ecuador, Brazil, Bolivia, and Colombia. Coincide with the report of the Panamerican Health Organization where the region of the Americas is the region with the highest homicide rate in the world (19.19 per 100,000 inhabitants in 2019), a value that is three times higher than the global average [16].

So what should be the next step in the implementation of a trauma system for Latin America? Trauma registries have provided information on the epidemiological profile of patients, but even this tool lacks a connection between the institution and its geographical area of influence. However, the search for a connection between this collected information and a diagnosis of the context involved requires generating a different analysis model.

The first point in articulating a trauma system is to recognize the role of prehospital care. Prehospital care derived from less complex centers can be a window to recognize the profile of the patients who are treated and their differences [17,18]. The hypothesis of this study was to analyze patients by their type of admission, dividing them between those referred and those who have a direct admission, can be a model to identify inequities in the profile of patients treated and recognize the area of influence of a trauma center. This analysis model could serve as a basis to identify the opportunity and the actors of a trauma system in a Latin American context. The objective of this study was to evaluate the impact of the profile of admission to a trauma center in Southwest Colombia on the mortality of patients with trauma.

Methods

Study design

A sub-analysis of the Panamerican Trauma Society registry associated with Fundación Valle del Lili (PTS-FVL) in Cali, Colombia was performed [19]. This institution is a complexity-level IV center that has 680 beds, distributed in 455 beds for hospitalization, 129 beds for adult intensive care, 30 for pediatric intensive care, 25 for intermediate intensive care, and 41 for neonates intensive care.

The Fundación Valle del Lili has established itself as a reference center in trauma care, achieving the operating standards of a level I trauma center. These include 24-hour coverage from a group of surgeons specialized in trauma and emergency management, along with the possibility of other other medical services such as emergency care, intensive care, and hospitalization. It is also a national and international educational reference centrer for general surgery residents general surgery residents and complements the training of surgeons in the trauma and emergency surgery subspecialty at the Universidad del Valle. This center cares for approximately 1,000 patients per year with moderate to severe trauma.

Participants

The sub-analysis included information collected by the PTS-FVL trauma registry from patients seen between January 1, 2012 and December 31, 2021. The registry collects information from patients diagnosed with trauma according to the ICD- 10 (S001 to S999), which required an observation period greater than 6 hours or hospitalization, including the deceased.

Variables

The PTS-FVL trauma registry collects sociodemographic, prehospital information, injury mechanisms, trauma severity using the Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS), admission status, hospitalization care, intraoperative information, clinical results, disposition and mortality. In total, it collects 244 variables for each patient included in the registry.

For the present sub-analysis, the following variables of interest were included: age, gender, admission condition (referred admission or direct admission to the institution), referred place of trauma (city), mechanism of trauma, type of associated trauma (traffic accident , fall, gunshot

wound or stab wound), severity of trauma by ISS and AIS of anatomical regions of head, thorax, abdomen and extremities, vital signs on admission, requirement of surgical procedures such as thoracotomy, laparotomy and orthopedic reduction, and intensive care requirement. In-hospital mortality was taken into account as a clinical outcome of interest.

Statistical analysis

The description of the information was made for the categorical variables as absolute frequency and relative frequency, while the continuous variables were described with median and interquartile ranges. For the comparison between continuous variables with a normal distribution, the student's t-test was used, otherwise the Mann-Whitney U test was used. Categorical variables were compared using chi-square or Fisher's exact tests.

The analysis is based on a comparison of the database between patients who were directly admitted to the institution and those who were referred from other institutions. Subgroups of interest such as severe trauma patients (defined as those with an ISS > 15) and moderate to severe head trauma patients (defined as those with a head AIS ≥ 3) were described. The relative risk (RR) and its 95% confidence interval were calculated for the primary outcome. An adjustment was made using robust Poisson regression-type random effects models for the year of admission variable.

Identification of the area of influence, defined as the place of origin of the referrals, was made by crossing the report of the place with the geographic coordinates by municipalities of the DIVIPOLA portal of the National Administrative Department of Statistics (*Departamento Nacional de Estadística*, DANE) [20]. Maps were built using the Google maps base through the QGIS Version 3.10 program. The four places with the highest frequency of referred patients were described.

Lastly, taking into account that there is no detailed information on prehospital care, such as transfer time and maneuvers performed, the conditions of trauma patients at the time of admission were analyzed, regarding age, type of trauma, severity of trauma, presence of hypotension and the condition of remission. Due to the differences detected in the populations of interest, the study populations were matched through a propensity score matching with respect to age, gender, mechanism of trauma, severity of trauma, and Revised Trauma Score (RTS) [21]. This technique makes it possible to match the groups in order to make comparisons of interest. The purpose of this approach is to reduce the bias of confounding variables not associated with the collected information that could have a significant effect on admission status and mortality outcome [22].

Cases and controls had a ratio of 1:1, the matching method between the cases was "nearest neighbor matching", with a calibration measure allowed of 0.05. Three study groups were created taking into account the following populations of interest: patients with severe trauma, patients with or without head trauma. This is because the number of cases by severity of trauma and head injury have a ratio that generated errors in the estimation of the matched groups. Robust Poisson regression multivariate mixed-effects models were built, with a RR effect measure and its 95% confidence intervals, evaluating age (as continuous, for every 10 years), penetrating trauma mechanism, trauma severity by ISS score (as continuous, per 10 points), admission hypotension (systolic blood pressure less than 90 mmHg), admission tachycardia (heart rate greater than 120 bpm), and referral status. Neurological status was not included in the model since 90% of the deceased had a Glasgow coma scale less than or equal to 13 and were collinear with the outcome of interest. These models were calculated with the aim of analyzing the impact of admission conditions with respect to referred patients.

The calculations performed in this study were performed using R Language Version 4.1.0 and STATA Version 14 [23]. All p values were calculated two-tailed, and the significance level was defined as $p < 0.05$.

Results

Description of study population and interest groups

A total of 10,814 patients were cared for between 2012 and 2021. The median proportion of admitted patients referred per year was 54.7% (IQR: 46.7-60.2) (Figure 1). The raw data between the population that was admitted referred versus those that were admitted directly to the institution were different in their sociodemographic characteristics, admission, trauma severity, and clinical outcomes. Penetrating trauma was higher in the group of referred patients (46.9% vs 24.4%) and 33.2% of the referred patients received a gunshot wound, as opposed to the direct admission group, among which 11.4% received a gunshot wound (Table 1).

According to the analysis of the populations of interest, among the patients who were admitted with severe trauma (ISS > 15), the group of those referred had a higher proportion of penetrating trauma and a tendency to more severe trauma. The distribution of thoracic, abdominal and extremity trauma was similar between the two groups; however, the referred group presented a greater number of patients with compromised neurological status (Glasgow Coma Scale < 8) 51% vs 36% (Table 2).

In the subgroup of patients with moderate to severe head injury, the referral group presented gunshot wounds in 33% of the cases and the distribution by anatomical areas was similar (Table 3). The proportion of patients who presented hypotension or tachycardia on admission was not different between the groups; however, severe neurological compromise was present in 62% of the patients referred vs 38% of the patients who were admitted directly. Likewise, the severity by anatomical area was higher in the group of those referred (AIS Thorax ≥ 3: 29% vs 10%; AIS Abdomen ≥ 3: 19% vs 6.5%) (Table 4).

Estimated risk of patients who were admitted referred regarding mortality

The collected data identified that the patients who were admitted referred were associated with a higher mortality. In the general population, the referred patients had an RR of 2.81 (95%CI 2.44-3.22) and adjusted for the year of care an RR of 2.72 (95%CI 2.14-3.45). This trend of higher mortality risk was also present in the study subpopulations (Table 5).

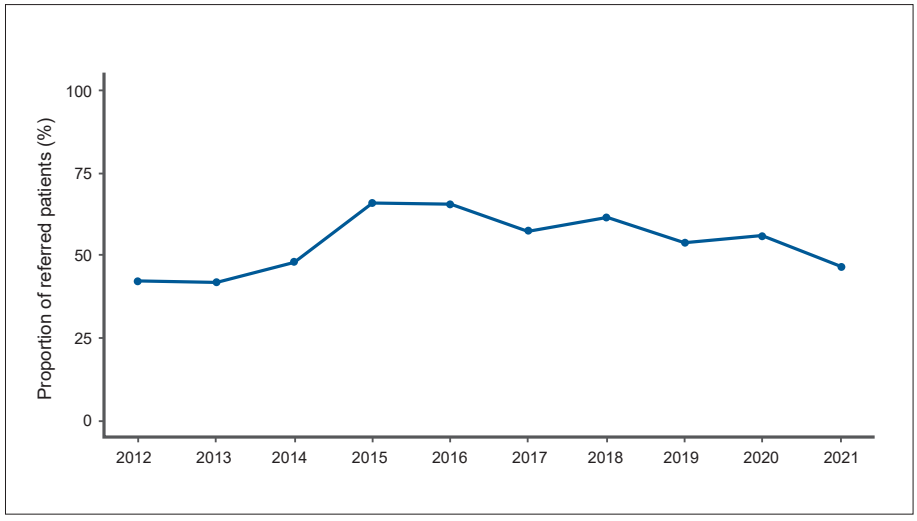

Figure 1. Annual proportion of patients referred with diagnoses of trauma between January 1, 2012 and December 31, 2021. Fundación Valle del Lili, Cali, Colombia. Own source.

Table 1. Baseline characteristics of patients diagnosed with trauma according to the ICD-10 who were admitted between January 1, 2012 and December 31, 2021. Fundación Valle del Lili, Cali, Colombia.

Variable	Direct admission (n=5076)	Referred admission (n=5738)
Age, median (IQR)	35 (23-55)	27 (20-41)
Male, n/total (%)	3338/4712 (70.8)	4598/5659 (81.2)
Mechanism of trauma, n/total (%)		
Blunt	3539/4751 (74.4)	2924/5576 (52.4)
Penetrating	1160/4751 (24.4)	2618/5576 (46.9)
Burns	52/4751 (1.1)	34/5576 (0.6)
Type of blunt trauma, n/total (%)		
Motor vehicle collision*	1410/5076 (27.7)	1906/5738 (33.2)
Fall	1793/5076 (35.3)	865/5738 (15.1)
Type of penetrating trauma, n/total (%)		
GSW, n/total (%)	579/5076 (11.4)	1910/5738 (33.2)
SW, n/total (%)	354/5076 (6.9)	547/5738 (9.5)
Injury severity Score, median (IQR)	6 (4-10)	12 (9-22)
ISS categorization, n/total (%)		
Mild (ISS < 8)	2591/4834 (53.6)	1354/5711 (23.7)
Moderate (ISS 9-15)	1424/4834 (29.4)	1946/5711 (34.0)
Severe (ISS 16-25)	577/4834 (11.9)	1532/5711 (26.8)
Grave (ISS >= 26)	242/4834 (5.01)	879/5711 (15.4)
Head AIS > 3, n/total (%)	699/4838 (14.4)	1967/5711 (34.4)
Thorax AIS > 3, n /total (%) *	578/4834 (11.9)	1498/5711 (26.2)
Abdomen AIS > 3, n/total (%) *	323/4834 (6.6)	816/5712 (14.2)
Extremities AIS > 3, n/total (%) *	896/4836 (18.5)	997/5714 (17.5)
Vital signs on admission		
Heart rate, median (IQR)	86 (75-100)	92 (78-110)
HR > 120 bpm, n/total (%) *	431/4848 (8.8)	955/5713 (16.7)
Systolic blood pressure, median (IQR)	124 (109-138)	117 (100-133)
SBP < 90 mmHg, n/total (%) *	409/4836 (8.4)	971/5694 (17.1)
Glasgow Coma Scale, median (IQR)	15 (15-15)	15 (7-15)
Glasgow Coma Scale < 8, n/total (%)	374/4839 (7.7)	1648/5638 (29.2)
Surgical procedures, n /total (%)		
Thoracotomy, n/total (%)	83/5076 (1.6)	237/5738 (4.1)
Laparotomy, n/total (%)	222/5076 (4.3)	629/5738 (10.9)
Orthopedic reduction, n/total (%)	2069/5076 (40.7)	1371/5738 (23.8)
ICU requirement, n/total (%)	1058/5076 (20.8)	3101/5738 (54.0)
In-hospital mortality, n/total (%)	248/5076 (4.8)	788/5738 (13.7)

SW: Stab wound; AIS: Abbreviated Injury Scale; HR: Heart rate; GSW: Gunshot Wound; ISS: Injury Severity Score; SBP: Systolic blood pressure; IQR: Interquartile range; ICU: Intensive Care Unit.

All comparisons in this table were statistically significant with $p<0.05$. Source: Data taken from the PTS-FVL Trauma Registry.

Table 2. Baseline characteristics of patients with severe trauma (ISS > 15) by type of admission.

Variable	Direct admission (n=819)	Referred admission (n=2411)
Age, median (IQR)	33 (24-49)	27 (21-39)
Male, n/total (%)	655/786 (83)	2056/2379 (86)
Mechanism of trauma, n/total (%)		
Blunt	451/804 (56)	1111/2372 (47)
Penetrating	346/804 (43)	1252/2372 (53)
Burns	7/804 (1)	9/2372 (1)
Typo of blunt trauma, n/total (%)		
Motor vehicle collision*	301/819 (37)	910/2411 (38)
Fall	141/819 (17)	173/2411 (7.2)
Type of penetrating trauma, n/total (%)		
GSW	272/819 (33)	1067/2411 (44)
SW	52/819 (6.3)	163/2411 (6.8)
Injury Severity Score, median (IQR)	22 (17-27)	25 (18-29)
Head AIS > 3, n/total (%)	433/819 (53)	1416/2411 (59)
Thorax AIS > 3, n /total (%)*	373 (46)	1049/2411 (44)
Admonen AIS > 3, n/total (%)*	218/819 (27)	619/2411 (26)
Extremities AIS > 3, n/total (%)*	163/819 (20)	419/2411 (17)
Vital signs on admission		
HR > 120 bpm, n/total (%) *	166/819 (20)	547/2411 (23)
SBP < 90 mmHg, n/total (%) *	237/819 (29)	672/2411 (28)
Glasgow Coma Scale < 8, n/total (%)	301/819 (36)	1226/2411 (51)
ICU requirement, n/total (%)	515/819 (63)	1909/2411 (79)
In-hospital mortality, n/total (%)	215/819(26)	755/2411(31)

SW: Stab wound; AIS: Abbreviated Injury Scale; HR: Heart rate; GSW: Gunshot Wound; ISS: Injury Severity Score; SBP: Systolic blood pressure; IQR: Interquartile range; ICU: Intensive Care Unit.

* Variables that were not significant in their comparison. The other variables had a statistically significant difference with p<0.05. Source: Data taken from the PTS-FVL Trauma Registry.

Geographic area of influence and main places of referral

Regarding the places of referral, it was identified that the area of influence of the FVL covers the south of Valle del Cauca and part of the North of the Department of Cauca (Figure 2). The first four sources of referrals were other institutions within the city of Santiago de Cali, Jamundí (Valle del Cauca), Santander de Quilichao (Cauca), and Puerto Tejada (Cauca).

In the description of the type of trauma according to the place of referral, a significant proportion of traffic accidents originating from Jamundí and Santander de Quilichao (around 40%) and a higher percentage of physical aggressions as a result of injuries by gunshot were identified in patients

Table 3. Baseline characteristics of patients with moderate to severe head injury (Head AIS ≥ 3) by type of admission.

Variable	Direct admission (n=699)	Referred admission (n=1967)
Age, median (IQR)	33 (22-57)	28 (20-41)
Male, n/total (%)	522/675 (77)	1631/1935 (84)
Mechanism of trauma, n/total (%)		
Blunt	533/680 (78)	1228/1931 (63)
Penetrating	146/680 (21)	703/1931 (36)
Burns	1/680 (0.1)	5/1931 (0.3)
Type of blunt trauma, n/total (%)		
Motor vehicle collision	291/699 (42)	937/1967 (48)
Fall	228/699 (33)	258/1967 (13)
Type of penetrating trauma, n/total (%)		
GSW	115/699 (16)	640/1967 (33)
SW	25/699 (3.6)	58/1967 (2.9)
Injury severity Score, median (IQR)	17 (10-25)	21 (13-27)
Head AIS > 3, n/total (%)	138/699 (20)	399/1967 (20)
Thorax AIS > 3, n /total (%)*	37/699 (5.3)	118/1967 (6)
Abdomen AIS > 3, n/total (%)*	55/699 (7.9)	163/1967 (8.3)
Extremities AIS > 3, n/total (%)*	109/699 (16)	365/1967 (19)
Vital signs on admission		
HR > 120 bpm, n/total (%)	117/699 (17)	379/1967 (19)
SBP < 90 mmHg, n/total (%) *	267/699 (38)	1221/1967 (62)
Glasgow Coma Scale < 8, n/total (%)	442/699 (63)	1559/1967 (79)
ICU requirement, n/total (%)	168/699 (24)	669/1967 (34)

SW: Sta wound; AIS: Abbreviated Injury Scale; HR: Heart rate; GSW: Gunshot Wound; ISS: Injury Severity Score; SBP: Systolic blood pressure; IQR: Interquartile Range; ICU: Intensive Care Unit.

* Variables that were not significant in their comparison. The other variables had a statistically significant difference with $p<0.05$. Source: Data taken from the PTS-FVL Trauma Registry.

Table 4. Baseline characteristics of patients without moderate to severe head injury (Head AIS < 3) by type of admission.

Variable	Direct admission (n=4377)	Referred admission (n=3771)
Age, median (IQR)	35 (23-55)	27 (20-41)
Male, n/total (%)	2816/4037 (70)	2967/3724 (80)
Mechanism of trauma, n/total (%)		
Blunt	3006/4071 (74)	1696/3640 (47)
Penetrating	1014/4071 (25)	1915/3640 (53)
Burns	51/4071 (1.3)	29/3640 (0.8)
Type of blunt trauma, n/total (%)		
Motor vehicle collision	1119/4377 (26)	969/3771 (26)
Fall	1565/4377 (36)	607/3771 (16)
Type of penetrating trauma, n/total (%)		
GSW	464/4377 (11)	1270/3771 (34)
SW	329/4377 (7.5)	489/3771 (13)

Table 4 Continued

Variable	Direct admission (n=4377)	Referred admission (n=3771)
Injury severity Score, median (IQR)	5 (4-9)	9 (5-16)
Head AIS > 3, n/total (%)	440/4377 (10)	1099/3771 (29)
Thorax AIS > 3, n /total (%)*	286/4377 (6.5)	698/3771 (19)
Abdomen AIS > 3, n/total (%)*	841/4377 (19)	834/3771 (22)
Extremities AIS > 3, n/total (%)*	322/4377 (7.4)	590/3771 (16)
Vital signs on admission		
HR > 120 bpm, n/total (%)	292/4377 (6.7)	592/3771 (16)
SBP < 90 mmHg, n/total (%) *	107/4377 (2.4)	427/3771 (11)
Glasgow Coma Scale < 8, n/total (%)	616/4377 (14)	1542/3771 (41)
ICU requirement, n/total (%)	80/4377 (1.8)	119/3771 (3.2)
In-hospital mortality, n/total (%)	80/4377 (1.8)	119/3771 (3.2)

SW: Stab wound; AIS: Abbreviated Injury Scale; HR: Heart rate; Gunshot Wound; ISS: Injury Severity Score; SBP: Systolic blood pressure; IQR: Interquartile range; ICU: Intensive Care Unit.

* Variables that were not significant in their comparison. The other variables had a statistically significant difference with p<0.05. Source: Data taken from the PTS-FVL Trauma Registry.

referred from Puerto Tejada (53.5%) compared to the rest of the cities (approximately 30%) (Table 6). There was a trend towards higher mortality (8%) in patients who were admitted referred compared to those who were admitted directly (4.8%).

Effect of the conditions of admission to FVL regarding mortality

Three databases were built where the groups of patients with direct admission and referred admission were balanced with propensity score matching. Characteristics for each subpopulation of interest, such as severe trauma, with head injury, and without head injury, are described in Tables 7, 8, and 9.

Multivariate models were also created from these subgroups to assess the impact of admission conditions on patient mortality, with respect to admission condition (Tables 10, 11, and 12). In the groups of patients with severe trauma (ISS>15) and without brain injury, it was identified that age, severity of trauma, and the presence of hypotension on admission were associated with a higher risk of mortality. In the group of patients with moderate to severe head trauma, the factors associated with mortality were age, penetrating trauma, severity of trauma, and hypotension on admission. In these analyses, admission status for remission was not identified as a risk factor for mortality.

Discussion

The connection of a trauma center with its environment and the actors involved in the managment of trauma patients allows for the recognition of problems . These connections have been established as invisible barriers in health care, which translate into health inequities, so they must be identified to generate solutions that articulate the institutions involved in a potential Trauma system [24].

The approach presented in this article seeks to describe in detail the patients who are admitted directly to our institution and those who are referred, conditions that differentiate the care of a trauma center from the rest of the hospitals in the area of influence in southwestern Colombia. We identified that there are two totally different population groups: the referred patients are a

Table 5. Univariate analysis between the condition of admission remitted and mortality.

Study populations	Direct admission	Referred admission	Unadjusted*		Adjusted**	
			RR (95% CI)	p	RR (95% CI)	p
General, n/total (%)	248/5076 (4.8)	788/5738 (13.7)	2,81 (2.44-3.22)	<0.001	2.72 (2.14-3.45)	<0.001
Severe trauma (ISS > 15), n/total (%)	215/819 (26.2)	755/2411 (31.3)	1,19 (1.04-1.35)	0.006	1.21 (1.00-1.47)	0.05
With traumatic brain injury, n/total (%)	168/699 (24.0)	669/1967 (34.0)	1,41 (1.22-1.63)	<0.001	1.42 (1.10-1.83)	0.006
Without traumatic brain injury, n/total (%)	80/4377 (1.8)	119/3771 (3.1)	1,72 (1.30-2.28)	<0.001	1.71 (1.25-2.35)	0.001

RR: Relative risk. * Unadjusted: Refers to the estimation of the relative risk by calculating 2x2 tables. **Adjusted: Refers to the calculation of the univariate relative risk corrected by a mixed-effects model of the robust Poisson regression type, with a random variable as the year of admission. Source: Data taken from the PTS-FVL Trauma Registry.

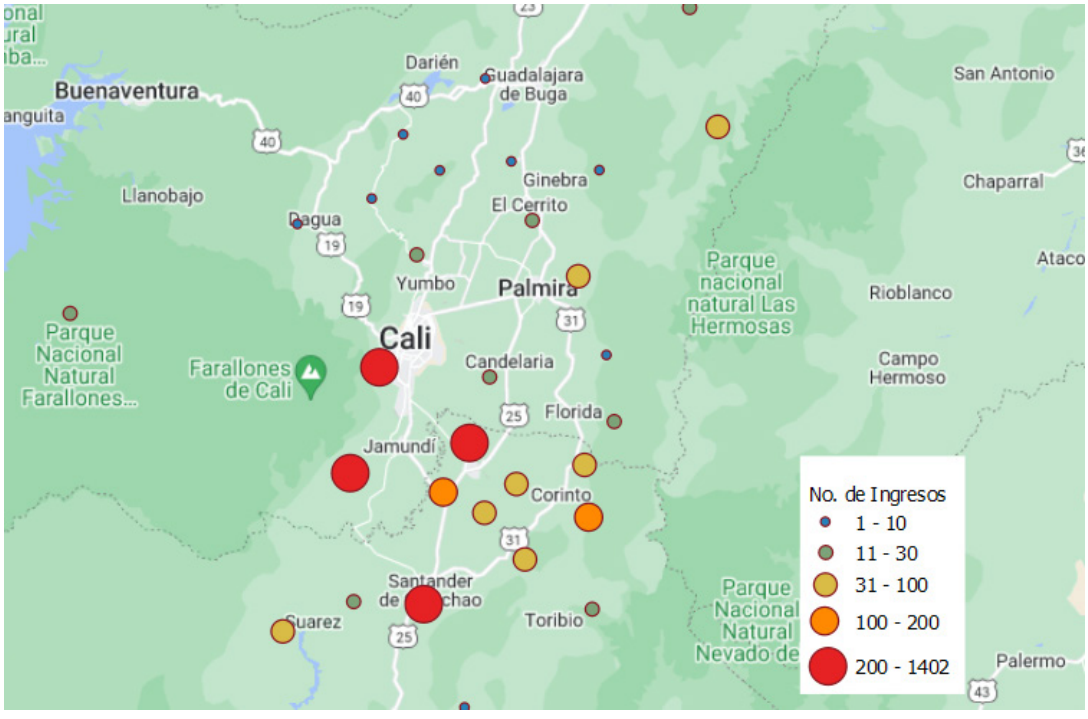

Figure 2. Geographical area of influence of Fundación Valle del Lili on the South of Valle del Cauca and North of Cauca, Colombia. Sources: Map base taken from Google Maps, built on QGIS 3.0. and data on the Number of Admissions taken from the PTS-FVL Trauma Registry.

Table 6. Characteristics of trauma mechanisms, admission conditions, and mortality of patients according to the four places with the highest proportion of referrals to FVL.

	Direct admission	Referred admission			
		Cali	Jamundí	Santander de Quilichao	Puerto Tejada
n	5076	1402	359	316	278
Transfer distance (km)	N/A	N/A	14	45	25
Estimated transportation time (min)	N/A	N/A	23	53	34
ISS > 15, n (%)	819 (16.1)	442 (31.5)	147 (40.9)	142 (44.9)	94 (33.8)
GSW, n (%)	579 (11.4)	504 (35.9)	115 (32.0)	87 (27.5)	149 (53.5)
Motor vehicle collision, n (%)	1410 (27.7)	258 (18.4)	161 (44.8)	156 (49.3)	82 (29.4)
SBP ≤ 90 mmHg al ingreso, n (%)	409 (8.1)	202 (14.4)	59 (16.3)	58 (18.3)	42 (15.1)
Glasgow Coma Scale ≤ 8 on admission, n (%)	374 (7.3)	297 (21.1)	99 (27.5)	158 (50)	46 (16.5)
In-hospital mortality, n (%)	248 (4.8)	115 (8.2)	37 (10.7)	37 (11.7)	22 (7.9)

GSW: Gunshot wound; ISS: Injury Severity Score; N/A: Not applicable; SBP: Systolic blood pressure. Source: Data taken from the PTS-FVL Trauma Registry.

Table 7. Propensity score matching of patients with severe trauma (ISS > 15).

Variable	Direct admission (n=694)	Referred admission (n=694)
Age, median (IQR)	32 (23-48)	32 (23-48)
Male, n (%)	583 (84)	583 (84)
Penetrating trauma, n (%)	290 (42)	290 (42)
Fall, n (%)	119 (17)	63 (9,1)
Motor vehicle collision, n (%)	260 (37)	317 (46)
ISS, median (IQR)	21 (17-27)	25 (18-29)
Heart rate > 120 on admission, n (%)	151 (22)	154 (22)
Systolic blood pressure < 90 mmHg on admission, n (%)	186 (27)	165 (24)
Glasgow Coma Scale < 8 on admission, n (%)	237 (34)	324 (47)
RTS, median (IQR)	6.9 (5.0-7.8)	6.3 (4.1-7.8)
In-hospital mortality, n (%)	177 (26)	187 (27)

ISS: Injury Severity Score; RTS: Revised Trauma Score; IQR: Interquartile range. Source: Data taken from the PTS-FVL Trauma Registry.

Table 8. Propensity score matching of patients with moderate to severe head trauma (AIS Head ≥ 3).

Variable	Direct admission (n=573)	Referred admission (n=573)
Age, median (IQR)	31 (21-52)	34 (24-56)
Male, n (%)	457 (80)	448 (78)
Penetrating trauma, n (%)	118 (21)	131 (23)
Fall, n (%)	173 (30)	111 (19)
Motor vehicle collision, n (%)	255 (45)	317 (55)
ISS, median (IQR)	17 (10-25)	19 (13-26)
Heart rate > 120 on admission, n (%)	92 (16)	92 (16)
Systolic blood pressure < 90 mmHg on admission, n (%)	86 (15)	84 (15)
Glasgow Coma Scale < 8 on admission, n (%)	219 (38)	285 (50)
RTS, median (IQR)	6.9 (5.0-7.8)	5.9 (5.0-7.8)
In-hospital mortality, n (%)	138 (24)	163 (28)

ISS: Injury Severity Score; RTS: Revised Trauma Score; IQR: Interquartile range. Source: Data taken from the PTS-FVL Trauma Registry.

Table 9. Propensity score matching of patients without traumatic brain injury.

Variable	Direct admission (n=694)	Referred admission (n=694)
Age, median (IQR)	30 (21-48)	29 (19-47)
Male, n (%)	1796 (76)	1761 (75)
Penetrating trauma, n (%)	934 (40)	854 (37)
Fall, n (%)	689 (30)	558 (24)
Motor vehicle collision, n (%)	545 (23)	753 (32)
ISS, median (IQR)	8 (4-10)	9 (4-10)
Heart rate > 120 on admission, n (%)	256 (11)	287 (12)
Systolic blood pressure < 90 mmHg on admission, n (%)	225 (9.6)	227 (9.7)
Glasgow Coma Scale < 8 on admission, n (%)	68 (2.9)	166 (7.1)
RTS, median (IQR)	7.84 (7.8-7.8)	7.84 (7.8-7.8)
In-hospital mortality, n (%)	49 (2.1)	39 (1.7)

ISS: Injury Severity Score; RTS: Revised Trauma Score; IQR: Interquartile range. Source: Data taken from the PTS-FVL Trauma Registry.

Table 10. Multivariate analysis for in-hospital mortality for the group of patients with severe trauma (ISS > 15) matched by propensity score matching.

Variable	RR (95% CI)	p
Age per 10 years	1.13 (1.09-1.18)	<0.001
Penetrating trauma	1.11 (0.85-1.44)	0.42
ISS for every 10 points	1.43 (1.34-1.52)	<0.001
Heart rate > 120 on admission	1.16 (0.95-1.41)	0.13
Systolic blood pressure < 90 mmHg on admission	1.52 (1.27-1.81)	<0.001
Referred admission	1.05 (0.84-1.33)	0.49

ISS: Injury Severity Score. Source: Data taken from the PTS-FVL Trauma Registry.

Table 11. Multivariate analysis for in-hospital mortality for the group of patients with head trauma (Head AIS ≥ 3) matched by propensity score matching.

Variable	RR (95% CI)	p
Age per 10 years	1.13 (1.09-1.18)	<0.001
Penetrating trauma	1.11 (0.85-1.44)	0.42
ISS for every 10 points	1.43 (1.34-1.52)	<0.001
Heart rate > 120 on admission	1.16 (0.95-1.41)	0.13
Systolic blood pressure < 90 mmHg on admission	1.52 (1.27-1.81)	<0.001
Referred admission	1.05 (0.84-1.33)	0.49

ISS: Injury Severity Score. Source: Data taken from the PTS-FVL Trauma Registry.

Table 12. Multivariate analysis for in-hospital mortality for the group of patients without head trauma matched by propensity score matching.

Variable	RR (95% CI)	p
Age per 10 years	1.13 (1.09-1.18)	<0.001
Penetrating trauma	1.11 (0.85-1.44)	0.42
ISS for every 10 points	1.43 (1.34-1.52)	<0.001
Heart rate > 120 on admission	1.16 (0.95-1.41)	0.13
Systolic blood pressure < 90 mmHg on admission	1.52 (1.27-1.81)	<0.001
Referred admission	1.05 (0.84-1.33)	0.49

ISS: Injury Severity Score. Source: Data taken from the PTS-FVL Trauma Registry.

group with a higher proportion of injuries due to penetrating trauma mechanism, greater severity of trauma, and greater physiological compromise upon admission.

In the univariate analysis of referred patients, mortality could have an increased risk, in some cases greater than 100%, compared to patients who had a direct admission. This risk persists despite performing analyzes in subgroups of interest, such as those with severe trauma or head trauma. Despite the fact that this risk factor exists statistically, it is a factor that should set off red flags since it is preventable and is an indicator of inequities in trauma care.

The analysis of the patients who are referred and their risk of mortality raises questions about the confounding variables that contribute to this health inequity. Although the analysis of the area of influence of the trauma center identified that in the main places of referral, the transfer by land transportation does not exceed more than 60 minutes, it is unknown what factors are associated with the initial care, initial resuscitation maneuvers, transfer factors and the total time in care meaning that patients arrive with a greater physiological compromise as a result of the trauma. Transfer time and initial resuscitation maneuvers are variables that have an impact on the survival of trauma patients [25].

Referred patients have a high proportion of injuries with penetrating mechanism compared to patients with direct admissions. Jamundí and Santander de Quilichao are two cities located on the Panamerican Highway, with a high accident rate, which may explain the greater influx of patients referred for traffic accidents, among whom mortality was almost double compared to that reported in patients with the same mechanism of trauma who were admitted directly to the FVL.

By analyzing in detail the factors that could explain the mortality of this group of patients, an attempt was made to match the groups of interest using the propensity score matching technique to achieve equality between the groups. It was identified that variables at the time of admission such as hypotension, severity of trauma and age are factors that have a greater risk for mortality [26,27]. This finding does not contradict the risk of referred patients, but rather it is recognized that it is the state in which patients arrive that makes the difference in care.

Proposals for the implementation of a trauma system state that the first strategies for its implementation should be related to the articulation of prehospital care, education, and teams specialized in trauma care [5,14]. In the United States, there are organized systems that document and systematize information related to care [28]; however, many Latin American countries, including Colombia, lack this inter-institutional culture. This is why it is difficult to make adequate diagnoses in the sectors associated with the management of a common entity. This analysis made it possible to identify the area of influence, to recognize that patients in remote areas have a higher risk of mortality and that this risk may be associated

with the conditions in which patients are admitted to the referenced institution.

These conclusions raise the question, how can a trauma center go further and connect with its referral institutions?

Colombian legislation, as in many Latin American countries, does not propose effective mechanisms in the comprehensive care of trauma patients or traceability from initial care to outcomes [29]. Prehospital care is fragmented, being susceptible to behaviors that prolong the initial time of care, affecting the possibility of receiving timely care [30]. A first glance on the reality of a trauma center can serve as a pilot test to identify which actors should be articulated in the creation of a trauma system, for the Colombian and Latin American reality.

One of the world references on the creation of a trauma system is the London Trauma Network System [31]. This system proposes the articulation of main trauma centers, trauma units at less complex institutions with the capacity to care for types of trauma that do not require specialized management, and community actors in relation to the identification and timely transfer of potential trauma patients. It is believed that this reference could be implemented in our Colombian context.

The creation of an inter-institutional network that begins to establish links through the education of a sponsor center to less complex institutions, could be a first step in making this concept a reality. This model has already been previously implemented in contexts related to a care route for the reduction of maternal mortality in Colombia with favorable results [32]. The other point to act on is the formation of trauma teams and the standardization of basic processes in the initial care of patients, which allows the establishment of tools to timely classify patients who must be transferred to more complex institutions or benefit from local interventions [33]. This organization applies from the emergency level to peripheral surgeons, who can acquire skills in the initial care of patients and apply concepts of damage control. The inter-institutional communication component directly between trauma surgeons and referring physicians allows a communication bridge to learn about the patient's conditions and thus anticipate the required resources.

We recognize the limitations of this study that it has retrospective information, which may have biases and loss of information on the outcomes and variables of interest included in this analysis. Similarly, the lack of information regarding technical details of prehospital care related to transfer time, resuscitation maneuvers, and conditions of referral to the institution may play as potential confounders in the effect on mortality. The analysis proposal on the perspective of observing the edge of influence in a trauma center based on the profile of the patients who are referred may lead to the understanding that the condition of remission may mean the severity and physiological compromise that a patient has.

Conclusions

The path of the social projection of a trauma center towards a trauma system must be supported by knowledge of the context to which it belongs. An analysis methodology on the influence of a trauma center in Southwest Colombia is proposed based on the profile of the referred patients. It was identified that this group of patients has a higher risk of mortality that could be associated with physiological conditions when they arrive at the referral center. This increased risk constitutes an inequity in health. Timely trauma care should be the product of a network of institutions for the creation of a "trauma system" adapted to the Colombian reality.

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Compliance with ethical standards

Informed consent: This registry was approved by the Institutional Ethics Committee of the Valle del Lili Foundation (Protocol No. 554), complying with the guidelines of resolution 8430 of 1995 and the Declaration of Helsinki, in which it is considered that the handling of this information constitutes a research without risk, therefore, the completion of informed consent is not required.

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