IJMS INTERNATIONAL JOURNAL of MEDICAL STUDENTS

Original Article

The Association of Blood Banks per City with Mortality Due to Traumatic Hemorrhagic Shock in Colombia: A Population-Based Analysis

Alejandro Munoz-Valencia,[1] Francisco J. Bonilla-Escobar,[2] Juan C. Puyana.[3]

Abstract

Background: Hemorrhagic shock is the second leading cause of death for injured people and disproportionately affects low resource economies. The potential role of spatial allocation of blood banks and the unmet transfusion needs of patients are yet to be characterized. We aimed to estimate the effect of the number of blood banks in mortality due to traumatic hemorrhagic shock (THS) in Colombia. **Methods:** We performed a population-based cross-sectional study using secondary data from the Colombian Government: including annual reports from the Blood Bank Network, mortality, and population estimates for 2015-2016. International Classification of Disease 10th code T79.4 identified THS as the primary cause of death. A city-clustered multivariate negative binomial regression, weighted by violent deaths rate, was used to obtain incidence rate ratios (IRR) of death due to THS with 95% confidence intervals (95%CI). **Results:** Of the 59,030 violent deaths in Colombia in 2015-2016, 36.76% were due to THS. Only 3.13% of Colombian municipalities had a blood bank. THS incidence decreased as the number of blood banks in a city increased, and the lowest incidence was observed at ten banks (IRR:0.18, 95%CI:0.15-0.22). Receiving medical care in a city with blood banks had a more substantial impact on THS (IRR:0.85; 95%CI:0.76-0.96). **Conclusion:** The number of blood banks per city was associated with lower incidence of THS deaths. These findings may highlight the inequitable distribution of blood systems and their association with preventable deaths. Further studies with more focused clinical and geographical data might clarify the geographic determinants of blood products' availability.

Key Words: Blood bank; Blood transfusion; Injury; Mortality; Hypovolemic shock (Source: MeSH-NLM).

Introduction

Injury-related deaths are a growing public health concern worldwide. According to the World Health Organization (WHO), injuries represented 8.6% of global deaths in 2016.[1] The latest report stated that injuries took the lives of 4.4 million people in 2019 and constituted 8% of all deaths globally. Among the injury-related causes of death include road traffic accidents (29%), drowning (5%), falls (15%), burns (3%), poisoning (2%), and violence against oneself (16%) or others (11%).[2] As for the WHO Americas region, injury-related deaths vary across countries, with an average of 9.4%. While the United States (US) has one of the lowest rates in the region (6.55%), Colombia has one of the highest injury-related death rates worldwide to the present day (15.04%).[1] The impact of injury-related deaths on society is noteworthy. In 2013, the cost of a single fatal injury was estimated at $1.1 million, which accounted for medical and work-loss costs. Thus, the total cost of injury-related deaths across the US is estimated at around $214 billion annually.[3] For 2019, this cost has gone up to $4.2 trillion, including medical care, work loss, the value of statistical life, and quality of life losses.[4]

The main threats to life in injured patients are hemorrhage and central nervous system (CNS) damage, regardless of the injury mechanism.[4] Approximately one out of every three trauma patients die from a hemorrhage.[5] Moreover, hypovolemic shock in patients with CNS damage increases mortality up to three-fold,[6] and plays a causative role in subsequent organ failure and late mortality.[7] Managing acute hemorrhage in severely injured patients involves timely interventions to stop the bleeding and prompt administration of blood products. Multiple guidelines and clinical management algorithms recommend the use of blood components in the setting of hypovolemic shock after trauma.[8,9] Additionally, the WHO determined blood banking

1 MD, PhD student. Institute for Clinical Research Education (ICRE), Department of Surgery, Global Surgery, University of Pittsburgh, Pittsburgh, PA, United States.

2 MD, MSc, PhD(c). Researcher, Department of Ophthalmology; Institute for Clinical Research Education (ICRE), University of Pittsburgh, Pittsburgh, PA, United States. Fundación Somos Ciencia al Servicio de la Comunidad, Fundación SCISCO/Science to Serve the Community Foundation, SCISCO Foundation, Cali, Colombia. Grupo de investigación en Visión y Salud Ocular, VISOC, Universidad del Valle, Cali, Colombia. Editor in Chief, IJMS.

3 MD, FRCSC, FACS, FACCP. School of Medicine, Department of Surgery, Professor of Surgery, Critical Care Medicine, and Clinical Translational Science, Director for Global Health-Surgery, University of Pittsburgh, Pittsburgh, PA, United States. Editorial Board Member, IJMS.

About the Author: *Alejandro Munoz-Valencia Recently graduated physician from National University of Colombia and University of Pittsburgh PhD student at the Institute of Clinical Research Education (ICRE).*

This work was awarded with the "**Global Surgery and Humanitarian Outreach**" from the American College of Surgeons (ACS). Project: "Effect of blood banks availability on mortality due to shock after trauma in a middle-income country". Authors: Alejandro Muñoz-Valencia, Francisco J. Bonilla-Escobar, Juan C. Puyana. San Francisco, US, 2019.

Correspondence:

Alejandro Munoz-Valencia

Address: 4200 Fifth Ave, Pittsburgh, PA 15260, United States

Email: almunva@gmail.com

Editor: Mihnea-Alexandru Găman,
Student Editors: Eugenia M. Ramos-Dávila & Hang-Long (Ron) Li
Copyeditor: Alisha Poppen
Proofreader: Laeeqa Manji
Layout Editor: Ana Maria Morales

Submission: Mar 1, 2022
Revisions: Mar 10; Aug 1, 2022
Responses: Jul 7, 2022, Jan 11, 2023
Acceptance: Jan 29, 2023
Publication: Mar 3, 2022
Process: Peer-reviewed

capabilities and blood products as essential components for all health facilities and systems providing care to injured patients.[10]

Despite the importance of blood banks as a source of essential blood products, the response of blood bank systems to the immediate transfusion need of everyday injured patients is yet to be thoroughly characterized. Assessments on whether blood banking systems meet the population's needs remain unexamined, especially in low-resource settings. Current global strategies focus on national blood donation thresholds with scarce guidance on the spatial distribution of blood bank infrastructure. For instance, the WHO recommends a donation threshold of at least 1% of the population (10 donations every 1,000 population), while the Lancet Commission on Global Health recommends 1.5%.[11] Geographic distribution and subsequent distance to healthcare facilities are known determinants of access to health services and resources.[12] Thus, understanding the distribution of national blood banking systems could facilitate measuring equity and timeliness of access to safe blood and blood products, particularly for those patients with hypovolemic shock after injury. Previous studies have mainly analyzed hypothetical scenarios of national emergencies or local mass-casualty scenarios.[13,14]

In this study, we aimed to characterize the distribution of a national blood banking system in a middle-income country with high injury-related mortality rates, Colombia, to evaluate the relationship between the number of blood banks and mortality rates due to THS at the city level. Our approach and results may contribute to understanding the impact of blood banking systems on the outcomes of patients with acute transfusion needs.

Methods

Study Setting and Design

This study is a retrospective cross-sectional and population-based research analyzing data from 2015 to 2016 at the city level. We used secondary data from the Colombian National Network of Blood Banks [Red Nacional de Bancos de Sangre], the National Mortality Registry, and population estimates from the National Administrative Department of Statistics [Departamento Administrativo Nacional de Estadisticas].[15,16] The mortality registry contains deidentified data from all death certificates issued across the country– including date, location, age, sex, injury intent (natural death, violent, or under investigation), and causes of death, according to the International Classification of Disease 10th revision (ICD-10). Colombia, a middle-income country in South America, is organized into 33 departments and divided into 1,119 municipalities, including cities and towns. It is the 24th largest and the 29th most populated country in the world, with a blood donation estimate of 2.1%, or 21 donations for every 1,000 population.

Data and Variables

We included in our analyses all violent deaths registered from January 2015 to December 2016 that occurred in a city with at least one blood bank. Data were obtained from the National Mortality Registry– including sex, marital status, age, healthcare coverage, educational level, place of occurrence (urban vs. rural), geographic location (city), type of violent death, the primary cause of death, and whether or not medical assistance was provided prior to death. The cause of death was the dependent variable in all analyses. Specifically, we used the ICD-10 code T79.4 to identify those who died due to shock immediately or later after injury.[17] The National Blood Network served as the source for location data of active blood banks. Each bank was coded using unique national identifiers, and its location was determined through the Colombian national coding system for municipalities.[18] A similar process was conducted to obtain the location of mortality registry data. Finally, population estimates were acquired from the Colombian National Administrative Department of Statistics.[16]

Statistical Analysis

Datasets for counts of violent deaths, number of blood banks, and population estimates as the number of inhabitants were merged into a single database using the location coding system as the joining variable. As deaths are a count variable, we assumed a Poisson data distribution. We used bivariate Poisson regressions with clustered estimators of variance by city and overall violent deaths rate (1/rate) as the sampling weight to identify confounders. Statistical significance for confounders was set at a p-value<0.1019.

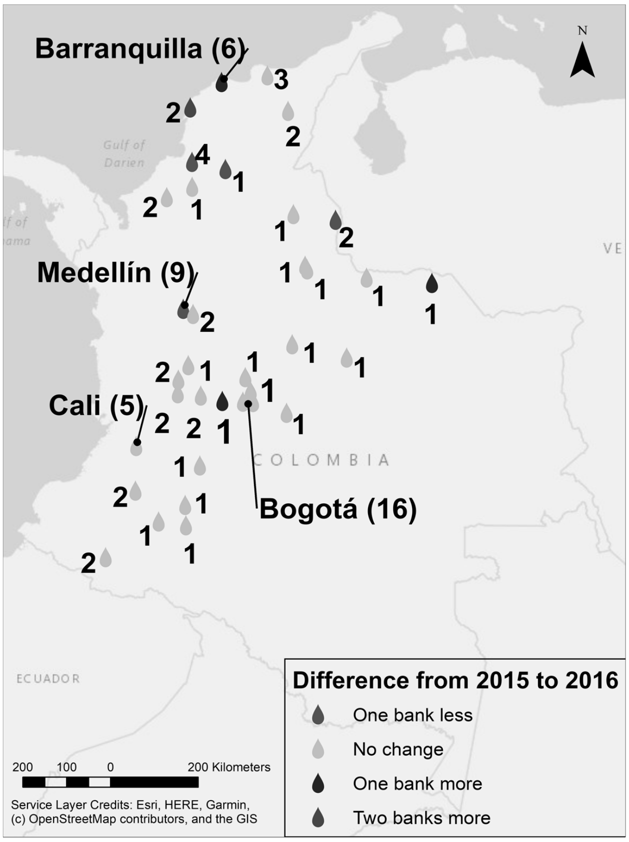
The Pearson goodness-of-fit test for the Poisson adjusted model was significant (p<0.001); therefore, the Poisson model was not a proper regression to be used. We used a multivariate negative binomial regression model adjusted by sex, age, health insurance status, rurality, type of violent death, whether or not health care was provided prior to death, and year of death, weighted by the rate of violent deaths and clustered by city. Incidence of ICD-10 code T79.4 (Traumatic Hemorrhagic Shock – THS) as a primary cause of death was described as Incidence Rate Ratios (IRR) using 95% Confidence Intervals (95%CI) and considering statistical significance at p-value <0.05. All the statistical analyses were conducted in Stata 16® (StataCorp, TX). Ethical approval to conduct this study was granted by the Institutional Review Board of the University of Pittsburgh, code HRP-723.

Results

In this middle-income country, there were 82 active blood banks in 2015 as compared to 81 in 2016. Uneven distribution of banks was observed across the country. (*Figure 1*) Only thirty-five (3.13%) of the 1,119 municipalities had a blood bank, and the number of banks per municipality ranged from 1 to 16. In this country, with 47.61 million inhabitants, 24.16 million (50.73%) live in a municipality without a blood bank. Of those with a bank, 8.03 million live in a city with 1 or 2 blood banks; 1.49 million with 3 or 4 banks; 3.59 million with 5 or 6 banks; and 10.34 million in a city with 9 or 16 banks. In fact, 25 (30.48%) of the banks are located in the two largest cities.

IJMS INTERNATIONAL JOURNAL of MEDICAL STUDENTS

Figure 1. Blood Banks Geographic Distribution in Colombia, a City-Specific Description of the Situation in 2016 Compared with 2015.



From January 1, 2015, through December 31, 2016, there were 59,030 violent deaths. THS was found to be the primary cause of death in 21,731 (36.76%). *Table 1* shows the characteristics of all violent deaths categorized by cause of death and blood bank presence. Males had more deaths in the THS and non-THS groups, 87.64% and 81.48%, respectively. Most THS deaths were observed in the 20-29 and 30-39 age groups, accounting for more than forty percent across groups (39.43% - 60.57%). While homicide (50.33%) and Road Traffic Accident (RTA) deaths (43.90%) were frequently caused by THS, suicide and other injuries were primarily due to other causes. Regarding the place of occurrence, THS represented a greater proportion of rural deaths (42.55%) compared to urban deaths (34.78%). There were no significant differences in medical assistance or year of occurrence.

Overall, the proportion of violent deaths attributed to THS was significantly less in those cities with a blood bank 33.50% vs. 40.68% ($p<0.001$). Similarly, the proportion of THS deaths significantly varied across age groups from 20 to 89 years, ranging from 4.19 to 11.94 percentage points less among violent deaths in cities with at least one blood bank ($p<0.001$). Regarding the type of violent death, homicide accounted for most deaths in cities with and without blood banks, 40.25% and 43.23%, respectively.

Table 1. Description of Violent Deaths by Blood Bank Availability and Cause of Death in Colombia 2015-2016 (N=59 030).

Characteristic	Blood Bank in the city				p-value*
	No		Yes		
	Death by THS		*Death by THS*		
	No Freq (%)	*Yes* Freq (%)	*No* Freq (%)	*Yes* Freq (%)	
Sex					
Female	2575 (66.76)	1282 (33.24)	4277 (75.45)	1392 (24.55)	<0.001
Male	13431 (58.08)	9694 (41.92)	16988 (64.57)	9321 (35.43)	<0.001
Age in years					
<10	895 (84.20)	168 (15.80)	839 (86.85)	127 (13.15)	0.09
10-19	1970 (61.68)	1224 (38.32)	2154 (62.63)	1285 (37.37)	0.42
20-29	4045 (54.97)	3313 (45.03)	5024 (59.16)	3468 (40.84)	<0.001
30-39	2929 (54.90)	2406 (45.10)	3537 (60.57)	2303 (39.43)	<0.001
40-49	1997 (55.70)	1588 (44.30)	2455 (66.01)	1264 (33.99)	<0.001
50-59	1605 (60.11)	1065 (39.89)	2187 (70.43)	918 (29.57)	<0.001
60-69	1004 (63.14)	586 (36.86)	1750 (75.08)	581 (24.92)	<0.001
70-79	784 (67.35)	380 (32.65)	1499 (77.91)	425 (22.09)	<0.001
80-89	495 (77.34)	145 (22.66)	1295 (83.60)	254 (16.40)	0.001
>89	160 (85.11)	28 (14.89)	398 (88.05)	54 (11.95)	0.31
Unknown	164 (67.49)	79 (32.51)	147 (80.33)	36 (19.67)	0.003
Type of death					
Suicide	1879 (85.02)	331 (14.98)	2321 (88.66)	297 (11.34)	<0.001
Homicide	5570 (47.67)	6114 (52.33)	6631 (51.48)	6250 (48.52)	<0.001
RTI	3243 (48.56)	3435 (51.44)	4969 (62.42)	2991 (37.58)	<0.001
Other	3145 (79.26)	823 (20.74)	3447 (79.06)	913 (20.94)	0.82
Unknown	2211 (88.80)	279 (11.20)	3917 (93.69)	264 (6.31)	<0.001
Medical assistance					
No	11884 (58.50)	8429 (41.50)	9124 (62.54)	5464 (37.46)	<0.001
Yes	3275 (61.58)	2043 (38.42)	10705 (70.10)	4565 (29.90)	<0.001
Unknown	889 (63.55)	510 (36.45)	1456 (67.97)	686 (32.03)	0.006
Place of occurrence					
Urban	8694 (61.08)	5539 (38.92)	20082 (67.19)	9807 (32.81)	<0.001
Rural	7243 (57.34)	5389 (42.66)	1114 (55.90)	879 (44.10)	0.23
Unknown	111 (67.27)	54 (32.73)	89 (75.42)	29 (24.58)	0.14
Healthcare coverage					
Contributory	3566 (56.37)	2760 (43.63)	6134 (67.43)	2963 (32.57)	<0.001
Subsidized	8898 (61.67)	5531 (38.33)	7584 (66.81)	3768 (33.19)	<0.001
No insurance	2683 (58.02)	1941 (41.98)	3835 (62.97)	2255 (37.03)	<0.001
Unknown	901 (54.57)	750 (45.43)	3732 (68.34)	1729 (31.66)	<0.001
Year					
2015	8078 (58.77)	5666 (41.23)	10433 (65.73)	5440 (34.27)	<0.001
2016	7970 (59.99)	5316 (40.01)	10852 (67.29)	5275 (32.71)	<0.001

Legend: THS: Traumatic Hemorrhagic Shock. RTI: Road Traffic Injury. * Chi-square or exact tests comparison across groups by row.

RTAs accounted for 24.88% in cities with a bank and 24.71% in those without one. The place of death occurrence was significantly different across groups. Although most of the deaths occurred in urban areas of municipalities with and without blood banks, urban location accounted for 93.40% among those with a bank and only 52.66% in municipalities without a bank. Moreover, of the 14,625 rural deaths, 86.37% occurred in a municipality without a blood bank compared to 32.26% of urban deaths in a city without a bank (p<0.001).

Medical care prior to death was received by 47.72% of the casualties in municipalities with blood banks. In contrast, only 19.67% of deaths received care before death when it occurred in municipalities without a bank (p<0.001). Health insurance status was similar between groups. Subsidized regime accounted for most deaths among municipalities with and without blood banks, 35.48% and 53.38%, respectively. The proportion of the uninsured showed no significant differences.

In *Table 2*, we show regression analysis results described in terms of adjusted and unadjusted IRR of THS. Compared to municipalities with only one blood bank, those with 2 or 3 banks did not show a significant difference in THS incidence. However, cities with four banks were associated with a reduction of 45.88% (p<0.001); five with a reduction of 58.38% (p<0.001); and six with a reduction of 71.93% (p<0.001), in the incidence of THS. A significant association was also found with 16 banks per city, showing a reduction of 29.06% (p<0.001). Cities with 9 or 10 banks did not have a significant difference. When comparing those that received medical care prior to the death against those who did not, the former had less incidence of THS (IRR: 0.90, p=0.013). Age was significantly associated with an IRR of 0.99 (p<0.001). As for the type of death, there were significant differences between suicide, homicide, and RTA. Suicide deaths showed significantly less incidence of THS (IRR: 0.48, p<0.001) compared to other types of death. Conversely, homicide and RTA deaths were associated with significantly higher incidence rates of THS (IRR=2.38, p<0.001, and IRR=.1.80, p<0.001, respectively). Incidence in rural areas compared to urban areas was not significantly different (p=0.35). No significant differences were found when comparing violent deaths by year (2015 vs. 2016, IRR=0.93, p=0.09).

Discussion

This study explored the association between blood bank availability and the incidence of deaths caused by THS. To our knowledge, this is the first study to use comprehensive population-level datasets of blood bank distribution, mortality, and population density to analyze this issue at a national level. Adjusted analysis showed a continuous reduction in death rates due to THS as the number of blood banks in a city increased. The association was statistically significant at four or greater blood banks. This trend reached its lowest value at ten banks per city (IRR=0.18, p<0.001). In addition, receiving medical care before death was not significant when considered independently (IRR=1.02, p=0.62); however, it resulted in a lower incidence of THS deaths when paired with blood bank availability (IRR=0.85, p=0.009).

These findings may reveal the role of the geographic distribution of blood banking facilities as vital elements for those strategies that aim to meet the transfusion needs of injured patients. The 28th World Health Assembly in 1975 first mentioned the idea of an adequate supply of blood products.[20] This concept has evolved towards the commitment of countries to ensure national blood supplies only by volunteer donors as well as the safety of blood units.[21,22] But, neither the geographic distribution nor target quantity of blood banks has been systematically addressed. Additionally, national estimates have historically set self-sufficiency goals that may not reflect disparities among the population.[22-25] For instance, we observed that only 35 cities in Colombia (3.13%) had at least one blood bank in 2015 and 2016. This fact would be overlooked if only national aggregated data were analyzed and regional geographical differences not considered.

Table 2. Incidence Rate Ratios of Death due to Traumatic Hemorrhagic Shock in Colombia 2015-2016.

Characteristic	$_u$IRR	95% CI	p-value	$_a$IRR	95% CI	p-value
Blood Banks per municipality						
1	-	-	-	-	-	-
2	0.79	0.75-0.84	<0.001	0.76	0.51-1.15	0.192
3	1.09	1.00-1.19	0.060	0.94	0.67-1.33	0.735
4	0.56	0.49-0.66	<0.001	0.54	0.45-0.66	<0.001
5	0.55	0.52-0.59	<0.001	0.42	0.34-0.23	<0.001
6	0.35	0.30-0.42	<0.001	0.28	0.23-0.34	<0.001
9	1.03	0.95-1.11	0.525	0.91	0.75-1.10	0.331
10	1.01	0.94-1.09	0.795	0.97	0.79-1.18	0.738
16	0.68	0.64-0.72	<0.001	0.71	0.59-0.86	<0.001
Medical assistance						
No	-	-	-	-	-	-
Yes	0.80	0.77-0.83	<0.001	0.90	0.82-0.98	0.013
Sex						
Female	-	-	-	-	-	-
Male	1.44	1.36-1.53	<0.001	1.11	1.06-1.015	<0.001
Age, in years	0.96	0.95-0.97	<0.001	0.99	0.98-0.99	<0.001
Type of death						
Other	-	-	-	-	-	-
Suicide	0.54	0.48-0.62	<0.001	0.48	0.39-0.59	<0.001
Homicide	2.32	2.16-2.48	<0.001	2.38	1.86-3.05	<0.001
RTI	1.79	1.67-1.93	<0.001	1.80	1.57-2.07	<0.001
Place of occurrence						
Urban	-	-	-	-	-	-
Rural	1.34	1.26-1.44	<0.001	1.06	0.94-1.20	0.352
Year						
2015	-	-	-	-	-	-
2016	0.95	0.92-0.99	0.016	0.94	0.86-1.01	0.090

As for 2019, the circumstances have remained unchanged, with almost the same number of blood banks (83 actives) and an identical distribution, with a difference in the number of violent deaths that has gone down to 28,220 (47% of 2015 -2016).[26,27]

Overall, the relevance of blood transfusion in preventing deaths in the trauma setting is exemplified by the emphasis on transfusion protocols as one of the first critical actions in the setting of hemodynamic instability due to hemorrhage.[9,28,29] These results align with those approaches, as we observed that blood bank availability, coupled with medical care, impacts the incidence of deaths by exsanguinating causes among injured patients.

The proportion of THS deaths and demographic characteristics within this population of trauma deaths are similar to previous descriptions of trauma settings reported by other authors from the National Trauma Data Bank.[30,31] However, the absence of key variables (blood bank data availability and geographic location) in other national trauma datasets and academic reports hinders the proper comparison that could have provided further meaningful conclusions. The Colombian reports of violent death do not show all data regarding each death since they only account for the cause of death of patients who received medical assistance before their death, making it challenging to create conclusions from these cases. Additionally, we cannot assess the severity score, such as shock index or the state of the patients if we do not have the complete history of each patient and whether or not the patient had one or multiple transfusions or if blood was available in their local blood bank. According to the National Institute of Health, only 220,000 nationals donated blood in the country with a population of 49.28 million in 2018, indicating a lack of donors countrywide.[27,32,33] Previous authors have found similar difficulties when analyzing trauma datasets.[34,35] Consequently, multiple endeavors have been proposed to overcome obstacles related to data reporting and data accessibility, especially in LMICs.[36,37] Nonetheless, non-standardized reports generated at local and rural hospitals still account for lack of reliability in the absence of more accurate registrations at a national level.

These limitations also highlight the nature of trauma settings in LMICs, which are often represented as unfavorable environments not equipped to collect all relevant and reliable information.[38] For these reasons, further analyses are required with multiple datasets that include more detailed geographic and clinical data such as injury descriptions, severity scores, and trauma mechanisms, as well as information about blood products' management and delivery circumstances in order to achieve a fuller understanding of the blood banking system's response to the transfusion need of injured patients.

Conclusion

In this study, we described the association of blood banks' availability with the number of violent deaths caused by traumatic hemorrhagic shock at a population level. Between 2015 and 2016, in this middle-income country, there was an inequitable distribution of blood facilities where the incidence of THS decreased as the number of blood banks in a city increased. Without any changes in neither distribution nor the number of blood banks in recent years, this study may suggest novel elements for strategies that aim to meet the transfusion needs of injured patients by inquiring about the importance of the geographic distribution of blood bank facilities. Such strategies could further tailor local and national policies to consider geographic and non-geographic determinants of blood products' availability and delivery, eventually developing successful strategies from blood banking systems to meet the populations' transfusion needs.

Summary – Accelerating Translation

Las muertes relacionadas con lesiones son un problema de salud pública creciente en todo el mundo. Aproximadamente uno de cada tres pacientes traumatizados muere a causa de una hemorragia. Múltiples pautas y algoritmos de manejo clínico recomiendan el uso de componentes sanguíneos en el contexto de un shock hipovolémico después de un trauma. Además, la Organización Mundial de la Salud (OMS) determinó que las capacidades de los bancos de sangre y los productos sanguíneos son componentes esenciales para todas las instalaciones y sistemas de salud que brindan atención a los pacientes lesionados. A pesar de la importancia de los bancos de sangre como fuente de hemoderivados esenciales, la respuesta de los sistemas de bancos de sangre a la necesidad inmediata de transfusiones de los pacientes lesionados cotidianos aún no se ha caracterizado a fondo. En este estudio, nuestro objetivo fue caracterizar la distribución de un sistema nacional de bancos de sangre en un país de ingresos medios con altas tasas de mortalidad por lesiones, Colombia, para evaluar la relación entre el número de bancos de sangre y las tasas de mortalidad por SHT en el país. nivel de la ciudad.

Este estudio es una investigación transversal retrospectiva y de base poblacional que analiza datos de 2015 a 2016 a nivel de ciudad. Se utilizaron datos secundarios de la Red Nacional de Bancos de Sangre de Colombia, el Registro Nacional de Mortalidad y estimaciones de población del Departamento Administrativo Nacional de Estadística. Los datos se obtuvieron del Registro Nacional de Mortalidad, incluyendo sexo, estado civil, edad, cobertura de salud, nivel educativo, lugar de ocurrencia (urbano vs. rural), ubicación geográfica (ciudad), tipo de muerte violenta, causa principal de muerte, y si se proporcionó o no asistencia médica antes de la muerte.

En este país de ingresos medios, había 82 bancos de sangre activos en 2015 en comparación con 81 en 2016. Se observó una distribución desigual de los bancos en todo el país. Solo treinta y cinco (3,13%) de los 1.119 municipios contaban con banco de sangre, y el número de bancos por municipio varió de 1 a 16. En este país, con 47,61 millones de habitantes, 24,16 millones (50,73%) viven en un municipio sin un banco de sangre. Del 1 de enero de 2015 al 31 de diciembre de 2016 hubo 59.030 muertes violentas. Se encontró que el shock hemorrágico traumático era la principal causa de muerte en 21.731 (36,76%). En general, la proporción de muertes violentas atribuidas al shock hemorrágico traumático fue significativamente menor en aquellas ciudades con banco de sangre 33,50% vs. 40,68% (p<0,001). En cuanto al tipo de muerte violenta, el homicidio representó la mayoría de las muertes en las ciudades con y sin banco de sangre, 40,25% y 43,23%, respectivamente. Las lesiones de tránsito representaron el 24,88% en las ciudades con banco y el 24,71% en las que no lo tenían. Aunque la mayoría de las muertes ocurrieron en las áreas urbanas de los municipios con y sin bancos de sangre, la ubicación urbana representó el 93,40% entre los que tenían banco y solo el 52,66% en los municipios sin banco. Además, de las 14.625 muertes rurales, 86,37% ocurrieron en municipio sin banco de sangre frente a 32,26% de muertes urbanas en ciudad sin banco (p<0,001). La atención médica previa a la muerte fue recibida por el 47,72% de las víctimas en los municipios con bancos de sangre. En contraste, solo 19,67% de las muertes recibieron atención cuando la lesión ocurrió en municipios sin banco (p<0,001). En comparación con los municipios con un solo banco de sangre, aquellos con 2 o 3 bancos no mostraron una diferencia significativa en

la incidencia de shock hemorrágico traumático. Sin embargo, las ciudades con cuatro bancos se asociaron con una reducción del 45,88% (p<0,001); cinco con una reducción del 58,38% (p<0,001); y seis con una reducción del 71,93% (p<0,001), en la incidencia de shock hemorrágico traumático. También se encontró asociación significativa con 16 bancos por ciudad, mostrando una reducción del 29,06% (p<0,001).

El análisis ajustado mostró una reducción continua en las tasas de mortalidad por shock hemorrágico traumático a medida que aumentaba el número de bancos de sangre en una ciudad. La asociación fue estadísticamente significativa en cuatro o más bancos de sangre. Esta tendencia alcanzó su valor más bajo en diez bancos por ciudad (razones de tasa de incidencia [IRR]=0,18, p<0,001). Además, recibir atención médica antes de la muerte no fue significativo cuando se consideró de forma independiente (IRR=1,02; p=0,62); sin embargo, resultó en una menor incidencia de muertes por shock hemorrágico traumático cuando se combinó con la disponibilidad del banco de sangre (IRR=0,85; p=0,009). Estos hallazgos pueden revelar el papel de la distribución geográfica de los bancos de sangre como elementos vitales para aquellas estrategias que tienen como objetivo satisfacer las necesidades de transfusión de los pacientes lesionados.

Sin embargo, este estudio también conlleva sus propias limitaciones. Los informes colombianos de muerte violenta no muestran todos los datos de cada muerte, ya que solo dan cuenta de la causa de muerte de los pacientes que recibieron asistencia médica, lo que dificulta sacar conclusiones de estos casos. No podemos evaluar la severidad de los casos si no tenemos el historial completo de cada paciente y si el paciente recibió o no una o múltiples transfusiones o si había sangre disponible en su banco de sangre local; según el Instituto Nacional de Salud, solo 220.000 personas donaron sangre en el país con una población de 49,28 millones en 2018. Estas limitaciones también resaltan la naturaleza de los entornos de trauma en los países de bajos y medianos ingresos, que a menudo se representan como entornos desfavorables que no están equipados para recopilar todos los datos relevantes e información confiable. Por estas razones, se requieren análisis adicionales con múltiples conjuntos de datos que incluyan datos geográficos y clínicos más detallados, como descripciones de lesiones, puntajes de gravedad y mecanismos de trauma, así como información sobre el manejo de los productos sanguíneos y las circunstancias de entrega para lograr una comprensión más completa de la respuesta del sistema de banco de sangre a la necesidad de transfusiones de pacientes lesionados.

References

1. World Health Organization Geneva W. Global Health Estimates 2016: Deaths by Cause, Age, Sex, by country and by region, 2000-2016. 2018.
2. Word Health Organization. World health statistics 2022: Monitoring health for the SDGs, sustainable development goals 2022.
3. Florence C, Simon T, Haegerich T, Luo F, Zhou C. Estimated Lifetime Medical and Work-Loss Costs of Fatal Injuries--United States, 2013. MMWR Morb Mortal Wkly Rep. 2015;64(38):1074-7.
4. Peterson C, Miller GF, Barnett SB, Florence C. Economic Cost of Injury — United States, 2019. Morb Mortal Wkly Rep 2021. 2021:70:1655–9.
5. Shackford SR, Mackersie RC, Holbrook TL, Davis JW, Hollingsworth-Fridlund P, Hoyt DB, et al. The epidemiology of traumatic death. A population-based analysis. Arch Surg. 1993;128(5):571-5.
6. Kauvar DS, Lefering R, Wade CE. Impact of hemorrhage on trauma outcome: an overview of epidemiology, clinical presentations, and therapeutic considerations. J Trauma. 2006;60(6 Suppl):S3-11.
7. Roberts I, Shakur H, Edwards P, Yates D, Sandercock P. Trauma care research and the war on uncertainty. BMJ. 2005;331(7525):1094-6.
8. Wong H, Curry N, Stanworth SJ. Blood products and procoagulants in traumatic bleeding: use and evidence. Curr Opin Crit Care. 2016;22(6):598-606.
9. ATLS - Advanced Trauma Life Support. 10th edition. ed. Chicago, IL: American College of Surgeons; 2017. pages cm p.
10. Mock C, Essential Trauma Care Project (World Health Organization), World Health Organization., International Society of Surgery., International Association for the Surgery of Trauma and Surgical Intensive Care. Guidelines for essential trauma care. Geneva: World Health Organization; 2004. x, 93 p. p.
11. Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. Lancet Lond Engl. 2015;386(9993):569–624.
12. Naylor KB, Tootoo J, Yakusheva O, Shipman SA, Bynum JPW, Davis MA. Geographic variation in spatial accessibility of US healthcare providers. Plos One. 2019;14(4):e0215016.
13. Simonetti A, Ezzeldin H, Walderhaug M, Anderson SA, Forshee RA. An Inter-regional US Blood Supply Simulation Model to Evaluate Blood Availability to Support Planning for Emergency Preparedness and Medical Countermeasures. Disaster Med Public Health Prep. 2018;12(2):201-10.
14. Abdella Y, Hajjeh R, Sibinga CTS. Availability and safety of blood transfusion during humanitarian emergencies. East Mediterr Health J. 2018;24(8):778-88.
15. Informe Anual Red Sangre 2015 & 2016 [Internet]. 2016 [cited December 15, 2018]. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/IA/INS/ins-informe-anual-red-sangre-2015.pdf.
16. Estimaciones de población 1985-2005 y proyecciones de población 2005-2020 nacional, departamental y municipal por sexo, grupos quinquenales de edad. [Internet]. 2018 [cited December 15, 2018]. Available from: https://www.dane.gov.co/files/investigaciones/poblacion/proyepobla06_20/Edades_Simples_1985-2020.xls.
17. World Health Organization. International statistical classification of diseases and related health problems. 10th revision, 2nd edition. ed. Geneva: World Health Organization; 2004.
18. Colombia DANE. Tabla de Municipios. 2018.
19. Hosmer DW, Lemeshow S, May S. Applied survival analysis : regression modeling of time-to-event data. 2nd ed. ed. Hoboken, N.J.: Wiley ; Chichester : John Wiley [distributor]; 2008.
20. World Health Organization %J Geneva W. Twenty-Eight World Health Assembly, Geneva, 13-30 May 1975 WHA28.72 Utilization and supply of human blood and blood products. 1975.
21. Communities COTE. Blood safety and self-sufficiency in the European community. Brussels, Belgium1994.
22. World Health Organization %J Geneva W. Availability, safety and quality of blood products. In: Assembly S-tWH, editor. 2010.
23. Desalvo F, Verlicchi F, Tomasini I. An estimate of future transfusion needs in the province of Ravenna made on the basis of Italian national statistics and past consumption. Blood Transfus. 2011;9(4):413-8.
24. Mayr WR. The reality of self-sufficiency. Transfus Clin Biol. 2005;12(5):362-4.
25. Benjamin RJ, Whitaker BI. Boom or bust? Estimating blood demand and supply as the baby boomers age. Transfusion. 2011;51(4):670-3.
26. Forero MIB. Informe Ejecutivo De La Red Nacional Servicios De Transfusión Colombia 2019. Colombia: Instituto Nacional De Salud; 2020.
27. DANE. Defunciones por ocurrencia 2008-2020, muertes violentas 2019. Colombia: DANE; 2019.
28. Cantle PM, Cotton BA. Prediction of Massive Transfusion in Trauma. Crit Care Clin. 2017;33(1):71-84.
29. Schuster KM, Davis KA, Lui FY, Maerz LL, Kaplan LJ. The status of massive transfusion protocols in United States trauma centers: massive transfusion or massive confusion? Transfusion. 2010;50(7):1545-51.
30. Boulanger L, Joshi AV, Tortella BJ, Menzin J, Caloyeras JP, Russell MW. Excess mortality, length of stay, and costs associated with serious

hemorrhage among trauma patients: findings from the National Trauma Data Bank. The American surgeon. 2007;73(12):1269-74.

31. Zarzaur BL, Croce MA, Magnotti LJ, Fabian TC. Identifying life-threatening shock in the older injured patient: an analysis of the National Trauma Data Bank. J Trauma. 2010;68(5):1134-8.
32. Vang M, Østberg M, Steinmetz J, Rasmussen LS. Shock index as a predictor for mortality in trauma patients: a systematic review and meta-analysis. Eur J Trauma Emerg Surg. 2022;48(4):2559-66.
33. MinSalud. The Challenge is to Increase Blood Donation in Colombia Colombia: Ministerio de Salud; 2018 [updated 27/06/2018. Available from: https://www.minsalud.gov.co/English/Paginas/The-Challenge-is-to-Increase-Blood-Donation-in-Colombia.aspx
34. Bonilla-Escobar FJ, Birda V, Puyana JC. Evaluating data quality in trauma registries. J Trauma Acute Care Surg. 2016;81(5):992-3.
35. Ordonez CA, Morales M, Rojas-Mirquez JC, Bonilla-Escobar FJ, Badiel M, Minan Arana F, et al. Trauma Registry of the Pan-American Trauma Society: One year of experience in two hospitals in southwest Colombia. Colomb Med. 2016;47(3):148-54.
36. Bonilla-Escobar FJ, Rodriguez C, Puyana JC. Trauma Care and Surveillance: International "eCapacity" Efforts and Honduras Experience. World journal of surgery. 2017;41(9):2415-6.
37. Rodriguez C, Bonilla-Escobar FJ, Restrepo-Lopera C, Markovtsova A, Medina MT, Puyana JC. A trauma registry experience from the main referral center of Honduras: A call for action. Injury. 2019;50(4):883-9.
38. Global Forum for Health Research (Organization). The 10/90 report on health research. Geneva, Switzerland: Global Forum for Health Research; 1999.

Acknowledgments

None.

Conflict of Interest Statement & Funding

The Authors have no funding, financial relationships or conflicts of interest to disclose. Dr. Juan C. Puyana and Alejandro Munoz-Valencia work is partially funded by the National Institute of Health (NIH) of the United States with the grant UH3HL151595. The opinions expressed in this article are the author's own and do not reflect the view of the National Institutes of Health, the Department of Health and Human Services, or the United States government.

Author Contributions

Conceptualization: AMV, FJBE. Methodology: AMV, FJBE. Supervision: JCP, FJBE. Analysis: FJBE. Funding: JCP. Writing draft and final version: AMV, FJBE, JCP.

Cite as

Munoz-Valencia A, Bonilla-Escobar FJ, Puyana JC. The Association of Blood Banks per City with Mortality Due to Traumatic Hemorrhagic Shock in Colombia: A Population-Based Analysis. Int J Med Stud. 2023 Jan-Mar;11(1):22-28.

ISSN 2076-6327

This journal is published by Pitt Open Library Publishing