Opportunities to expand delivery of prehospital tranexamic acid to bleeding trauma patients – findings from a prospective multicentre trauma study in the Western Cape Province, South Africa

N Abdullah,[1] PhD, MPhil; **J Young,**[2] MSPH; **W Stassen,**[3] MPhil, PhD; **C Wylie,**[1] MPhil; **H J Lategan,**[4] MB ChB; **G Oosthuizen,**[4] MB ChB, PhD; **S de Vries,**[5] MB ChB, MPhil; **J Verster,**[6] MB ChB; **EpiC Study Site Collaborators,**[7*] **J M Dixon,**[2] MD, MPH; **N-K Mould-Millman,**[2] MD, PhD

[1] *Emergency Medical Services, Western Cape Government Health and Wellness, Cape Town, South Africa*
[2] *Department of Emergency Medicine, University of Colorado Anschutz Medical Campus, Aurora, USA*
[3] *Division of Emergency Medicine, Department of Family, Community and Emergency Care, University of Cape Town, South Africa*
[4] *Division of Surgery, Department of Surgical Sciences, Stellenbosch University, Cape Town, South Africa*
[5] *Collaborative for Emergency Care in Africa, Cape Town, South Africa*
[6] *Division of Forensic Medicine, Department of Pathology, Stellenbosch University, Cape Town, South Africa*
[7] *Western Cape Government Health and Wellness, Cape Town, South Africa*

Corresponding author: *N Abdullah (Naseef.Abdullah@westerncape.gov.za)*

Background. Traumatic haemorrhage is a leading cause of preventable injury-related deaths. Tranexamic acid (TXA) has demonstrated a 38% all-cause mortality reduction when administered to severe haemorrhagic shock patients in South Africa (SA). Yet its prehospital utilisation in SA remains limited owing to prehospital provider qualification restrictions, despite the region's high trauma burden. Among the 4% of prehospital providers licensed to administer TXA, prehospital eligibility and TXA administration is poorly reported. This utilisation gap suggests multifactorial barriers beyond the current scope of practice restrictions that impede effective implementation of this evidence-based intervention.
Objective. To assess patterns of TXA administration and omission during prehospital emergency care in the Western Cape Province, SA.
Methods. This is a secondary analysis from the EpiC prospective multicentre study. The current study examined 4 094 patients at risk of haemorrhage in the Western Cape from August 2021 to December 2024. First, we assessed patient and injury characteristics as well as prehospital and hospital treatments among three prehospital treatment groups: those who received TXA; those who received a lifesaving circulation intervention and no TXA; and those who received neither. Second, a subset of patients was selected for three clinical scenarios: patients with moderate to severe risk of shock; those with severe shock meeting TXA eligibility criteria; and those requiring hospital-based interventions for haemorrhage. Prehospital provider qualifications, clinical interventions and outcomes were assessed using descriptive statistics, and Sankey diagrams were used to visually depict the quantity and flow of prehospital trauma patients stratified by prehospital provider qualification.
Results. Only 2.8% (*n*=116) of all haemorrhage-risk patients received prehospital TXA despite 82% (*n*=3 325) presenting within the 3-hour window for administration. Among eligible patients with severe risk of shock who were managed by an advanced prehospital provider (*n*=161), only 19% (*n*=30) received TXA. Basic and intermediate prehospital providers, who cannot administer TXA under current regulations, managed 67% (*n*=326) of these patients. These providers frequently delivered other life-saving circulatory interventions (70 - 79%).
Conclusion. This study reveals that only a small percentage of eligible trauma patients receive TXA despite its established mortality benefit. The principal barrier identified is the current scope-of-practice restriction preventing basic and intermediate prehospital providers from administering TXA, despite managing two-thirds of eligible patients and possessing the knowledge and skills to deliver TXA. We strongly recommend that the scope of TXA be extended to intermediate prehospital providers in SA.

Keywords: tranexamic acid, wounds and injury, haemorrhage, emergency medical services

S Afr Med J 2026;116(4):e3787. https://doi.org/10.7196/SAMJ.2026.v116i4.3787

Injury represents a global public health challenge, causing ~4.4 million deaths annually and accounting for 10% of years lived with disability.[1] Injury remains the leading cause of death among young, socioeconomically active people.[2,3] This burden is disproportionately borne by 80% of the world's population residing in low- and middle-income countries (LMICs), where 90% of injury-related deaths occur.[1,4,5] In these regions, mortality rates prior to arriving at a hospital can be as high as 80%.[6]

Prehospital emergency care constitutes the first critical link in the trauma care continuum, offering the potential to mitigate morbidity and mortality through timely, life-saving interventions before hospital arrival.[7-9] However, underdeveloped emergency medical services (EMS) in LMICs contribute to preventable deaths and long-term disability.[10-12] South Africa (SA) exemplifies this crisis, with trauma-related mortality nearly double the global average,[13,14] and with injury accounting for 34% of EMS activations and 25% of public emergency department visits.[15,16]

Uncontrolled haemorrhage is a leading cause of preventable injury-related deaths.[7] The median time from onset of haemorrhagic shock to death is reported as 2 hours, further emphasising the need for timely and effective interventions.[17] As a substantial proportion of deaths from injury occur early, optimising EMS capabilities could reduce injury-related mortality by up to 45%.[18-21]

Tranexamic acid (TXA), an antifibrinolytic agent, reduces mortality when administered early in traumatic haemorrhage.[22-24] While the life-saving benefits of TXA in hospital settings are well established, its role in prehospital trauma care remains an area of ongoing research.[25] In high-income countries with advanced trauma systems, early TXA administration (within 1 hour) to patients with severe haemorrhagic shock has been associated with significant reductions in both 24-hour and 30-day mortality.[26,27] A recent multicentre study in SA demonstrated a 38% all-cause mortality reduction with TXA administration within 3 hours of injury, predominantly due to hospital-based TXA administration.[28] Despite the significant trauma managed in the SA prehospital setting, prehospital eligibility and TXA administration practice are poorly reported, representing a critical knowledge gap in trauma care optimisation.

SA is one of the few African nations with a structured, formalised EMS system with trained providers, and where the majority of SA citizens utilise the public healthcare system.[12,15,29] To address the nation's emergency care requirements, the SA National Department of Health has adopted a tiered prehospital qualification structure. The current SA prehospital scope of practice guidelines restrict TXA administration to advanced prehospital providers, who collectively represent merely 4% of the nation's prehospital workforce.[30] Paradoxically, a large proportion of non-advanced providers restricted from this capability are authorised to perform complex procedures such as prehospital thoracentesis and to administer medications, including adrenaline for cardiac arrest and anaphylaxis, naloxone for opioid overdoses, midazolam for seizures and magnesium sulphate for toxaemia in pregnancy.[31] These interventions carry substantially higher safety risks than TXA.[31,32] Moreover, the clinical scenarios requiring these complex interventions occur with markedly lower frequency than trauma presentations.[16,31-34] Despite the potential therapeutic value of these permitted medications, none has a demonstrated mortality reduction comparable to TXA.[28] This may flag a potential pragmatic opportunity for the re-allocation of TXA to non-advanced cadres of prehospital providers in SA.

This study aims to assess patterns of TXA administration and omission during prehospital emergency care in the Western Cape Province of SA. We employ a series of clinical scenarios to identify intervenable opportunities to expand prehospital TXA administration to the prehospital trauma population, as a means to improve trauma patient outcomes in the region.

Methods

Study design

This study is a secondary analysis of data collected from the Epidemiology and Outcomes of Prolonged Trauma Care (EpiC) study, a prospective, observational, multicentre study aimed at advancing the understanding of outcomes of major trauma patients in the Western Cape Province, with a particular focus on haemorrhage.[35] The EpiC study evaluates how the delivery and timing of pre- and in-hospital life-saving interventions (LSIs), such as TXA, affect mortality and morbidity outcomes.

The EpiC study included adult trauma patients (aged ≥18 years) who sustained injuries within 24 hours prior to their first healthcare system contact, and who were alive (i.e. had signs of life or attempted resuscitation) at the time of EMS or hospital contact. Patients were excluded if they were prisoners, pregnant women, or had trauma secondary to burns, hangings or strangulation, drowning, envenomation, electrocution, or bites/stings, or were pronounced dead on scene. Additionally, cases with substantial missing data or lost records were withdrawn from the study.

Study setting

The Western Cape Province experiences a particularly high incidence of injury-related mortality.[13,14] The provincial government-funded and operated EMS system offers unrestricted emergency medical and trauma care to a population of >7 million across 129 462 km^2, where interpersonal violence is a major contributor to the regional injury burden, accounting for nearly half of all injury-related deaths.[13] TXA was added to the national EMS scope of practice for advanced EMS practitioners in 2018, marking a significant advancement in prehospital haemorrhage control capabilities.[31] The prehospital TXA dosing regimen during the study period was a 1 g intravenous (IV) bolus over 10 minutes, followed by initiating a 1 g IV infusion over 8 hours.[31]

The EpiC study sites in the Western Cape include six health facilities (Ceres Hospital, Delft Community Health Centre, Khayelitsha Hospital, Khayelitsha Site B Community Health Centre, Tygerberg Hospital and Worcester Hospital), along with the four EMS bases and two forensic pathology services laboratories that geographically overlap with the six health facilities.

Study participants

The study population comprised severely injured patients from the EpiC dataset, from whom we selected patients who had a primary EMS encounter (i.e. from scene to healthcare facility) with Western Cape EMS from August 2021 to December 2024, and who experienced blunt and/or penetrating trauma with, or at risk for, haemorrhage, defined by meeting any one of the following criteria:

- physiological parameters: systolic blood pressure (SBP) ≤100 mmHg or heart rate ≥110 bpm or shock index ≥1.0 (either during primary EMS response or upon hospital arrival)
- prehospital haemorrhage interventions: EMS administration of any circulation intervention for hypovolaemia or administration of TXA or adrenaline during the primary EMS encounter
- early clinical indicators: any haemorrhage-related hospital physician diagnosis within 24 hours of arrival at the first facility (shock, haemorrhagic hypovolaemia, cardiac tamponade, tension pneumothorax, or cardiac arrest)
- hospital resuscitation measures: received hospital TXA, vasopressors, inotropes, or any blood products within 3 hours of hospital arrival
- severe injury mechanism: presence of a pelvic fracture or penetrating trauma (gunshot wound or stabbing/laceration of the neck, thorax, or abdomen) with an associated Abbreviated Injury Scale severity score ≥2
- autopsy finding: haemorrhage identified as the mechanism of death on autopsy report among patients who died during EMS encounter or hospital stay.

Treatment groups

We divided the study population into three exposure groups based on key treatments administered by EMS providers. The primary exposure group consisted of patients who received TXA during their EMS encounter, termed the '+TXA' group. An additional exposure group of interest was patients who did not receive prehospital

TXA but did receive another life-saving circulation intervention (LSCI) from EMS. We refer to this as the '+LSCI –TXA' group. LSCIs were defined as any one of the following in the EpiC study: cardiopulmonary resuscitation (CPR); peripheral IV insertion; IV fluids for hypovolaemia; manual pressure for haemorrhage control; vessel clamping; pelvic binder; pressure dressing; or tourniquet. The comparison was termed the 'neither' group and consisted of patients who received neither TXA nor a LSCI during their primary EMS encounter. For the purposes of our study, we divided the SA prehospital qualification ranks into three distinct classifications based on the scope of practice to administer TXA and LSCIs. 'Basic' providers can administer all LSCIs except for IV, and cannot give TXA. 'Intermediate' providers can perform all LSCIs but cannot give TXA. 'Advanced' providers can administer both TXA and all LSCIs (Table 1).

Clinical scenarios

Among the study population (*N*=4 094), three distinct sub-cohorts were created based on clinical scenarios related to TXA eligibility. Each sub-cohort was restricted to patients who were encountered by EMS within 3 hours of their injury (which is the window for TXA eligibility).[28,31] Clinical scenario 1 included patients with moderate to severe risk of haemorrhagic shock (prehospital SBP ≤100 or shock index ≥1.0). Here, we aimed to describe how transportation time and provider qualification relate to TXA administrative practices. Clinical scenario 2 had more stringent criteria, and included patients with only severe shock (prehospital SBP ≤90 or prehospital shock index ≥1.2) who were eligible for prehospital TXA based on current local guidelines (i.e. no severe head injury, no severe burn, no CPR during EMS encounter) and had an EMS transport duration >15 minutes (selected because Western Cape EMS providers may be excused from delivering TXA during short transports). Here, we aimed to assess TXA administration among patients who were clearly eligible for TXA. Clinical scenario 3 included patients who received hospital-based interventions for haemorrhage management in an emergency centre within 3 hours of injury. These hospital interventions include receiving either TXA, any blood products, vasopressors, or inotropes, since these were surrogate indicators for the presence of traumatic shock.

Analysis

Descriptive analysis of patient demographics, injury characteristics, clinical interventions and outcomes was reported for each exposure group. Continuous variables were reported as medians and interquartile ranges (IQRs), while categorical variables were reported as frequencies and percentages. The Kruskal-Wallis rank sum test was used to assess differences in medians across multiple independent groups for continuous variables. This non-parametric method was selected due to visual evidence of non-normality observed in histograms. *P*-values were reported and evaluated at 95% confidence level. For categorical variables, Pearson's χ^2 test was used and the corresponding *p*-values were reported. Fisher's exact test was applied when one or more expected cell counts were <5. For the clinical scenarios, Sankey diagrams were used to visually depict the quantity and flow of prehospital trauma patients stratified by prehospital provider qualification levels. All analyses were performed in R version 4.4.2 (R Foundation for Statistical Computing, Austria). Sankey diagrams were produced in R using the package networkD3.

Ethical considerations

Ethics

al approval was received with a waiver of informed consent from the Health Research Ethics Committee at Stellenbosch University, the primary institutional review board (IRB) (project ID 14866; ref. no. N20/03/036). The Colorado Multiple IRB ceded primary ethics oversight to Stellenbosch (Protocol 20-2176). The US Defense Health Agency Office of Human Research Oversight provided second-level review and concurrence (OHRO log no. E01863.1x).

Results

A total of 4 094 patients met the study inclusion criteria and were deemed at risk of haemorrhage (Fig. 1). As depicted in Table 2, these patients had a median (IQR) age of 32 (26 - 40) years, and 77% (*n*=3 152) were male. The majority of the sample (*n*=2 203, 66%) had penetrating injuries as their primary injury type. Severe injuries (new injury severity score (NISS) >15) occurred in 32% (*n*=1 301), and moderate injuries (NISS 9 - 15) in 21% (*n*=846). Patients triaged as emergent (considered 'red' on the SA Triage Scale) made up 25% (*n*=1 029) of the cohort. A total of 25% (*n*=828) had a prehospital SBP of ≤90, and 14% (*n*=567) had severe shock (shock index ≥1.2).

Median (IQR) time from injury to EMS arrival was 0.93 (0.48 - 2.00) hours. EMS arrived on scene within 3 hours of injury for 82% (*n*=3 325) of patients, which is the time window for TXA administration eligibility. A total of 67% (*n*=2 739) of the cohort had an EMS transport duration of >15 minutes, which was selected to represent the shortest possible transport time during which TXA could be reasonably expected to be administered.

Prehospital TXA administration occurred in 116 patients (2.8%) within the study cohort. Among patients who received TXA, the majority (*n*=95, 83%) received a 1 g dose, while 15 patients (14%) received a 2 g dose, and 4 patients (3.5%) received alternative dosing (0.5 g or 3 g). The median (IQR) time from injury to prehospital TXA was 0.98 (0.67 - 1.60) hours. More than half the cohort (*n*=2 135, 52%) received at least one LSCI other than TXA from a prehospital provider. Mortality rates were 0.5% (*n*=20) during EMS encounters, and 7.1% (*n*=291) died in hospital.

We divided the study population into three exposure groups based on key treatments administered by EMS providers (Table 2).

Table 1. Study classification of prehospital providers based on scope of practice to administer TXA and LSCIs

Prehospital qualification	Licensed to administer LSCIs (excluding IV catheters)	Licensed to insert IV catheters	Licensed to administer TXA	Study classification of EMS professionals
BAA	Yes	No	No	Basic
AEA	Yes	Yes	No	Intermediate
ECT	Yes	Yes	No	Intermediate
ALS	Yes	Yes	Yes	Advanced
ECP	Yes	Yes	Yes	Advanced

TXA = tranexamic acid; LSCI = life-saving circulation intervention; IV = intravenous; EMS = emergency medical services; BAA = basic ambulance assistant; AEA = ambulance emergency assistant; ECT = emergency care technician; ALS = advanced life support; ECP = emergency care practitioner.

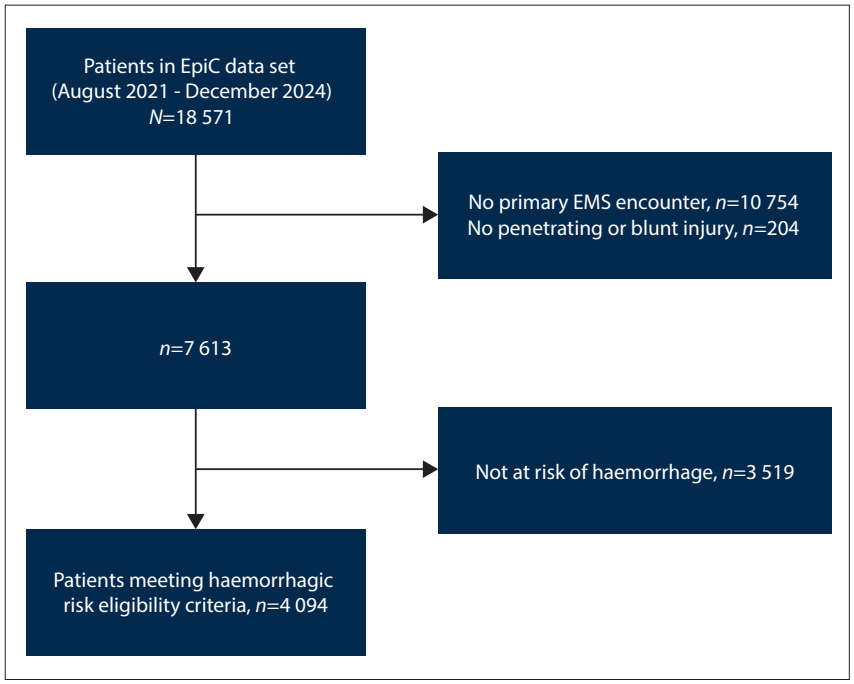

Fig. 1. Flow diagram depicting final study sample. (EpiC = Epidemiology and Outcomes of Prolonged Trauma Care;[35] EMS = emergency medical services.)

The +TXA group consisted of the 2.8% of patients who received TXA. An additional 49% (*n*=2 020) of the cohort fell in the +LSCI –TXA group. The remaining 48% (*n*=1 958) of patients in the study were in the 'neither' treatment group.

Patients managed by an advanced prehospital provider (authorised to administer TXA) comprised 32% (*n*=1 305) of the study population. Of these patients, 8.9% (*n*=116) received TXA and 66% (*n*=860) received a LSCI. More than half of the cohort (*n*=2 247, 55%) received prehospital care from an intermediate prehospital provider (unable to give TXA owing to scope of practice limitations). These prehospital providers are licensed to administer all LSCIs, and 50% (*n*=1 126) of patients managed by these providers received a LSCI. Of the patients who were managed by basic prehospital providers (capable of performing the majority of LSCIs), 28% (*n*=145) received a LSCI.

Injury force type differed across treatment groups ($p<0.001$), with penetrating injuries accounting for 53% (*n*=61) in the +TXA group and 57% (*n*=1 154) in the +LCSI –TXA group. The majority of patients (*n*=87, 76%) in the +TXA group had a NISS >15, while 40% (*n*=809) and 21% (*n*=405) had a NISS >15 in the +LCSI –TXA and 'neither' groups, respectively. Almost two-thirds (*n*=71, 61%) in the +TXA group were triaged by EMS as 'emergent/red', compared with 37% (*n*=742) and 11% (*n*=216) in the +LCSI –TXA and 'neither' groups, respectively. The prevalence of SBP ≤90 differed across treatment groups ($p<0.001$): 45% (*n*=52) of patients in the +TXA group, 30% (*n*=600) in the +LSCI –TXA group and 9% (*n*=176) in the 'neither' group. Prevalence of severe shock (shock index ≥1.2) also varied across treatment groups ($p<0.001$), with 35% (*n*=41) in the +TXA group, 20% (*n*=42) in the +LSCI –TXA group and 6% (*n*=114) in the 'neither' group. A similar proportion of +TXA and +LSCI –TXA patients received TXA in hospital (14%, *n*=16; 15%, *n*=299). The prevalence of blood products given in hospital differed across treatment groups ($p<0.001$). Blood products were administered more frequently to the +TXA group than the +LSCI –TXA group (44% (*n*=51) v. 21% (*n*=422)). There was no difference in EMS transport duration category (≤15 minutes v. >15 minutes) across treatment groups ($p>0.9$).

Next, we present the results of the clinical scenarios. In clinical scenario 1, 1 507 (36.81%) patients met the inclusion criteria for moderate to severe risk of shock. Clinical scenario 2 consisted of 488 (11.92%) patients with severe risk of shock and indication for prehospital TXA. In clinical scenario 3, there were 513 (12.53%) patients, all of whom received hospital-based interventions for haemorrhage. Figs 2 - 4 display the frequency of treatment groups by provider qualification levels. Across all three clinical scenarios (Figs 2 - 4), for cases with a long EMS transport duration (>15 minutes), intermediate prehospital providers managed more than half of all patients (scenario 1: *n*=599, 56%; scenario 2: *n*=285, 58%; scenario 3: *n*=158, 51%). Across all scenarios, intermediate providers administered LSCIs to the majority of the patients they treated (scenario 1: *n*=391, 70%; scenario 2: *n*=225, 79%; scenario 3: *n*=113, 72%). Between 33% and 38% of patients in each scenario were managed by an advanced prehospital provider (scenario 1: *n*=328, 33%; scenario 2: *n*=161, 33%; scenario 3: *n*=118, 38%). Of those cases managed by an advanced provider, the frequency of TXA administration was ≤20% (scenario 1: *n*=57, 17%; scenario 2: *n*=30, 19%; scenario 3: *n*=24, 20%). Advanced providers administered other LSCIs with high frequency among patients who did not receive TXA (scenario 1: *n*=214, 79%; scenario 2: *n*=108, 82%; scenario 3: *n*=78, 83%). Few patients managed by advanced providers capable of administering TXA fell into the 'neither' group. TXA administration frequency was similar among those with short (<15 minutes) transport times (scenario 1: *n*=27, 5.3%; scenario 3: *n*=15, 7.5%) compared with those with transportation times >15 minutes (scenario 1: *n*=57, 5.7%; scenario 3: *n*=24, 7.8%) (scenario 2 only included patients with transport times >15 minutes).

Discussion

This study provides the first description of prehospital TXA eligibility and administration in SA, focusing on the Western Cape's government-run EMS system. Despite the well-established mortality benefit of early TXA administration in reducing haemorrhage-related mortality, both internationally and in SA,[23,28,33] our findings reveal that prehospital TXA administration in the Western Cape remains infrequent – only 3% of trauma patients at risk of haemorrhage received TXA during their prehospital care.

More than half (58%) of patients who were at risk of severe haemorrhage, met TXA eligibility criteria and had a transport duration >15 minutes (Fig. 3) were managed by intermediate prehospital providers (ambulance emergency assistant (AEA) and emergency care technician (ECT) qualifications). These providers are presently restricted from administering TXA despite managing the substantial trauma burden reported in SA. Interestingly, the majority of their clinical scope of practice includes a wide range of life-saving medications with high

Table 2. Characteristics of patients at risk of haemorrhage, by prehospital intervention group (*N*=4 094)

Characteristic	Overall, *n* (%)*	+TXA, *n*=116, *n* (%)*	+LSCI† –TXA, *n*=2 020, *n* (%)*	Neither, *n*=1 958, *n* (%)*	p-value‡
Age, years, median (IQR)	32 (26 - 40)	33 (26 - 43)	32 (26 - 40)	32 (26 - 40)	0.8
Male sex	3 152 (77)	92 (79)	1 658 (82)	1 402 (72)	<0.001
Injury force type					<0.001
Blunt	1 647 (40)	50 (43)	753 (37)	844 (43)	
Blunt + penetrating	244 (6.0)	5 (4.3)	113 (5.6)	126 (6.4)	
Penetrating	2 203 (54)	61 (53)	1 154 (57)	988 (50)	
Patient acuity					n/a§
Emergency (red)	1 029 (25)	71 (61)	742 (37)	216 (11)	
Very urgent (orange)	1 548 (38)	40 (34)	824 (41)	684 (35)	
Urgent (yellow)	1 191 (29)	5 (4.3)	388 (19)	798 (41)	
Routine (green)	295 (7.2)	0 (0)	60 (3.0)	235 (12)	
Deceased (blue)	9 (0.2)	0 (0)	6 (0.3)	3 (0.2)	
Triage early warning score	5 (3 - 6)	6 (5 - 9)	5 (4 - 7)	4 (3 - 5)	<0.001
Minimum SBP, median (IQR)	114 (95 - 130)	98 (78 - 117)	104 (90 - 124)	121 (107 - 134)	<0.001
SBP ≤90	828 (20)	52 (45)	600 (30)	176 (9.1)	<0.001
Maximum heart rate, median (IQR)	102 (86 - 115)	110 (92 - 126)	103 (86 - 115)	102 (86 - 114)	<0.001
Heart rate ≥110 bpm	1 666 (41)	58 (50)	820 (41)	788 (41)	0.13
Maximum shock index, median (IQR)	0.87 (0.73 - 1.05)	1.07 (0.82 - 1.43)	0.92 (0.76 - 1.13)	0.83 (0.70 - 0.96)	<0.001
Shock index ≥1.2	567 (14)	41 (35)	412 (20)	114 (5.9)	<0.001
Alert AVPU	3 428 (89)	69 (70)	1 593 (85)	1 766 (95)	<0.001
New injury severity score					<0.001
Minor (<9)	1 935 (47)	12 (10)	767 (38)	1 156 (59)	
Moderate (9 - 15)	846 (21)	16 (14)	440 (22)	390 (20)	
Severe (>15)	1 301 (32)	87 (76)	809 (40)	405 (21)	
Prehospital care					
Highest ranked EMS provider					n/a¶
Advanced	1 305 (32)	116 (100)	747 (37)	442 (23)	
Intermediate	2 247 (55)	0	1 126 (56)	1 121 (58)	
Basic	519 (13)	0	145 (7.2)	374 (19)	
Injury to EMS arrival ≤3 hours	3 325 (82)	115 (99)	1 715 (86)	1 495 (77)	<0.001
EMS transport >15 minutes	2 739 (67)	79 (68)	1 353 (68)	1 307 (68)	>0.9
Received EMS TXA	116 (2.8)	116 (100)	0	0	n/a¶
TXA dose					n/a¶
1 g	95 (83)	95 (83)	0	0	
2 g	16 (14)	16 (14)	0	0	
Other	4 (3.5)	4 (3.5)	0	0	
Injury to EMS TXA, hours, median (IQR)	0.98 (0.67 - 1.60)	0.98 (0.67 - 1.60)	n/a	n/a	n/a¶
EMS arrival to EMS TXA, hours, median (IQR)	0.35 (0.22 - 0.58)	0.35 (0.22 - 0.58)	n/a	n/a	n/a¶
Received any LSCI	2 135 (52)	115 (99)	2 020 (100)	0	n/a¶
Received adrenaline	19 (0.5)	6 (5.2)	12 (0.6)	1 (<0.1)	<0.001§
Received IV fluids	1 303 (32)	99 (85)	1 204 (60)	0	n/a¶
First facility interventions					
TXA <24 hours of arrival	471 (12)	16 (14)	299 (15)	156 (8.0)	<0.001
Blood products <24 hours of arrival	618 (15)	51 (44)	422 (21)	145 (7.4)	<0.001
Vasopressors or inotropes <24 hours of arrival	174 (4.3)	16 (14)	115 (5.7)	43 (2.2)	<0.001§
Patient outcomes					
Died during EMS encounter	20 (0.5)	0 (0)	16 (0.8)	4 (0.2)	0.04§
Died in hospital	291 (7.1)	23 (20)	195 (9.7)	73 (3.7)	<0.001

TXA = tranexamic acid; LSCI = life-saving circulation intervention; IQR = interquartile range; EMS = emergency medical services; SBP = systolic blood pressure; AVPU = alert, verbal, pain and unresponsive; IV = intravenous.
*Unless otherwise indicated.
†Prehospital LSCI defined as any one of the following: cardiopulmonary resuscitation, intraosseous access procedure, peripheral IV insertion, IV fluids, manual pressure for haemorrhage control, needle decompression, clamping, pelvic binder, pressure dressing, sutures for haemorrhage control, or tourniquet.
‡Kruskal-Wallis rank sum test was used for continuous variables; Pearson's χ^2 test was used for categorical variables.
§Fisher's exact test was used to calculate *p*-value for indicated rows as the expected cell count is <5. *P*-value is missing for variables where cell size is 0.
¶*P*-values were not calculated for variables that are, by definition, related to the treatment groups.

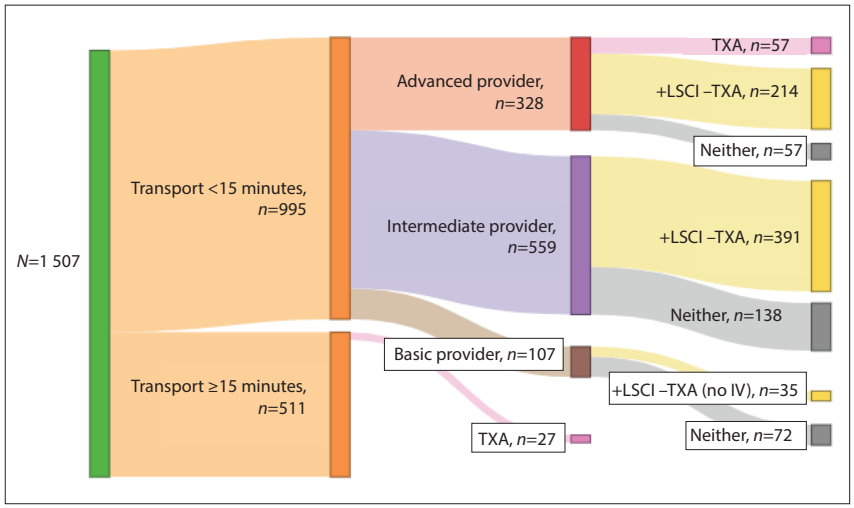

Fig. 2. Sankey diagram of prehospital care for patients with moderate to severe risk of shock (clinical scenario 1). (TXA = tranexamic acid; LSCI = life-saving circulation intervention.)

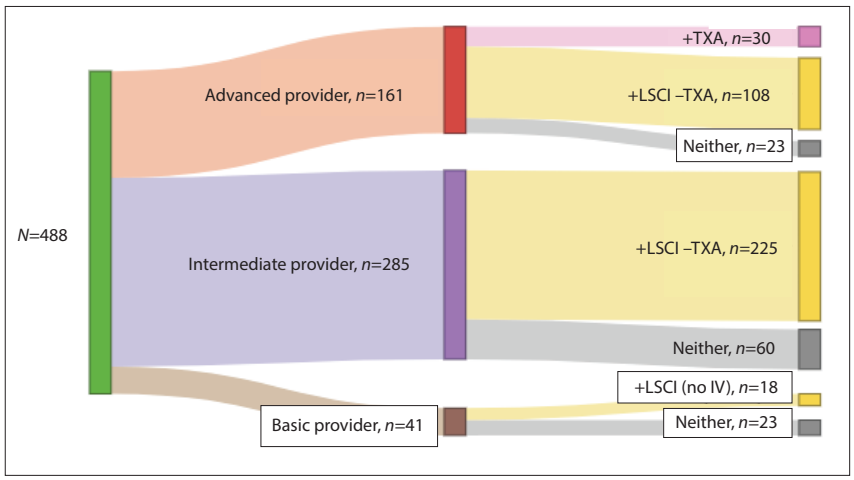

Fig. 3. Sankey diagram of prehospital care for patients with severe risk of shock (prehospital systolic blood pressure ≤90 or prehospital shock index ≥1.2) + indication for prehospital tranexamic acid (TXA) + emergency medicine services transport >15 minutes (clinical scenario 2). (LSCI = life-saving circulation intervention; IV = intravenous.)

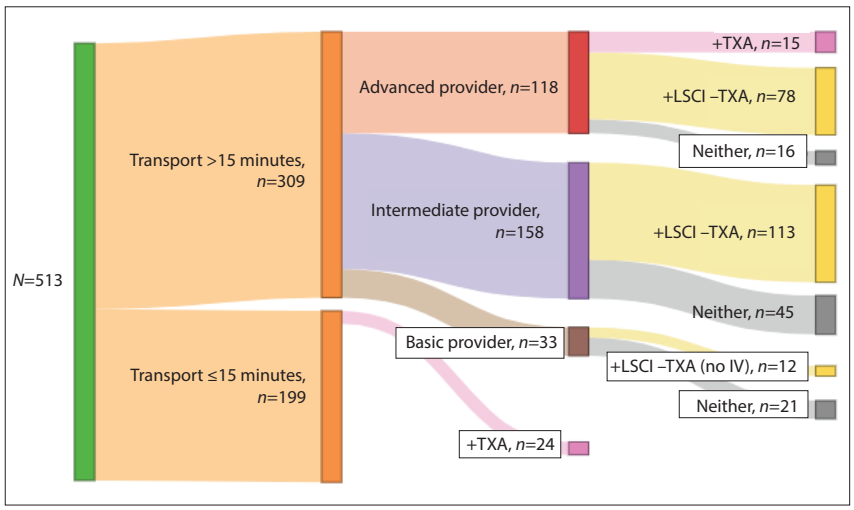

Fig. 4. Sankey diagram of prehospital care for patients who received hospital-based interventions for haemorrhage management within 3 hours of injury (received tranexamic acid (TXA), any blood products, vasopressors, or inotropes) (clinical scenario 3). (LSCI = life-saving circulation intervention; IV = intravenous.)

risk and safety profiles (e.g. adrenaline for cardiac arrest and anaphylaxis, magnesium sulphate during eclampsia, naloxone during opioid overdoses and methoxyflurane for pain).[31] Based on our findings and their clinical scope of practice, we anticipate that intermediate prehospital providers can identify trauma cases likely to benefit from prehospital TXA, and could fairly easily be upskilled to deliver prehospital TXA, thereby improving the overall prehospital delivery of TXA in this EMS system. In the Western Cape, prehospital training packages have demonstrated feasibility and efficacy in improving prehospital trauma care practices.[36]

Notably, even when advanced prehospital providers (advanced life support (ALS) and emergency care practitioner (ECP) qualifications) managed patients at risk of severe haemorrhage with an indication for TXA and with transport durations >15 minutes, <1 in 5 patients received TXA. Incidentally, most of those patients received a LSCI (Fig. 3). Cumulatively, almost half of all patients in the study population received neither TXA nor prehospital circulatory supportive interventions. These findings raise concerns when contextualised against the regional backdrop of high trauma mortality, and the local evidence demonstrating that early TXA can reduce all-cause mortality by up to 38% when given within 3 hours of injury.[28] We concede that there may have been legitimate reasons why TXA was not administered that may not be recorded by the EpiC study, such as clinical contraindications and patient refusal. Notwithstanding, these findings highlight missed opportunities for early pharmacological haemorrhage control despite provider capability and logistical feasibility. Owing to the substantial trauma burden, prehospital providers may be desensitised to urgent clinical practices.[16,36]

An important finding was that 1 g IV TXA was the most common dosage, despite SA guidelines and historic international evidence supporting a 2 g IV regimen as being more efficacious.[37] More recent international and local evidence suggests that there may be equivalent effectiveness of 1 g intramuscular (IM) compared with 2 g IV TXA; however, 2 g IV TXA remains the current standard of care, and only IV TXA is approved in SA for haemorrhage from trauma.[28,38] The US military incorporated 2 g IV or IM bolus administration of TXA in the Tactical Combat Casualty Care guidelines a decade ago.[32,39-41] Although IM administration offers a pharmacokinetic

profile comparable with IV delivery and would be ideally suited for SA prehospital conditions, current pharmaceutical limitations prevent widespread implementation in this setting.[39,42] Specifically, the absence of concentrated TXA formulations necessitates large-volume administration, meaning that IM delivery is not patient-centred. Trauma researchers and pharmaceutical manufacturers are keenly aware of this gap, and are collaborating to develop concentrated formulations to address this constraint, which could potentially facilitate the adoption of evidence-based 2 g IM dosing protocols across LMICs, should that remain the standard.

Our findings have implications for SA practice, policy and public health. Expanding the scope of TXA administration to AEA and ECT providers who manage the majority of the prehospital trauma burden could have a substantial public health impact by reducing trauma deaths. We estimate that such a policy shift could enable timely TXA delivery to more than two-thirds of currently eligible patients. Applying previously published mortality benefit estimates (a 38% reduction in all-cause mortality with early TXA), we anticipate significant gains in trauma population survivorship if this expansion is implemented. Additionally, supplementary training, clinical decision support tools and continuous quality assurance mechanisms may improve uptake even among mid-level and professional qualification providers. The integration of automated eligibility screening tools into electronic patient care records, combined with ongoing audit-feedback cycles, may further reduce treatment omissions and sustain delivery across the EMS system.

Study limitations and future directions

This study is subject to several limitations. The analysis was limited to data from the EpiC cohort, which, while robust, only represents a cross-section of trauma in the Western Cape. As an observational study, variability in documentation quality, under-reporting of interventions and provider-level decision-making rationales (not recorded in the dataset) may also introduce bias.

Future research should expand the current analysis to the full provincial EMS dataset and incorporate prospective data collection to assess real-time decision-making, provider-level barriers and system-level facilitators of TXA delivery. Moreover, health economic analyses estimating the cost-effectiveness of expanding TXA scope to AEA and ECT providers could further support policy advocacy. Finally, implementation science approaches will be critical in designing and evaluating system-wide interventions aimed at improving haemorrhage management in LMIC prehospital settings.

Conclusion

This study reveals a critical gap in prehospital haemorrhage management in the Western Cape of SA, with only 2.8% of patients at risk of traumatic haemorrhage receiving TXA despite its established mortality benefit. The principal barrier identified is the current scope-of-practice restriction preventing intermediate providers (AEA and ECT qualifications), who manage two-thirds of eligible patients, from administering TXA. This creates a regulatory dilemma, as TXA is safe and efficacious in this setting, and AEAs and ECT providers perform more complex procedures and administer more high-risk medications than TXA. Even advanced providers (ALS and ECP qualifications) administered TXA to <20% of eligible patients, suggesting additional system-wide barriers. Based on previous evidence demonstrating a 38% reduction in all-cause mortality with early TXA, expanding administration authorisation to AEA and ECT providers represents a large opportunity to expand prehospital TXA delivery to help reduce trauma mortality in SA. Future work should assess strategies to implement and sustain TXA use, accompanied by prehospital practice policy reform to align TXA clinical practice guidelines with the epidemiological reality of trauma care delivery in the Western Cape Province of SA.

***Author information.** The group author 'EpiC Study Site Collaborators' is comprised of: Mohamed Mayet, MB ChB – Khayelitsha Hospital; Lesley Hodsdon, MB ChB – Worcester Regional Hospital; L'Oreal Snyders, MB ChB – Delft Community Health Centre; Leigh Wagner, MB ChB – Khayelitsha Site-B Community Health Centre; Karlien Doubell, MB ChB – Ceres District Hospital; Denise Lourens, MB ChB – Worcester Forensic Pathology Services Laboratory. All are employees of Western Cape Government Health and Wellness, Cape Town, SA.

Data availability. Public access to the data set is closed. The data sets included and/or analysed during the current study are available from the corresponding author upon reasonable request and upon meeting contractual and regulatory requirements.

Declaration. None.

Acknowledgements. We would like to recognise the staff of the Western Cape Government EMS for their collaboration on this study. We would also like to thank the staff of the Collaborative for Emergency Care in Africa for their important contribution to the study in the form of data abstraction: Mandy Abels, Razia Amien, Lauren Barron, Saeeda Benjamin, Raeesah Bray, Anthony Carr, Melany Codling, Zuleiga Davids, Ameerah Davids, Aneeka Domingo, Magzane Ghall, Chloe Ile, Daisy Inglis, Alana Joste, Farren Kleinsmith, Vusumzi Kose, Mudiwa Llobell, Jani Marais, Kelsey McIntyre, Minnie Minnaar, Tanisha Morris, Tevarus Naicker, Azia Parker, Justin Petersen, Tahrir Rasool, Astrid Samuels, Kirsten Scoble, Regan Smith, Anronel Stofberg, Andre Swanepoel, Alexa Mentz, Catherine Wandie, and Shariefa Williams.

Author contributions. NA and NM conceived the study. NA interpreted findings and drafted the manuscript. JY curated the data set, performed the analyses and assisted with results interpretation. WS, CW, HJL, GO, SdV, JV and ESSC provided project administrative oversight, supervised data collection, provided contextual input and made critical revisions to the article. JMD and NM interpreted findings and provided critical revisions. WS, CW, HJL, SdV and NM secured funding and project resources. All authors approved the final version of the manuscript.

Funding. The EpiC study was supported by US Defense Health Agency award numbers/grant log numbers: W81XWH-20-2-0042, W81XWH-22-1-0883, HT9425-23-1-1025, ID0720010-301-24.

Conflicts of interest. The authors declare no conflicts of interest. They have received funding from the US Defense Health Agency in the form of grants to their institutions.

AI contribution. No artificial intelligence-assisted technologies were used in the production of the submitted work.

1. World Health Organization. Injuries and violence. Geneva: WHO, 2024. https://www.who.int/news-room/fact-sheets/detail/injuries-and-violence (accessed 27 February 2025).
2. National Safety Council. Injury facts: International overview. Itasca: NSC, 2022. https://injuryfacts.nsc.org/international/international-overview/ (accessed 27 February 2025).
3. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990 - 2019: A systematic analysis for the Global Burden of Disease Study 2019. Lancet 2020;396(10258):1204-1222. https://doi.org/10.1016/s0140-6736(20)30925-9
4. Haagsma JA, Graetz N, Bolliger I, et al. The global burden of injury: Incidence, mortality, disability-adjusted life years and time trends from the Global Burden of Disease study 2013. Injury Prev 2016;22(1):3-18. https://doi.org/10.1136/injuryprev-2015-041616
5. Gosselin R. Injuries: The neglected burden in developing countries. Bull World Health Org 2009;87(4):246-246. https://doi.org/10.2471/blt.08.052290

6. Mock CN, Jurkovich GJ, nii-Amon-Kotei D, Arreola-Risa C, Maier RV. Trauma mortality patterns in three nations at different economic levels. J Trauma Acute Care Surg 1998;44(5):804-814. https://doi.org/10.1097/00005373-199805000-00011
7. Jones AR, Miller J, Brown M. Epidemiology of trauma-related hemorrhage and time to definitive care across North America: Making the case for bleeding control education. Prehospital Disaster Med 2023;38(6):780. https://doi.org/10.1017/S1049023X23006428
8. Mould-Millman NK, Sasser S, Wallis L. Prehospital research in sub-Saharan Africa: Establishing research tenets. Acad Emerg Med 2013;20:1304-1309. https://doi.org/10.1111/acem.12269
9. Bedard AF, Mata LV, Dymond C, et al. A scoping review of worldwide studies evaluating the effects of prehospital time on trauma outcomes. Int J Emerg Med 2020;13(1):64. https://doi.org/10.1186/s12245-020-00324-7
10. Suryanto S, Plummer V, Boyle M. EMS systems in lower-middle income countries: A literature review. Prehospital Disaster Med 2016,32(1):64-70. https://doi.org/10.1017/S1049023X1600114X
11. Kironji AG, Hodkinson P, de Ramirez SS, et al. Identifying barriers for out of hospital emergency care in low and low-middle income countries: A systematic review. BMC Health Serv Res 2018;18(1):291. https://doi.org/10.1186/s12913-018-3091-0
12. Mould-Millman NK, Dixon JM, Sefa N, et al. The state of emergency medical services (EMS) systems in Africa. Prehospital Disaster Med 2017;32(3):273-283. https://doi.org/10.1017/S1049023X17000061
13. Matzopoulos R, Prinsloo M, Pillay-van Wyk V, et al. Injury-related mortality in South Africa: A retrospective descriptive study of postmortem investigations. Bull World Health Org 2015;93(5):303-313. https://doi.org/10.2471/BLT.14.145771
14. Groenewald P, Neethling I, Evans J, et al. Mortality trends in the City of Cape Town between 2001 and 2013: Reducing inequities in health. S Afr Med J 2017;107(12):1091-1098. https://doi.org/10.7196/SAMJ.2017.v107i12.12458
15. Hardcastle TC, Clarke D, Oosthuizen G, Lutge E. Trauma, a preventable burden of disease in South Africa: Review of the evidence, with a focus on KwaZulu-Natal. S Afr Health Rev 2016;2016(1):179-189.
16. Abdullah N, Saunders C, McCaul M, Nyasulu P. A retrospective study of the pre-hospital trauma burden managed by the Western Cape Government Emergency Medical Services. S Afr J Pre Hosp Emerg Care 2021;2(1):18-26. https://doi.org/10.24213/2-1-4440
17. Tisherman SA, Schmicker RH, Brasel KJ, et al. Detailed description of all deaths in both the shock and traumatic brain injury hypertonic saline trials of the resuscitation outcomes consortium. Ann Surg 2015;261(3):586. https://doi.org/10.1097/SLA.0000000000000837
18. Moresky RT, Razzak J, Reynolds T, et al. Advancing research on emergency care systems in low-income and middle-income countries: Ensuring high-quality care delivery systems. BMJ Glob Health 2019;4(Suppl 6):e001265. https://doi.org/10.1136/bmjgh-2018-001265
19. Kalkwarf KJ, Drake SA, Yang Y, et al. Bleeding to death in a big city: An analysis of all trauma deaths from hemorrhage in a metropolitan area during 1 year. J Trauma Acute Care Surg 2020;89(4):716-722. https://doi.org/10.1097/TA.0000000000002833
20. Smith AA, Ochoa JE, Wong S, et al. Prehospital tourniquet use in penetrating extremity trauma: Decreased blood transfusions and limb complications. J Trauma Acute Care Surg 2019;86(1):43. https://doi.org/10.1097/TA.0000000000002095
21. Drake SA, Holcomb JB, Yang Y, et al. Establishing a regional trauma preventable/potentially preventable death rate. Ann Surg 2020;271(2):375-382. https://doi.org/10.1097/SLA.0000000000002999
22. Roberts I, Shakur H, Coats T, et al. The CRASH-2 trial: A randomised controlled trial and economic evaluation of the effects of tranexamic acid on death, vascular occlusive events and transfusion requirement in bleeding trauma patients. Health Technol Assess 2013;17(10):1-79. https://doi.org/10.3310/hta17100
23. Acharya P, Amin A, Nallamotu S, et al. Prehospital tranexamic acid in trauma patients: A systematic review and meta-analysis of randomised controlled trials. Front Med 2023;20(10):1284016. https://doi.org/10.3389/fmed.2023.1284016
24. Fouche PF, Stein C, Nichols M, et al. Tranexamic acid for traumatic injury in the emergency setting: A systematic review and bias-adjusted meta-analysis of randomised controlled trials. Ann Emerg Med 2024;83(5):435-445. https://doi.org/10.1016/j.annemergmed.2023.10.004
25. Alhenaki AM, Ali AS, Kadir B, Ahmed Z. Pre-hospital administration of tranexamic acid in trauma patients: A systematic review and meta-analysis. Trauma 2022;24(3):185-194. https://doi.org/10.1177/14604086211001163
26. Guyette FX, Brown JB, Zenati MS, et al. Tranexamic acid during prehospital transport in patients at risk for hemorrhage after injury: A double-blind, placebo-controlled, randomised clinical trial. JAMA Surg 2020;156(1):11-20. https://doi.org/10.1001/jamasurg.2020.4350
27. The PATCH-Trauma Investigators, ANZICS Clinical Trials Group. Prehospital tranexamic acid for severe trauma. N Engl J Med 2023;389(2):127-136. https://doi.org/10.1056/NEJMoa2215457
28. Wogu AF, Dixon JM, Xiao M, et al. Tranexamic acid is associated with post-injury mortality in a resource-limited trauma system: Findings from the epidemiology and outcomes of prolonged trauma care cohort study. Transfusion 2025;65(S1):S276-S287. https://doi.org/10.1111/trf.18171
29. Sobuwa S, Christopher L. Emergency care education in South Africa: Past, present and future. Australas J Paramed 2019;16:01-5. https://doi.org/10.33151/ajp.16.647
30. Tiwari R, Naidoo R, English R, Chikte U. Estimating the emergency care workforce in South Africa. Afr J Prim Health Care Fam Med 2021;13(1):9. https://doi.org/10.4102/phcfm.v13i1.3174
31. Health Professions Council of South Africa. Clinical practice guidelines. Pretoria: HPCSA, 2019. https://hpcsa.co.za/c9d35f68-f0de-4082-b50f-187302c96603 (accessed 26 September 2024).
32. Al-Jeabory M, Szarpak L, Attila K, et al. Efficacy and safety of tranexamic acid in emergency trauma: A systematic review and meta-analysis. J Clin Med 2021;10(5):1030. https://doi.org/10.3390/jcm10051030
33. Chen HY, Wu LG, Fan CC, Yuan W, Xu WT. Effectiveness and safety of prehospital tranexamic acid in patients with trauma: An updated systematic review and meta-analysis with trial sequential analysis. BMC Emerg Med 2024;24(1):202. https://doi.org/10.1186/s12873-024-01119-2
34. Setliff J, Dalton J, Sadhwani S, et al. Examining the safety profile of a standard dose tranexamic acid regimen in spine surgery. Neurosurg Focus 2023;55(4):E16. https://doi.org/10.3171/2023.7.FOCUS23384
35. Suresh K, Dixon JM, Patel C, et al. The epidemiology and outcomes of prolonged trauma care (EpiC) study: Methodology of a prospective multicenter observational study in the Western Cape of South Africa. Scand J Trauma Resusc Emerg Med 2022;30(1):55. https://doi.org/10.1186/s13049-022-01041-1
36. Mould-Millman NK, Dixon JM, van Ster B, et al. Clinical impact of a prehospital trauma shock bundle of care in South Africa. Afr J Emerg Med 2022;12(1):19-26. https://doi.org/10.1016/j.afjem.2021.10.003
37. Drew B, Auten JD, Cap AP, et al. The use of tranexamic acid in tactical combat casualty care: TCCC proposed change 20-02. J Spec Oper Med 2020;20(3):36. https://doi.org/10.55460/ZWV3-5CBW
38. Gunn F, Stevenson R, Almuwallad A, et al. A comparative analysis of tranexamic acid dosing strategies in traumatic major hemorrhage. J Trauma Acute Care Surg 2024;96(2):216-224. https://doi.org/10.1097/TA.0000000000004177
39. Steele D, Ballard PK, Burke R, Ferguson B. Intramuscular tranexamic acid administration on the battlefield. Case Rep Emerg Med 2022;2022:9689923. https://doi.org/10.1155/2022/9689923
40. Utsumi S, Kawakami A, Amemiya Y. Optimal dose of tranexamic acid in traumatic brain injury: Systematic review and network meta-analysis of randomised controlled trials. J Trauma Acute Care Surg 2025;98(5):816-823. https://doi.org/10.1097/TA.0000000000004500
41. Vu EN, Wan WCY, Yeung TC, Callaway DW. Intramuscular tranexamic acid in tactical and combat settings. J Spec Oper Med 2018;18(1):62-68. https://doi.org/10.55460/plw2-kn9z
42. Brenner A, Shakur-Still H, Chaudhri R, et al. Tranexamic acid by the intramuscular or intravenous route for the prevention of postpartum haemorrhage in women at increased risk: A randomised placebo-controlled trial (I'M WOMAN). Trials 2023;24(1):782. https://doi.org/10.1186/s13063-023-07687-1

Received 27 June 2025; accepted 2 October 2025.