Barriers and facilitators to the administration of pre-hospital tranexamic acid: a paramedic interview study using the theoretical domains framework

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ABSTRACT

Background: Tranexamic acid (TXA) is an antifibrinolytic drug used to prevent bleeding. It was introduced as an intervention for post-traumatic haemorrhage across emergency medical services (EMS) in the United Kingdom (UK) during 2012. However, despite strong evidence of effectiveness, pre-hospital TXA administration rates are low. This study used the theoretical domains framework (TDF) to identify barriers and facilitators to the administration of TXA to trauma patients by EMS providers (paramedics) in the UK.

Methods: Interviews were completed with 18 UK paramedics from a single EMS provider organisation. A convenience sampling approach was used, and interviews continued until thematic saturation was reached. Semi-structured telephone interviews explored paramedics' experiences of administering TXA to trauma patients, including identifying whether or not patients were at risk of bleeding. Data were analysed inductively using thematic analysis (stage 1). Themes were mapped to the theoretical domains of the TDF to identify behavioural theory-derived barriers and facilitators to the administration of TXA to trauma patients (stage 2). Belief statements were identified and assessed for importance according to prevalence, discordance and evidence base (stage 3).

Results: Barriers and facilitators to paramedics' administration of TXA to trauma patients were represented by eleven of the 14 domains of the TDF. Important barriers included a lack of knowledge and experience with TXA (Domain: Knowledge and Skills), confusion and restrictions relating to the guidelines for TXA administration (Domain: Social/professional role and identity), a lack of resources (Domain: Environmental context and resources), and difficulty in identifying patients at risk of bleeding (Domain: Memory, attention and decision processes).

Conclusions: This study presents a behavioural theory-based approach to identifying barriers and facilitators to the pre-hospital administration of TXA to trauma patients in the UK. It identifies multiple influencing factors that may serve as a basis for developing an intervention to increase pre-hospital administration of TXA.

KEY MESSAGES

Section 1: What is already known on this subject
• The administration of Tranexamic acid (TXA) for post-traumatic haemorrhage was introduced as an intervention across all emergency medical service (EMS) provider organisations (ambulance services) in the UK during 2012. • Despite a strong evidence base, a nationwide approach to implementation, and inclusion in UK ambulance guidelines, only around 5% of all patients at risk of haemorrhage following trauma receive TXA in the pre-hospital setting; this is concerning, as the earlier TXA is given the more effective it is. • Paramedics are best placed to administer TXA in the pre-hospital setting, however the barriers to TXA administration by paramedics are currently unknown.
Section 2: What this study adds
• In this qualitative study of 18 paramedics, important barriers to paramedic TXA administration were described and included a lack of knowledge and experience with TXA (Domain: Knowledge and Skills), confusion and restrictions relating to the guidelines for TXA administration (Domain: Social/professional role and identity), a lack of resources (Domain: Environmental context and resources), and difficulty in identifying patients at risk of bleeding (Domain: Memory, attention and decision processes). • This study presents a behavioural theory-based approach to identifying barriers and facilitators to the pre-hospital administration of TXA to trauma patients in the UK, and identifies multiple influencing factors that may serve as a basis for developing an intervention to increase pre-hospital administration of TXA.

BACKGROUND

Trauma remains one of the most common causes of death and disability globally.[1] Across England and Wales, trauma accounts for around 16,000 deaths per year.[2] One of the main causes of death from trauma is bleeding,[3] accounting for over half of all trauma deaths.[4]

Tranexamic acid (TXA) is an antifibrinolytic drug that prevents bleeding, and has been used in surgical practice for half a century.[5] More recently, TXA has been administered to treat traumatic bleeding after injury, and in a large international trial it was shown to significantly reduce the risk of death from bleeding following trauma.[6] This is well supported by other research, in which administration of TXA is shown to effectively control bleeding[7] and significantly reduce the development of multiorgan failure,[7-8] with no adverse effects.[9]

Early administration of TXA is critical.[5,10] A meta-analysis of two large trials of TXA administration (CRASH-2[6] and WOMAN[11]) found that immediate treatment improved survival by more than 70%, and that this survival benefit decreased by 10% for every 15 minutes of treatment delay.[12] As such, the administration of TXA for post-traumatic haemorrhage was introduced as an intervention across all emergency medical service (EMS) provider organisations (ambulance services) in the UK during 2012.[13] However, despite a strong evidence base, a nationwide approach to implementation, and inclusion in the Joint Royal Colleges Ambulance Liaison Committee (JRCALC) guidelines since 2013, only around 5% of all patients in the UK Trauma Audit and Research Network (TARN) who are at risk of haemorrhage following trauma receive TXA in the pre-hospital setting[14].

EMS providers (paramedics) are therefore best placed to administer TXA, as they are usually the first to attend a trauma patient, and TXA administration occurs sooner when given by paramedics compared to hospital staff.[15] Given the clear benefits of pre-hospital TXA treatment for trauma patients at risk of bleeding, it is important to understand the barriers associated with its

administration by paramedics in the UK. A recent systematic review of the literature found no previous work explicitly exploring these barriers (Nicholson H, personal communication, 2021). The research reported in this paper used the Theoretical Domains Framework[16] (TDF) to address this knowledge gap.

METHODS

Approval for this study was obtained from the Health Research Authority (19/HRA/5247) and the University of the West of England Faculty of Health and Applied Sciences Research Ethics Committee (HAS.19.08.016).

Semi-structured telephone interviews were conducted with 18 operational paramedics from the South Western Ambulance Service NHS Foundation Trust (SWASFT) to explore the barriers and facilitators to TXA administration to trauma patients. This qualitative approach was chosen to enable researchers to explore, explain and describe complex processes and behaviours within the context in which they occur.

Setting

SWASFT is a large EMS provider organisation, with responsibility for the provision of ambulance services across an area of 10,000 square miles of South West England, serving a total population of over 5.5 million. The Trust has been a pioneer of TXA in pre-hospital practice, and in 2011 was the first ambulance service in the UK to implement administration of TXA to trauma patients.

Participant recruitment

A convenience sampling approach was used for recruitment. Participants were eligible to take part if they were working operationally as a paramedic, aged 18 years or over, and had sufficient proficiency in the English language to be able to engage in an interview. Paramedics with less than one year's experience were excluded.

The study was promoted in the weekly SWASFT news bulletin and eligible participants were invited to contact the research team to take part. Potential participants received a study information sheet, privacy notice and consent form via email and were asked to return the signed consent form if they wished to participate. Verbal confirmation of consent was audio-recorded at the start of the telephone interview. A £10 gift voucher was given to each participant to acknowledge their contribution. Recruitment concluded when interviews ceased yielding new information related to identifying patients at risk of bleeding and TXA administration.

Design

A topic guide (Appendix 1) was developed by the study team, including three paramedics, two senior academics in Emergency Care, the research manager of SWASFT, and a member of the National Institute for Health Research (NIHR) Research Design Service. Questions explored participants' experiences of attending trauma patients, in relation to identifying patients at risk of bleeding, and administering TXA. Telephone interviews lasted between 20-45 minutes, and were conducted by an experienced qualitative researcher (LG) at a time convenient to the participant. Audio-recordings of the interviews were made using Skype for Business. Recordings were transcribed verbatim and anonymised.

Patient and public involvement (PPI)

The SWASFT Patient Involvement in Research Group (PIRG) were involved from the early stages of the study; the study team were in regular consultation with the group who advised on key questions, structure of the interviews (including length and incentive offered), and participant recruitment methods.

Data Analysis

The Theoretical Domains Framework (TDF) was used to explore the data for theory-based influences on behaviour. The TDF is a theory-based validated tool, developed by a collaboration of behavioural scientists and implementation researchers, which has been used to help understand the behaviour

of health professionals in a variety of settings.[16] It synthesises 33 theories of behaviour and behaviour change, clustered into 14 domains which are used for data coding to detect a range of possible theory-based barriers and enablers to behaviour and behaviour change.[16]

Data were analysed across three stages (Table 1), beginning with inductive coding, followed by coding core themes into the domains outlined by the TDF (Insert Table 1 here).

Table 1. The three stages of data analysis

Stage	Procedures
1: Thematic Analysis	Thematic analysis was used to analyse each data source, in a data-driven inductive approach. Transcripts were imported into the data-management software NVivo 10, where two researchers (HN and LG) read the transcripts several times, and then independently coded selections of text to represent instances of a concept. Codes were reviewed in terms of their relationship to other codes and combined to create more developed themes. From this analysis, distinctions could be made between the different levels of themes (e.g. main overarching themes and subthemes within them).
2: Coding themes into TDF domains	Two researchers (HN and LG) independently coded themes into the TDF domains; going back to the original data coded within each theme to check this was an accurate representation of the domain.
3: Thematic synthesis and generation of belief statements	The researchers came together to compare coding of themes into domains. Themes that were coded in different domains by the researchers were discussed to establish consensus. In instances where single domain allocation agreement could not be reached, a third researcher (SV) was asked for input. One researcher (LG) generated 'belief statements' to represent the specific belief from each theme, and provide detail about the role of the domain in influencing the target behaviour (TXA administration). This strategy was reviewed by the second researcher (HN) to ensure an accurate representation of content

RESULTS

Participant characteristics

Eighteen operational paramedics took part in semi-structured telephone interviews during December 2019. The majority of participants were male (78%). Participants represented the full range of paramedic qualification routes, and experience as a qualified paramedic ranged from 13 months to 34 years. Participants' job titles comprised: Clinical Lead (n = 1); Hazardous Area Response

Team Paramedic (n = 1); Learning Development Officer (n = 1); Lead Paramedic (n = 2); Newly Qualified Paramedic (n = 4); Operations Officer (n = 2); and Paramedic (n = 7). All but one participant had experience of administering TXA themselves, while the other participant had not personally administered TXA but had seen it being given by the Helicopter Emergency Medical Services (HEMS) team.

Key Theoretical Domains

A total of 947 utterances from the 18 interviews were coded into the 14 domains of TDF. Eleven domains of the TDF collectively captured the major barriers and facilitators to paramedic administration of TXA to trauma patients: Knowledge; Skills; Social/professional role and identity; Beliefs about capabilities; Beliefs about consequences; Reinforcement; Goals; Memory, attention and decision processes; Environmental context and resources; Social influences; Emotion. The domains of 'Knowledge' and 'Skills' were combined to form one domain of 'Knowledge and Skills' due to the interconnection of the domains in participant responses, therefore ten domains are presented in the findings of this paper (Table 2).

148 Table 2: Summary of belief statements and illustrative quotes by domain of the TDF.

Domain	Barrier/ Facilitator	Belief statement	Quote	Example quote	No. of transcripts	Richness of description
Beliefs about capabilities	Barriers	I/my colleagues do not have the confidence to administer TXA to a trauma patient	Q13	*There's a couple of patients that I thought about it but I wasn't 100% sure so I kind of left it to somebody else to make the decision I suppose (P018)*	7	Medium
		Paramedics get insufficient feedback on whether or not TXA was appropriately given, which hinders our confidence in administering it	Q14	*We rarely get a chance to follow up on our patients, we never know whether what we've done is right or wrong so we don't know if a particular patient we went to did get TXA in hospital and did benefit from it. (P008)*	4	
	Facilitators	I feel comfortable administering TXA to a trauma patient	Q12	*I haven't known of any adverse reactions or hypertension or anything from giving the drug. So, I think they're sort of, they're not scared of using it. (P014)*	9	Medium
		I observe HEMS administer TXA frequently, which has given me more confidence to administer it	Q15	*I've also had quite a lot of experience using it on … on HEMS, without any adverse effects that I've ever been aware of, and I've also seen it given fairly liberally in A&E. (P005)*	4	
Beliefs about consequences	Barrier	If I administer TXA, it means that they are a major trauma patient (and so they need to go to a trauma centre)	Q18	*I think people get a bit nervous of it because it kind of signifies actually we have got quite a significant injury here and I think sometimes people are a bit scared of making that call. (P009)*	5	Medium
	Both	I am aware/not aware of the safety of TXA	Q16	*I suppose I don't fully understand what the drug can do. You know - is it going to be a dangerous drug that if I give it and they are not bleeding, is it going to harm them? (P018)*	8	Medium
	Facilitator	The benefits of administering TXA outweigh the risks	Q17	*The risks of not giving it outweigh the risks of giving it, if you know what I mean. (P009)*	14	High

Emotion	Barrier	The stress of a trauma job means that TXA is sometimes forgotten/not prioritised	Q34	*There's so much going on, we want to get lines in, we want to get fluids, we want to sort airways out. Sometimes it does slip your mind because you're just trying to think about so many things and you know TXA sometimes is a bit of an afterthought. (P017)*	3	Low
Environmental context and resources	Barrier	I/we do not have sufficient resources (staff; time) to administer TXA	Q27 Q28	*I think one of the biggest barriers I see of TXA…is the time it takes to draw up because it's quite labour intensive (P001).* *And I think also the need to give it over 10 minutes is probably the biggest barrier. Because if you do sort of comply with the guideline and give it over 10 minutes its - one it's very difficult to do and - secondly it ties you up for 10 minutes trying to administer that through an IV. And generally, in those sorts of situations, there's other things that you'd like to be doing really. (P005)*	13	High
	Facilitators	TXA might be administered more often if it could be given in a different way	Q29	*The more simple the medicine administration the more likely it's going to get thought of and done…if we were allowed to add it into the fluid bag as part of an infusion, I don't know if that would work any better (P007).*	5	Medium
		TXA might be administered more often if paramedics had specialised equipment to help them identify bleeding	Q30	*If there was another diagnostics tool like ultrasound just to see if physically you can see the bleed, rather than going on the observations - I think that would just be a big positive and that would like, give people even more confidence to give it in those certain situations. (P004)*	6	
Goals	Barrier	Administration of TXA is not seen as a priority for trauma jobs	Q21	*And I think some people in situations where you've got somebody that's that injured it is*	8	Medium

				'right let's get going, let's get out, let's get in the ambulance, and let's get to hospital'. I think some people are worried about wasting too much time doing interventions when that sort of thing you can do it on the way. (P009)		
Knowledge and Skills	Barriers	Paramedics do not understand how TXA works	Q1 Q2	*Essentially it was due to a lack of knowledge around how the drug works and what the drug is actually indicated for… I think the level of understanding of what the drug actually does is quite low within the paramedics, you know. Just from who I've spoken to and the conversations I've had. (P001)* *Maybe a few people are unsure of the doses. I know…that a lot of people assume that its one ampule is the dose. I mean its … its not, its actually two ampules. Uh, so I come across, not so much now, but I come across people giving just one ampule or 500mg and they think that that's the dose. (P005)*	11	High
		I have not had enough training on when to administer TXA	Q5	*I think maybe perhaps it hasn't been emphasised enough during training. (P014)*	16	
	Both	I do/do not have much experience using TXA	Q6	*I can probably count on one hand the amount of times I've given it in the past three and a half years just purely because we don't see that much trauma. (P017)*	13	High
	Facilitator	I/we know the evidence base behind administering TXA	Q3 Q4	*I've done a bit of reading up on TXA, I've listened to some podcasts and things on it and I think I've got a good idea of what the current thinking is on it. (P005)* *We're mindful the quicker we give TXA the greater benefit. (P007)*	13	High

Memory, attention and decision processes	Barrier	It can be difficult to identify whether or not trauma patients are at risk of bleeding	Q24 Q25	*I think in theory it's easy because I can run off a list of things that we should be looking for but I think in practice it's not that easy. (P017)* *I think if they are really unwell it's really obvious, it's the ones that the sort of moderate ones that can be really difficult. (P008)*	15	High
	Both	When the patients' bleeding risk is unclear (i.e. no obvious external/internal bleeding) I use one/a number of the following factors to make my decision on whether or not to administer TXA: - Clinical observations (CO) - Mechanism of injury (MOI) - Patient presentation (PP) - Type of injury (TOI) - Patient history (PH) - Clinical judgement (CJ)	Q22 Q23	*So characteristics, I'd be looking for systemic changes such as tachycardia, and hypotension. (P017)* *I think actually to be honest, I've gone by mechanism a lot of the time, and if the mechanism is suggestive of an internal bleed then I've used that clue to guide things really. (P005)*	CO: 18 MOI: 18 PP: 15 TOI: 11 PH: 4 CJ: 4	High
	Facilitator	It would be helpful to have a triage tool/flow chart like the major trauma tool to help me decide when to administer TXA	Q26	*Maybe kind of like a flow chart type thing, like we have with the major trauma tool. A flow chart to maybe encourage patients with more moderate bleeding to be given it - could help. (P008)*	9	Medium
Reinforcement	Barriers	The lack of immediate visible effect of TXA on patients inhibits its use by paramedics.	Q20	*I do remember that whenever I, as a student even seeing TXA being used, I was kind of, it was a bit of an anti-climax because I was kind of like what's going to happen now. I was like ah okay [nothing]. And it was, you kind of, you look at these things and you are expecting to see something great and fantastic happening but it doesn't. (P003)*	2	Low

		I/my colleagues have a fear of repercussion of administering TXA to patients who do not need it	Q19	*The fear of repercussion can obviously impact people's clinical decisions, and that can either be the repercussion from the patient or the repercussions from management. (P003)*	5	
Social influences	Barrier	Trust culture hinders administration of TXA (TXA is only given for major trauma)	Q31	*It probably is almost like a cultural thing that TXA is a kind of a major trauma thing, rather than a routine for use drug. (P002)*	4	Low
	Both	My colleagues' opinions affect my administration of TXA	Q32	*I discussed it with another paramedic who was on with me at the time, so we had this discussion as to whether to administer or not and that's how we came to the decision. (P017)*	6	Medium
	Facilitator	I usually check with a senior colleague/doctor before administering TXA	Q33	*I'd probably call up [the hospital] and say 'this is what I'm bringing you, I'm going to be an hour, do you want me to start TXA?' (P007)*	7	Medium
Social/ professional role and identity	Barriers	The restrictions of working to a PGD hinder the administration of TXA to patients who would benefit from it	Q7	*I don't know whether it needs to be a change in the wording of the guidance to encourage [TXA administration]. I am just actually having a look at the guidance now, even the fact that itself that it is a PGD. I just don't really get why it should be a PGD. (P003)*	18	
		I/my colleagues are unsure as to which conditions/injuries we are able to administer TXA for	Q8 Q9	*I also think that gynaecological and GI bleeds or trauma also need to be clarified in the guidance. I'd like to see that given a mention because people are never sure whether to give that or not. (P005)* *It's like any of our guidelines in the JRCALC, they can be a little bit vague, and that's what they are they are guidelines but they can be a little bit too open to interpretation in my mind. (P009)*	6	High

	Both	There are differences in TXA administration guidelines between paramedics and HEMS/doctors	Q11	*I think, obviously the critical care and HEMS and things probably get on board a little bit quicker. So then obviously when sometimes when they turn up they'll start doing things or administering things slightly differently because their guidelines are slightly different, and obviously, a doctor can do things slightly differently to a paramedic. (P007)*	4	Low
	Facilitator	Paramedics should be able to administer TXA for more conditions/injuries	Q10	*I think for a drug that we do use, maybe there's scope to expand or extend our protocols for use in patients that have other symptoms, maybe not just a very specific set of vital signs. (P007)*	12	High

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Knowledge and Skills

More than half of the participants reported that a lack of knowledge about the physical effect of TXA was a barrier to its use (Q1-2). Additionally, participants emphasised the relative novelty of TXA in paramedic practice, and noted that consequently paramedics may not think of using it when attending trauma patients. However, knowledge of the evidence-base behind TXA use (i.e. effectiveness, timing and indications) was cited as a facilitator to TXA administration (Q3-4).

Training in TXA and its administration was discussed by almost all participants, who felt that the current training was inadequate, and that more could be done to raise awareness of the benefits and safety of TXA administration for trauma patients (Q5). Participants also identified a need for additional training on elderly trauma, and how to identify internal bleeding, in order to increase TXA administration rates.

Individual experience was also reported as a major barrier/facilitator in TXA administration (Q6); while some participants felt that their own experience of using the drug (or watching a colleague administer it) had boosted their confidence in administering TXA, others felt that their inexperience acted as a barrier to use, and reflected that this was due to a lack of paramedic exposure to trauma patients.

Social/professional role and identity

All participants reported that administering TXA under the current Patient Group Direction (PGD) felt restrictive or confusing, and could therefore hinder the administration of TXA to patients who would benefit from it (Q7). A third of participants cited uncertainty over which conditions/injuries TXA is indicated for (Q8-9), and two thirds felt that paramedics should be able to administer TXA in more instances, such as persistent heavy nosebleeds or where bleeding risk was uncertain (Q10).

There was also discussion regarding the disparity between paramedic TXA guidelines and those of HEMS doctors; participants noted that HEMS doctors did not have to work with the same 'restrictions' on TXA administration, and that this could cause confusion amongst paramedics (Q11).

Beliefs about capabilities

Participants differed greatly in their self-perceived confidence and comfort administering TXA to trauma patients, and thus beliefs about capabilities could be either a barrier or a facilitator, depending on participant (Q12-13). For those who expressed a lack of confidence in administering TXA, an additional barrier was the lack of feedback given to paramedics regarding patient outcome (i.e. whether TXA was administered/not administered correctly, Q14). However, some participants reported that watching their HEMS colleagues administer TXA had boosted their own confidence and comfort in using the drug, acting as a facilitator to future use (Q15).

Beliefs about consequences

The consequences of administering TXA were discussed in terms of safety, with some participants suggesting that they were unaware of the risks of inappropriate administration (Q16). However the majority of participants felt that the benefits of administering TXA outweighed the risks (Q17).

Some participants felt that the act of administering TXA signalled that their patient was a major trauma patient, who would need to be admitted to a major trauma centre (Q18). Participants noted that this could act as a barrier to TXA administration if there were concerns that their patient may not be accepted by the receiving staff at this facility.

Reinforcement

The most frequent barrier within this domain was the fear of repercussion from administering TXA to patients who did not need it (Q19). Repercussion was spoken about both in terms of formal discipline from the Trust, but also judgement from colleagues and/or other clinical staff. A further barrier within this domain was the lack of an immediate visible effect of TXA on trauma patients;

participants felt that this inhibited use of the drug, as paramedics rarely saw any positive effects from its administration during the pre-hospital phase of care (Q20).

Goals

Participants reported that the administration of TXA was often not seen as a priority for trauma patients, and that other treatments such as administering fluids would take precedent (Q21). Participants also spoke about the prioritisation of distracting injuries, and noted that TXA was often only considered once all of these other issues had been resolved. Some participants also cited the guidelines stating that TXA should be given within 3 hours; reflecting that this 3-hour window reduced the perceived urgency of administering TXA.

Memory, attention and decision processes

This was one of the most frequently populated domains. Within this domain, participants discussed the decision-making process around whether they believed trauma patients were at risk of bleeding or not. A number of factors were used to help paramedics identify whether or not a trauma patient was at risk of bleeding. The most commonly discussed were mechanism of injury and clinical observations. Other factors included patient presentation, type of injury, patient history and clinical judgement (Q22-23).

The majority of participants commented on the difficulty of identifying patients at risk of bleeding after trauma (Q24-25). Generally, it was reported that obvious bleeding or those in severe shock were easily identified, however less obvious bleeding, including occult/internal haemorrhage, was much harder to identify. This could be compounded by evolving clinical signs, the challenge of more subtle presentations in the elderly, misleading clinical signs and and/or a lack of a mechanism of injury.

Half of the participants reflected that it would be useful to have a decision-making tool, similar to a triage flowchart or major trauma tool, to assist them in identifying a patient's bleeding risk, and support subsequent decision-making regarding TXA administration (Q26).

Environmental context and resources

A lack of sufficient resources (time and staffing) was one of the most frequently cited barriers to TXA administration (Q27). Participants felt that there were not enough 'hands' to administer TXA over 10 minutes, as in a typical a two-person crew, one person would be busy for 10 minutes and unable to assist with other treatments (Q28). Participants reported that unless there was obvious significant bleeding that they would instead prioritise transfer of the patient to hospital. This was noted by paramedics to be more likely when there were short transfer times to hospital, as paramedics felt that TXA could be administered on arrival by hospital staff.

The time taken to prepare TXA for administration was also reported as a potential barrier for its use by paramedics. Some participants emphasised the fact that an adult dose of TXA requires two vials to be administered, and stated that this could cause confusion or take additional time in stressful or time-pressured situations. Some participants felt that alternative administration could negate these issues and make the presentation of the drug more clinician-friendly to promote use (Q29). For example, participants felt that TXA might be given to patients more frequently by paramedics if it came in a pre-filled syringe, or if they were able to administer it as a rapid bolus, or infuse it with fluids.

Increased or better equipment was cited by participants as a possible facilitator to TXA administration, including ideas such as a triage tool, flowchart or ultrasound (Q30).

Social influences

Within this domain, belief statements centred around the influence of Trust culture and colleagues. TXA was seen as something that is only given for major trauma (Q31). Participants reported concern that they may be judged negatively by colleagues if they administered TXA to patients with less severe injuries.

The opinion of colleagues was therefore seen to influence participants' administration of TXA, and participants noted that they often had clinical discussions with other paramedic colleagues on scene

to decide whether or not administration was appropriate (Q32). Others reported checking with a senior colleague/hospital staff before administering TXA (Q33).

Participants noted a more liberal approach to TXA administration by HEMS team members, and reported that witnessing this approach encouraged their own use of TXA (Q15). However, it seemed as though the knowledge that HEMS were likely to administer TXA could also act as a barrier to paramedic administration, as some participants expressed a preference to wait for a HEMS team member to administer it.

Emotion

Paramedics emphasised the nature of trauma jobs as stressful, and felt that this stress could lead to TXA administration being overlooked or deprioritised (Q34).

DISCUSSION

Although TXA is recommended as a pre-hospital intervention for post-traumatic haemorrhage, administration rates, remain low.[14] We applied the Theoretical Domains Framework[16] to help understand barriers and facilitators to TXA administration a from behavioural theory standpoint. The most frequently mentioned influences and related key issues determining administration of TXA were categorised in the TDF domains of: Knowledge and skills (knowledge and experience with TXA); Memory attention and decision processes (difficulty in identifying patients at risk of bleeding); Social/professional role and identity (confusion and restrictions relating to the guidelines for TXA administration); Environmental context and resources (a lack of resources).

Paramedics' lack of knowledge of, and experience with, TXA was a considerable influencing factor for its use. Although there is little pre-hospital research on TXA, this issue has been raised in prior literature regarding the administration of other treatments/drugs by ambulance staff.[17-18] Not surprisingly, confidence in self-perceived knowledge appears to facilitate administration rates; in our study, paramedics who reported knowledge of research relating to TXA felt that this was a facilitator

to its use. This suggests that increasing awareness of findings in TXA research amongst paramedics may help to increase administration rates. In particular, participants in the current study reported a general lack of awareness amongst the paramedic community regarding the diminishing survival effect of TXA with delay to treatment. This lack of awareness of the need for early administration could potentially result in under-prioritisation of TXA administration. A case series review of pre-hospital TXA use by the British Columbia Ambulance Service found that on several occasions TXA was not administered because individual practitioners determined that there were other priorities that required their attention.[19]

The second key barrier was TXA administration guidelines, which participants perceived to be restrictive and confusing. UK legislation permits all paramedics to administer a limited range of medications to manage emergency conditions.[20] NHS ambulance services can also authorise paramedics to use additional prescription-only medications, under Patient Group Directions (PGDs),[20] which provide written instructions for the supply or administration of medicine in an identified clinical situation that meets pre-determined criteria. Currently, UK paramedics administer TXA under a PGD, which provides a legal mechanism for administration in circumstances where a patient meets the pre-determined clinical inclusion criteria.[20] In our study, paramedics were concerned that they may be judged as having exceeded their legal privileges if a patient did not clearly meet the pre-defined criteria, which resulted in reluctance to administer TXA and many reported deferring this decision to senior colleagues or doctors, who were seen to have less restrictive guidelines surrounding TXA use. Similar attitudes towards PGDs were found in a UK survey of specialist paramedics, where a significant minority of participants reported that PGDs could be restrictive and did not always allow them to supply the appropriate medication.[20]

While a major facilitator to TXA administration was participants' beliefs that the benefits of giving TXA to a patient who needed it outweighed the potential risks of administering it to someone who did not, many paramedics reported being significantly risk-averse when it came to administering

296 TXA, suggesting a lack of clarity and empowerment surrounding TXA guidelines, training, and
297 support.

298 Thirdly, time and staffing restrictions were seen as a key barrier to TXA administration by
299 paramedics; participants reported that administration recommendations (an intravenous (IV)
300 injection delivered over 10 minutes) limited their ability to perform other necessary interventions,
301 and could delay transfer to hospital. Similar issues are discussed in the military literature, with the
302 administration of TXA being seen as incompatible with a tactical situation.[21] The paramedics in
303 our study suggested a solution similar to that of the authors of the military study, which is exploring
304 administration via slow IV push, to improve administration rates.[21]

305 Paramedics in the UK are expected to minimise on-scene time and TXA administration is
306 contraindicated if other critical interventions leave insufficient time to do so.[22] It is therefore
307 unsurprising that many of the paramedics in this study reported concerns regarding potential delays
308 as a result of TXA administration, and noted that transfer to hospital was sometimes prioritised over
309 this intervention. Similar concerns have been found previously.[19] It may help for paramedics to be
310 made aware that the median time from emergency call to hospital arrival in trauma patients
311 conveyed directly to a Major Trauma Centre in England is 1.4 hours,[23] leaving ample opportunity
312 to deliver TXA in the pre-hospital phase of care.

313 The fourth key barrier to TXA administration was the perceived difficulty in identifying whether or
314 not trauma patients were at risk of bleeding; paramedics in our study reported that TXA was often
315 not administered due to uncertainties over the patients' bleeding risk. Recently published UK data
316 suggest that patients who received TXA from paramedics have physiological observations (such as
317 pulse and blood pressure) more obviously suggestive of bleeding.[24] Studies on TXA use in the pre-
318 hospital military setting in both the UK and the United States also found that those who received
319 TXA had more obvious injuries.[21] One of the ideas put forward by participants was the possibility
320 of an assistive 'tool' to help them identify which trauma patients are at risk of bleeding. However, it

may also help to provide paramedics education that TXA can be safely administered to a wide spectrum of patients with traumatic bleeding and does not need to be restricted to the most severely injured.[6]

Study limitations, strengths and future directions

Interview data were coded using the TDF approach after inductive thematic analysis had been completed. However, the TDF was not used to design the interview topic guide, as is usually recommended for this approach. This was because the framework was adopted after data had been collected. Consequently, there may have been missed opportunities to prompt paramedics to reflect on barriers that did not spontaneously come to mind.

All participants were from a single EMS provider organisation, whose culture and practices may differ from other EMS providers in the UK and internationally. This is especially important since SWASFT was a pioneer in UK pre-hospital TXA use, and so paramedics from this ambulance service may hold more positive views towards TXA administration than those from other Trusts.

Implications

Our findings suggest several potential facilitators to TXA administration, including different administration routes, further training on the benefits of TXA, and an evidence-based tool to identify patients who might benefit from TXA. This tool, and associated training, could raise awareness of the importance of early TXA administration, and provide paramedics with objective support for decision-making and a potential 'permission to administer', therefore negating concerns regarding the PGD and Trust policy.

CONCLUSIONS

The administration rate of TXA to trauma patients by paramedics in the UK is lower than expected, and there is limited evidence to explain why. This study highlights the factors that influence

344 paramedics' use of TXA and identifies several potential barriers and facilitators. The results of this
345 study could inform the design of an intervention to improve pre-hospital TXA administration rates.

346

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All participants gave informed written consent. Ethical approval for this study was obtained from the Health Research Authority (19/HRA/5247) as well as the University of the West of England Health and Applied Sciences Faculty Ethics Committee (HAS.19.08.016).

CONSENT FOR PUBLICATION

Not applicable

DATA AVAILABILITY STATEMENT

The datasets generated and analysed during this study are not publicly available due to participant confidentiality, but are available from the corresponding author on reasonable request.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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AUTHORS CONTRIBUTIONS

LG participated in study coordination, performed and coded the interviews, analysed the data, and drafted the manuscript. HN participated in study conception, design and coordination, coded the interviews, analysed the data, and participated in editing the manuscript. MR participated in study conception, design and coordination, and was Chief Investigator with overall responsibility for the study. AB, SB, KK and HT participated in study conception and design. SV participated in study conception, design and coordination, and participated in interpretation of the results. JB

participated in study conception, design and coordination. All authors were responsible for the critical revision of the manuscript for publication and approved the final version to be published.

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