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SCIENTIFIC REVIEW

Prehospital hemorrhage management in low- and middle-income countries: A scoping review

Ashwin J. Kulkarni[1,2,3] | **Amber Batra**[2,4] | **Zachary J. Eisner**[1,2,3] | **Peter G. Delaney**[2,5] | **Haleigh Pine**[2,4] | **Maxwell C. Klapow**[2,6] | **Krishnan Raghavendran**[2,7]

[1]University of Michigan Medical School, Ann Arbor, Michigan, USA

[2]LFR International, Los Angeles, California, USA

[3]Michigan Center for Global Surgery, Ann Arbor, Michigan, USA

[4]Washington University in St. Louis, St. Louis, Missouri, USA

[5]Department of Orthopaedic Surgery, Cleveland Clinic, Cleveland, Ohio, USA

[6]Department of Social Policy and Intervention, University of Oxford, Oxford, UK

[7]Department of Surgery, University of Michigan, Ann Arbor, Michigan, USA

Correspondence

Ashwin J. Kulkarni, University of Michigan Medical School, 1500 E Medical Center Dr, Floor 2 Reception C, Ann Arbor, MI 48109, USA.
Email: ashkulk@med.umich.edu

Abstract

Introduction: Low- and middle-income countries (LMICs) account for 90% of deaths due to injury, largely due to hemorrhage. The increased hemorrhage mortality burden in LMICs is exacerbated by absent or ineffective prehospital care. Hemorrhage management (HM) is an essential component of prehospital care in LMICs, yet current practices for prehospital HM and outcomes from first responder HM training have yet to be summarized.

Methods: This review describes the current literature on prehospital HM and the impact of first responder HM training in LMICs. Articles published between January 2000 and January 2023 were identified using PMC, MEDLINE, and Scopus databases following PRISMA-ScR guidelines. Inclusion criteria spanned first responder training programs delivering prehospital care for HM. Relevant articles were assessed for quality using the Newcastle-Ottawa scale.

Results: Of the initial 994 articles, 20 met inclusion criteria representing 16 countries. Studies included randomized control trials, cohort studies, case control studies, reviews, and epidemiological studies. Basic HM curricula were found in 15 studies and advanced HM curricula were found in six studies. Traumatic hemorrhage was indicated in 17 studies while obstetric hemorrhage was indicated in three studies. First responders indicated HM use in 55%–76% of encounters, the most frequent skill they reported using. Mean improvements in HM knowledge acquisition post-course ranged from 23 to 58 percentage points following training for pressure and elevation, gauze application, and tourniquet application.

Conclusions: Our study summarizes the current literature on prehospital HM in LMICs pertaining to epidemiology, interventions, and outcomes. HM resources should be a priority for further development.

KEYWORDS

education, global surgery, patient safety, trauma

1 | INTRODUCTION

The majority of the global injury burden falls on low- and middle-income countries (LMICs), where over 90% of the 5.8 million annual injury deaths occur.[1] Injuries account for 10% of all global deaths, which is 32% higher than the combined mortality of HIV/AIDS, malaria, and tuberculosis.[2] Hemorrhage, most often resulting from road traffic injuries (RTIs), is responsible for 30%–40% of global injury-related deaths.[3] Over 50% of these hemorrhage-related deaths happen in the prehospital setting,[3] with 93% of them occurring in LMICs.[4] The global hemorrhage burden is also increasing, with a 10% rise in RTI deaths since 2000,[5,6] largely driven by increased motorization in LMICs.

Meanwhile, obstetric hemorrhage is the primary cause of maternal mortality worldwide, accounting for 25% of all maternal deaths.[7] Women in LMICs bear a disproportionate burden, with 95% of pregnancy-related deaths occurring in these regions.[8] Postpartum hemorrhage (PPH) is the leading cause, responsible for 60% of maternal deaths in LMICs, resulting in over 100,000 deaths annually.[9]

Morbidity and mortality resulting from the untreated hemorrhage burden on LMICs is exacerbated by a lack of emergency medical services (EMS).[9] Currently, just 19% of African countries have access to government financed EMS and only 26% have access to a toll-free emergency telephone number.[10] As recently as 2012, less than 9% of Africans had access to an EMS system.[10] Robust prehospital care is vital for surviving acute hemorrhage,[2,10] but it is not widely available in LMICs.[11] While the 2018 WHO report recognized hemorrhage management (HM) as a highly effective way to save lives from injury,[3] the current state of prehospital HM and patient outcomes from HM interventions in LMICs has yet to be summarized.

2 | AIMS

This scoping review has two primary aims: (1) to define current practices for prehospital HM through currently published literature and (2) to summarize outcomes of HM trainings of lay and professional first responders in a prehospital setting within LMICs. Through these aims, our objective is to provide valuable insights to guide the development of comprehensive HM training curricula for future prehospital interventions.

3 | METHODS

3.1 | Literature search

A scoping review focused on prehospital HM in LMICs was carried out, classifying LMICs as countries with a GNI of $12,535 or less according to the World Bank.[12] Following PRISMA-Scr guidelines,[13] we searched for relevant articles published between January 1, 2000, and January 1, 2023, in Medline, PubMed, and Scopus databases using the search terms outlined in Table 1, limiting potential reviewer bias. Our most recent search occurred on April 12, 2023.

Included studies focused on EMS and prehospital care, encompassing care provided at the scene of injury or during transportation to definitive care. Both layperson first responders ("Tier-1" EMS) and professional EMS personnel ("Tier-2" EMS) were considered. Tier-1 providers included transportation providers, military personnel, police officers, and civilians providing formal or informal bystander intervention while Tier-2 systems involved trained, part or full-time first responders using ambulances for patient transportation. Studies involving physician interventions were excluded. Additionally, studies conducted outside an LMIC, in a hospital setting, or not focusing on HM were also excluded (Table 2).

3.2 | Data collection

Two authors conducted independent searches in Medline, PubMed, and Scopus databases. They also independently performed study selection and data extraction. After compiling all matching manuscripts in Microsoft Excel, electronic duplicates were removed before assessing abstracts. Titles, abstracts, and full texts were reviewed independently by both authors, with discrepancies resolved through discussion with a third author until consensus was reached.

Data extraction then took place in Microsoft Excel with information including but not limited to author names, title, journal, study type, publication year, country, LMIC status, trainees' occupation and level of training, curricular elements, equipment used, funding source, training costs, number trained, and clinical impact of prehospital intervention. Subsequent analysis was then performed in R. Studies were further categorized based on hemorrhage classification (traumatic vs. obstetric), considering differences in curricular elements and equipment used (Table 3).

3.3 | Critical appraisal

Authors conducted study appraisal to ensure a comprehensive assessment of knowledge due to the heterogeneity of prior research and diversity of prehospital infrastructure in LMICs. The Newcastle-Ottawa scale[14] was used to score each eligible manuscript, evaluating reliability, comparability (controls), selection bias (representativeness of non-randomized cohorts), and outcome (follow-up) (Table 4). Study appraisal

TABLE 1 Search terms.

Condition of interest (AND)	Setting of interest (AND)	Intervention of interest (AND)
Blood loss OR ecchymosis OR epistaxis	Low- and middle-income	Prehospital OR
OR exsanguination OR choroid	Country OR LMIC OR	Emergency medical
Hemorrhage OR hyphema OR retinal	Developing country OR	Services OREMS OR
Hemorrhage OR vitreous hemorrhage OR	Developing countries OR	First responder OR first
Hematemesis OR melena OR peptic ulcer	Low- and middle-income	Aid OR injury OR
Hemorrhage OR hemarthrosis OR	Countries OR low income	Trauma
Hematocele OR epidural hematoma OR	Country OR middle-	
Subdural hematoma OR hematuria OR	Income country OR	
Hemobilia OR hemoperitoneum OR	Africa	
Hemoptysis OR hemothorax OR		
Intracranial hemorrhage OR subarachnoid		
Hemorrhage OR oral hemorrhage OR		
Gingival hemorrhage OR postoperative		
Hemorrhage OR purpura OR IgA		
Vasculitis OR Retrobulbar hemorrhage		
OR hemorrhagic shock OR uterine		
Hemorrhage OR postpartum hemorrhage		

TABLE 2 Inclusion and exclusion criteria for scoping review.

	Inclusion criteria	Exclusion criteria
Location	Low income countries (GNI per capita less than $4405) middle income countries (GNI per capita less than $12,535)	High income countries (HICs) (GNI per capita greater than $12,536)
Setting	Prehospital	Hospital
Clinical scope	Hemorrhage management	Not related to hemorrhage management
Care provider	Non-physician	Physician[a]
Dates	January 1, 2000—January 1, 2023	Before January 1, 2000
Study types	All study types including but not limited to cluster- randomized trials, cohort studies, case control studies, reviews, and epidemiological studies	None

[a]Any individual having received a degree of: MD, DO, DM, DS, MSurg, MBBS, DCM, DMSc, or MCM.

followed the same protocol as study selection, with two authors scoring each manuscript and resolving discrepancies through discussion and consensus with a third author.

4 | RESULTS

The initial search showed 1304 articles between PMC, MEDLINE, and Scopus databases published before January 1, 2000. We excluded an additional 772 articles after reviewing titles and objectives. Abstracts of the remaining 222 articles were then screened and 166 articles were further excluded, leaving 56 articles. We then obtained and screened full-text versions of the remaining 56 articles. After eliminating 38 articles, 20 were deemed eligible for manuscript review (Figure 1).

4.1 | Study reliability and risk of bias

Manuscripts classified as either cohort or case control studies were eligible for scoring using the Newcastle-Ottawa scale to assess study quality using selection, comparability, and outcomes measures.[15] Fourteen studies[16–19,21,23–26,29–31,34,35] qualified for inclusion with scores outlined in Table 4. Individual assessments were conducted by two authors using the Newcastle Ottawa

TABLE 3 Systematic review results and manuscript quality assessment.

References	Setting	LMIC status	Occupation of trainees	First responder tier	Level of training	Training duration	Obstetric bleeding vs traumatic bleeding	Hemorrhage-related curricular elements	HM Equipment used	Method of curricula	Funding source	Costs associated with training/equipment (per capita)	*N* trained/assessed	HM clinical impact	NOS scoring (selection, comparability, outcome)	Summary
Aekka et al. [16]	India	Lower-middle income	Police officers, firefighters, commercial drivers, professional first respondersnursing staff	Tier 1, Tier 2	BLS, LFR	10 hours	Traumatic bleeding	Circulation check Pressure and elevation Gauze application Tourniquet tying	Curriculum manuals First aid kits gauze, tourniquets	In person and virtual	Academic	Unknown	48	58% increase in HM competence following course	3; 1; 2	Cohort of lay people taught basic trauma management by local trainers and assessed directly following the course.
Eisner et al. [17]	Sierra Leone	Low income	Motorcycle taxi drivers, teachers, Red Cross volunteers, commercial drivers, Bike Monitoring Officers	Tier 1	LFR	5 hours	Traumatic bleeding	Circulation check Pressure and elevation Gauze application Tourniquet tying External v internal bleeding Burn care	Curriculum manuals First aid kits gauze, tourniquets	In person	NGO, Academic	$5.09 (per first aid kit)	4529	HM skills used in 61.2% of first responder encounters; 55% increase in HM skills following course; 52% knowledge retention at 6 months	3; 2; 3	Cohort of lay people taught basic trauma management by both US and local trainers and assessd immediately following as well as six months following the course.
Jayaraman et al. [18]	Uganda	Low income	Police officers, taxi drivers, community leaders	Tier 1	LFR	5 hours	Traumatic bleeding	Pressure and elevation Gauze application Tourniquet tying	None	In person	Private Donor (Mulago Foundation)	$15.59 (first aid kit, training)	309	Unknown	3; 1; 2	Cohort of community professionals (police officers, taxi drivers, local leaders) instructed in prehospital trauma care and assessed at six months following the course.
Mock et al. [19]	Ghana	Lower-middle income	Taxi drivers, bus drivers	Tier 1	LFR	6 hours	Traumatic bleeding	Pressure and elevation Gauze application Tourniquet tying	First aid kits Gauze, tourniquets	In person	Private Donors	$15 (first aid kit)	334	Unknown	3; 1; 3	Cohort of commerical drivers trained in basic trauma management and assessed in skill usage 12 months following the course.
Kausar et al. [20]	Egypt, Nigeria	Lower-middle income	Nurse, nurse midwives	Tier 2	PHTLS, NASG training	4 hours	Obstetric bleeding	Administration of crystalloid IV fluids Administration of uterine massage Administration of uterotonic medications (oxytocin, ergometrine, misoprostol) Vaginal procedures (bimanual compression, manual removal of placenta, dilation and curettage for retained tissue) Blood transfusions Indications for hospitalization/surgery (compression sutures, arterial ligation, hysterectomy)	NASG First aid kits	In person	Private Donor (John D. and Catherine T. MacArthur Foundation)	Unknown	176	50% less blood loss, reduced rates of hysterectomy (8.9% vs 4%), decreased mortality (8.5% vs 2.3%)	NA	Randomized control trial analyzing reductions in blood loss, hysterectomy, and mortality by using non-pneumatic anti-shock garment for post-partum hemorrhage.
Johnston et al. [21]	Bangladesh, Ghana, Peru, Sierra Leone	Low income, lower-middle income, upper-middle income	Police officers, firefighters, military, motorcycle taxi drivers, prison guards	Tier 1	LFR	1 hour	Traumatic bleeding	Stop the bleed curriculum Circulation check Pressure and elevation Gauze application Tourniquet tying	First aid kit Combat application tourniquet	In person	NGO	Unknown	748 trained total (27 Bangladesh, 194 Ghana, 240 Peru, 300 Sierra Leone)	100% demonstrated acquisition of skills proficiency in pressure, gauze application, tourniquet use	3; 2; 2	Cohort from four countries instructed by local trainers in the American College of Surgeons Basic Bleeding Control course and assessed immediately following the class.
Rosenberg et al. [22]	Rwanda	Low income	Prehospital ambulance service (SAMU); Professional Emergency Responders	Tier 2	PHTLS	Unknown	Traumatic bleeding	Pressure and elevation Gauze application Tourniquet tying IV Fluids	Medic bags (stethoscope, bandages, suture material, gloves, hemostats, gauze, tourniquets, medications) IV fluids	In person	Governmental (NIH), NGO	Unknown	Unknown	HM performed in 76% of first responder encounters	NA	Retrospective study analyzing injuries associated with motorcycle-related road traffic accidents responded to by SAMU, the leading prehospital ambulance service in Rwanda, from 2012 to 2016.
Delaney et al. [23]	Uganda	Low income	Motorcycle taxi drivers	Tier 1	LFR	5 hours	Traumatic bleeding	Circulation check Pressure and elevation Gauze application Tourniquet tying External v internal bleeding Burn care	Curriculum manuals First aid kits Gauze, tourniquets	In person	NGO, Academic	$7.13	154	HM used in 55% (138/250) of first responder encounters; 23% improvement in knowledge in HM skills	3; 1; 2	Cohort of motorcyle taxi drivers taught first aid by a local Red Cross trainer with assessments immediately after the course and analysis of incident reporting at six months.
Sibley et al. [24]	Ethiopia	Low income	Midwives	Tier 1	LFR	12 hours	Obstetric bleeding	Identifying bleeding, birth delay, sickness, pregnancy swelling, trouble breathing Administration of uterine massage Indications for hospitalization/surgery	HBLSS Take action cards	In person	Governmental (USAID)	$260,000 (to implement program fully)	300	Pospartum hemorrhage case management scores twice as high for attendants of HBLSS trainings. 49% improvement in HM skills, 65% retainment of knowledge at 1 year.	4; 1; 3	Cohort intervention aimed at analyzing the effectiveness of the Home-Based Life Saving Skills program at reducing post-partum hemorrhage and maternal mortality with knowledge retention analysis at 12 months.
Merchant et al. [25]	Mozambique	Low income	Hospital nurses, community laypeople	Tier 1, Tier 2	LFR, ALS	2.5 hours	Traumatic bleeding	Pressure and elevation Gauze application Tourniquet tying Peripheral IV placement	First aid kits Tree leaves (alternative gauze) Capaluna (Mozambique cultural sheet for hemorrhage control) Cloth with pens (alternative tourniquet	In person	Academic	Unknown	100	24% increase in pre-post test scores among LFRs, 17% for PFRs	4; 1; 2	Case control of laypeople and hospital personnel trained in basic trauma resuscitation training with assessments comparing the two groups following the course.

TABLE 3 (Continued)

References	Setting	LMIC status	Occupation of trainees	First responder tier	Level of training	Training duration	Obstetric bleeding vs traumatic bleeding	Hemorrhage-related curricular elements	HM Equipment used	Method of curricula	Funding source	Costs associated with training/equipment (per capita)	*N* trained/assessed	HM clinical impact	NOS scoring (selection, comparability, outcome)	Summary
Capone et al. [26]	Brazil	Upper-middle income	Factory employees	Tier 1	LFR	7 minutes	Traumatic bleeding	Pressure and elevation Gauze application Tourniquet tying	None	TV	NGO	Unknown	202	Three-fold improvement in HM in TV-trained group compared to control group; 65% increase in HM knowledge before and after TV training; 74% retention of knowledge at 13 months	4; 1; 2	Randomized control trial comparing improvements in life supporting aid scores (LFSA) among factory employees with and without exposure to a LFSA skills demonstration on TV and with re-assessment at 13 months.
Nia et al. [27]	Iran	Lower-middle income	Village healthcare workers	Tier 2	BLS	40 hours	Traumatic bleeding	Burn care Pressure and elevation Gauze application Tourniquet tying	First aid kits (gauze, tourniquets)	In person	Academic	Unknown	76	HM was most common intervention in first response at 40.6%, with 4.3% reduction in mortality in trained group	NA	Randomized control trial comparing patient outcomes among those treated by village healthcare workers trained to deliver first aid and those treated by village healthcare workers who were not trained.
Mostumi et al. [28]	Botswana	Upper-middle income	Professional First Responders LFRs	Tier 1, Tier 2	LFR, ALS	None (retrospective study)	Traumatic bleeding	None (retrospective study)	None	NA	Academic	NA	NA	Hemorrhage was responsible for 47.3% of road traffic deaths, 68.2% of which were considered preventable	NA	Retrospective study investigating the rate of preventable deaths by road traffic collisions in Botswana over a five year period.
Tiska et al. [29]	Ghana	Lower-middle income	Commercial drivers	Tier 1	LFR	6 hours	Traumatic bleeding	Circulation check Pressure and elevation Gauze application Tourniquet tying	First aid kits	In person	Academic	$3	300	45% improvement in HM; follow up scores unknown	3; 1; 3	Cohort of lay people taught basic trauma management by local trainers and assessed at 12 months and 24 months.
Parvin-Nejad et al. [30]	Sierra Leone	Low income	Nursing students	Tier 1	LFR	1 hour	Traumatic bleeding	Stop the bleed curriculum Circulation check Pressure and elevation Gauze application Tourniquet tying	First aid kits	In person	Academic	Unknown	121	75% of encounters reported HM, with HM survival rates of 98% (direct pressure) and 100% (tourniquet); follow up scores not reported (only incident reports)	3; 1; 3	Cohort of nursing students instructed in prehospital trauma care by US and local trainers and assessed at one month follow up.
VanRooyen et al. [31]	Sudan	Low income	Military personnel (variable medical experience)	Tier 1, Tier 2	LFR, ALS	40 hours	Traumatic bleeding	Circulation check Pressure and elevation Wound packing Gauze application Tourniquet tying	Medic bags (stethoscope, bandages, suture material, gloves, hemostats, gauze, tourniquets, medications)	In person	NGO (Samaritan's Purse)	Unknown	41	35% increase in pre-post test scores among LFRs	3; 1; 2	Cohort of military personnel with variable prior medical experience taught civilian prehospital care and assessed immediately following the course.
Stanton et al. [32]	Ghana	Low income	Community health officers/professional emergency responders	Tier 2	ALS	2 years (via Ghanaian Health Service)	Obstetric bleeding	Administration of uterine massage Administration of oxycontin injection Palpation for twins Indications for hospitalization/surgery	Oxycontin Uniject device Medic bags (stethoscope, bandages, suture material, gloves, hemostats, gauze, tourniquets, medications))	In person	NGO (Bill and Melinda Gates Foundation), Academic	$1.40 (per oxycontin dose)	54 trained with 28 in oxycontin group; 1586 women enrolled including 889 in oxycontin group	Mean reduction in blood loss of 45.1 ml in oxytocin group; 51% decrease in PPH hemorrhage > 500 ml.	NA	Randomized control trial comparing postpartum blood loss among mothers treated with oxycontin and those not treated with oxycontin.
Binks et al. [33]	South Africa	Upper-middle income	EMS + Ambulance first responders Professional Emergency Responders	Tier 2	PHTLS	2 years (via South African HPSCA)	Traumatic bleeding	None (previously trained)	Medic bags (stethoscope, bandages, suture material, gloves, hemostats, gauze, tourniquets, medications)	NA	Governmental (Department of Health South Africa)	NA	26	Defining high-acuity pre-hospital care to more effectively use first responder resources. Loss of consciousness, respiratory distress, and severe hemorrhage disqualified situations as being counted as low acuity	NA	Case report classifying low-acuity and high-acuity conditions of hemorrhage by gathering data from a group of professional first responders.
Hancock el. al [34]	Chad	Low-income	Motorcycle taxi drivers Red cross affiliates Non-governmental organization employees from Am Timan	Tier 1	LFR	5 hours	Traumatic bleeding	Circulation check Pressure and elevation Gauze application Tourniquet tying External v internal bleeding Burn care	First aid kits (gauze, bandages, tourniquets)	In person	NGO, Academic	$12.79 per kit	136 trained and assessed	HM skills used in 61% of encounters.	4; 1; 2	Cohort of lay people who were taught taught basic trauma management, filled out incident report forms, and given 12-month follow-up interviews.
Delaney et al. [35]	Guatemala	Middle-income	Firefighters Law enforcement Civilians	Tier 1	LFR	5 hours	Traumatic bleeding	Circulation check Pressure and elevation Gauze application Tourniquet tying External v internal bleeding Burn care	First aid kits (gauze, bandages, tourniquets)	In person	NGO, Academic	NA	354 trained, 287 assessed	29% increase in pre-post test scores among LFRs including a 36% increase in HM control	4; 2; 1	Cohort of firefighters, law enforcement, and civilians who were taught basic trauma management and assessed immediately following the couse.

TABLE 4 Classifications of obstetric and traumatic HM training.

	Equipment and/or curricular element	Percent of studies that used element (%)	Number of studies that used element (*n*)
Traumatic HM	Gauze application	88.2	15
	Pressure and elevation	88.2	15
	Tourniquet tying	82.4	14
	First aid kits (gauze, tourniquets, bandaids)	82.4	14
	Circulation Check	58.8	10
	Burn care	29.4	5
	External v internal bleeding	23.5	4
	Medic bags (stethoscope, bandages, suture material, gloves, hemostats, gauze, tourniquets, medications)	17.6	3
	Curriculum manuals	17.6	3
	Stop the bleed curriculum	11.8	2
	Peripheral IV placement	5.9	1
	Capaluna (Mozambique cultural sheet for hemorrhage control)	5.9	1
	Cloth with pens (alternative tourniquet)	5.9	1
	Combat application tourniquet	5.9	1
	Tree leaves (alternative gauze)	5.9	1
Obstetric HM	Indications for hospital referral	100	3
	Uterine massage	100	3
	Medication administration (oxycontin, ergometrine, misoprostol)	66.7	2
	Blood transfusions	33.3	1
	Identifying bleeding, birth delay, sickness, pregnancy swelling, trouble breathing	33.3	1
	IV fluid administration	33.3	1
	Non-pneumatic anti-shock garment (NASG)	33.3	1
	Oxycontin Uniject device	33.3	1
	Uterine palpation for twins	33.3	1
	HBLSS Take Action cards	33.3	1

Abbreviation: HM, hemorrhage management.

scale, with most studies (70%, $n = 10$)[17,19,21,24–26,29,30,34,35] scoring 7 or higher, indicating high quality and minimal bias risk. All studies were included as none scored 5 or lower.

4.2 | Characteristics of included studies

Out of the 20 included manuscripts, cohort studies (60%, $n = 12$)[16–19,21,23,24,29–33] were the majority. Other studies included case control or case reports (10%, $n = 2$),[25,33] randomized control trials (20%, $n = 4$),[20,26,27,32] and retrospective cohort studies (10%, $n = 2$).[22,28]

Sixty percent ($n = 16$) of studies presented findings from Africa,[17–25,28–31,34–36] involving data from 12 countries. Three studies were conducted in Central or South America,[21,26,35] and three in South Asia or the Middle East.[16,21,27] The training length administered showed no significant difference based on geographic location or the occupation of trainees (laypeople vs. professional first responders) (Figure 2).

Fifty-five percent ($n = 11$) of studies[17–19,21,23,24,26,29,30,34,35] described training Tier-1 first responders, 25% ($n = 5$) of studies[20,22,27,32,33] focused on Tier-2 first responders, and 20% ($n = 4$) of studies[16,25,28,31] covered both Tier-1 and Tier-2. Commonly reported occupations of Tier-1 first responders included taxi drivers (30% of studies, $n = 6$), commercial drivers (20%, $n = 4$), police (20%, $n = 4$), firefighters (20%, $n = 4$), and military personnel (10%, $n = 2$). Tier-2 first responders were most frequently represented by professional emergency responders (55.6%, $n = 5$) and prehospital nursing staff, including midwives (33.3%, $n = 3$) (Table 3).

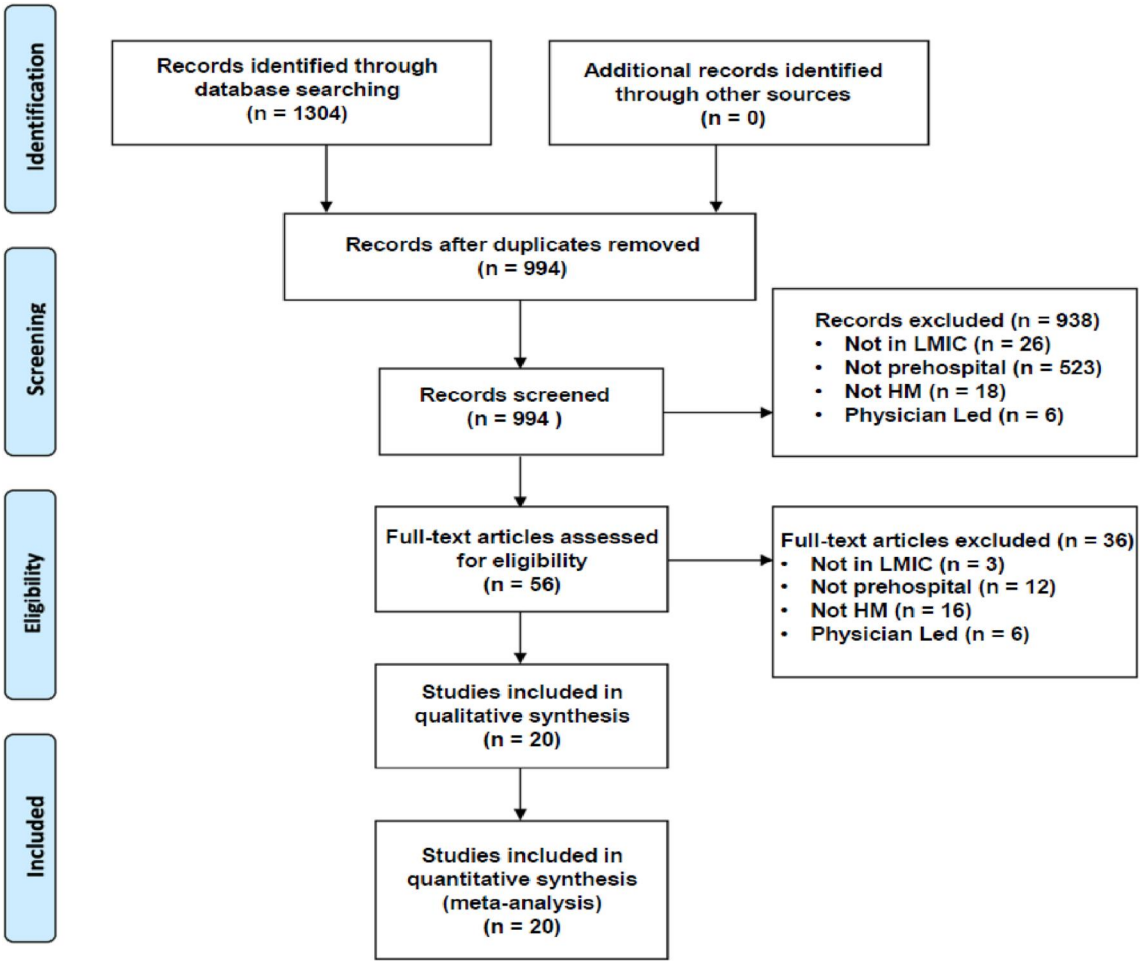

FIGURE 1 Systematic scoping review. [Colour figure can be viewed at wileyonlinelibrary.com]

The first responder HM training courses varied in length, ranging from 7 min to 40 h, with a median program length of 5 h (n = 18). Tier-1 first responder courses were shorter, with a median of 5 h (n = 11),[17–19,21,23,24,26,29,30,34,35] compared to Tier-2 and combined Tier-1/Tier-2 courses, which had a median length of 10 h (n = 7).[16,20,25,27,31–33] Notably, a 7-min Tier-1 course was delivered through TV training, the only virtual course found.[26] Two Tier-2 studies included personnel who underwent 2 years of training under the Ghanaian Health Service and South African Health Professions Council, respectively.[32,33]

Six Tier 1[17,18,23,24,29,34] courses and one Tier 2[32] course reported per-capita costs of supplies ranging from oxytocin to first responder kits, with a median of $7.13 (IQR: 3.0, 15.0) per responder. One Tier-1 study focusing on obstetric-related hemorrhage reported the total cost of continued program expansion to be $260,000.[24] Costs pertaining solely to first responder training was not reported in any studies. Funding sources ranged from academic (n = 11),[16,17,23,25,27–30,32,34,35] non-governmental organizations (NGO, n = 9),[17,21–23,26,31,32,34,35] government (n = 3),[22,24,33] and private donors (n = 3)[18–20] from home countries and abroad.

4.3 | Equipment and curricula

Tier-1 programs predominantly used first aid kits containing gauze/tourniquets (73%, n = 8),[17,19,21,23,29,30,34,35] while Tier-2 and combined Tier-1/Tier-2 programs utilized first aid kits (33%, n = 3)[16,20,25] and medic bags (44%, n = 4)[22,31–33] which included stethoscopes, bandages, suture material, and medications.

Among obstetric HM studies, a variety of equipment such as oxytocin injection devices, non-pneumatic anti-shock garments (NASGs), and education cards were used (Table 3). Some studies (15%, n = 3)[18,26,28] did not report the use of training equipment.

Universal curricular elements in Tier-1 training for traumatic HM included applying pressure and elevation, using gauze, and tying tourniquets (100%, n = 11).[17–19,21,23,24,26,29,30,34,35] Other common elements included checking circulation (64%, n = 7),[17,21–23,29–31,34,35] burn care (36%, n = 4),[17,23,34,35] and

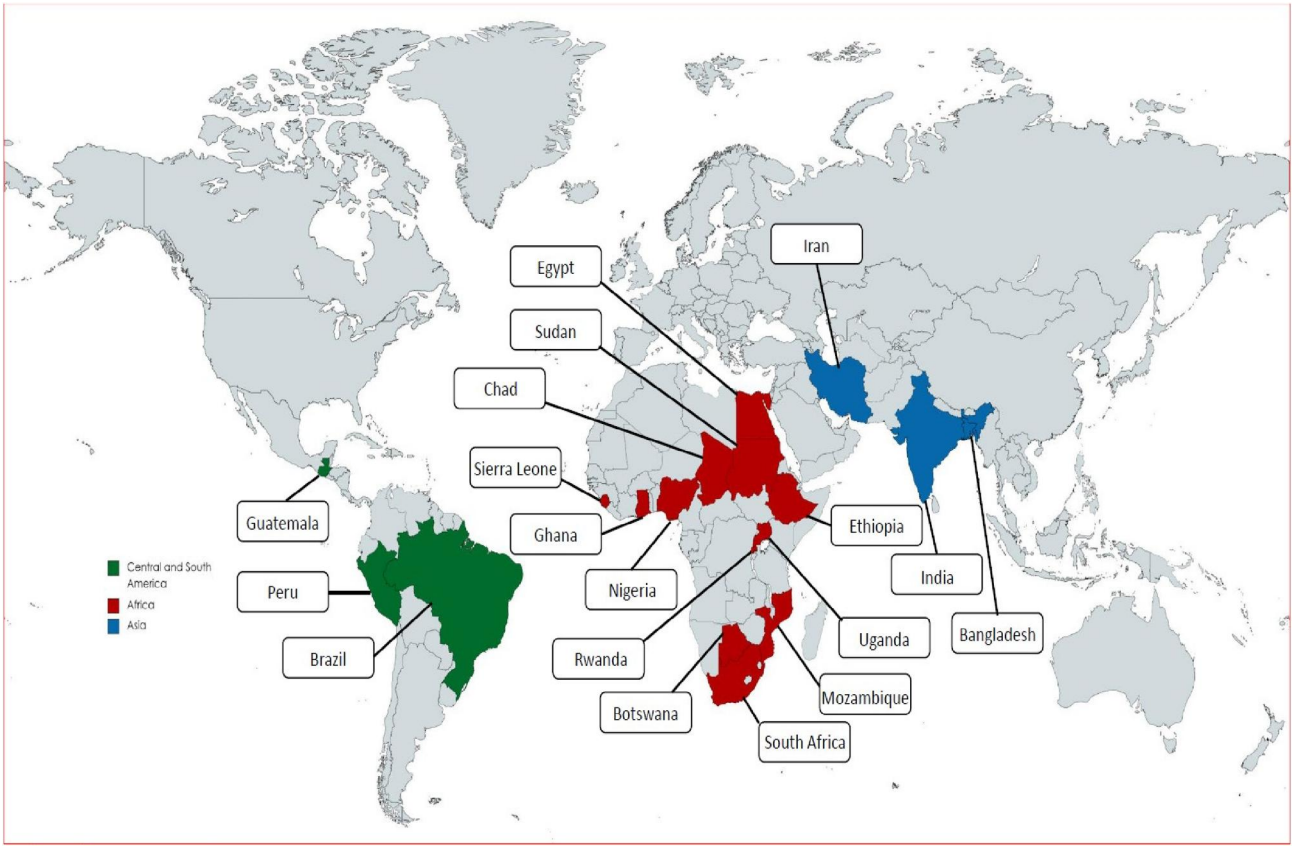

FIGURE 2 Map of included study locations. [Colour figure can be viewed at wileyonlinelibrary.com]

identifying internal versus external bleeding (36%, $n = 4$).[17,23,34,35] Tier-2 and combined Tier-1/Tier-2 traumatic HM programs included the above curricular elements along with IV fluid administration (33%, $n = 3$).[20,22,25] Additionally, Tier-2 and combined Tier-1/Tier-2 programs incorporated diverse range of trainings, including Basic Life Support (BLS, 22%, $n = 2$),[16,27] Advanced Life Support (ALS, 44%, $n = 4$),[25,28,31,32] Prehospital Trauma Life Support (PHTLS, 33%, $n = 3$),[20,22,33] and NASG training (11%, $n = 1$),[20] often with overlapping curricula.

For obstetric HM, both Tier-1 and Tier-2 curriculum universally included uterine massage and indications for hospital transport (100%, $n = 3$).[20,24,32] Interventions also focused on NASG application, oxytocin administration, and identifying excessive birth bleeding.

4.4 | Interventions and training uptake

In 45% ($n = 9$) of the studies,[17–19,23,24,26,29,30,34] the frequency of prehospital hemorrhage control interventions was monitored over a median follow-up period of 12 months (IQR: 6.0, 12.0). Across all studies, the median frequency of prehospital hemorrhage control interventions for all incidents was 61% (IQR: 48%, 76%). Both Tier-1 and Tier-2 first responders had similarly high median frequencies of traumatic HM interventions, with 61% and 76% for Tier-1 and Tier-2 first responders, respectively.

Obstetric HM studies[20,24,32] involved 54 community health officers administering oxytocin or placebo doses to 1586 women, resulting in an average of 29 interventions per trained individual. Additionally, 176 midwives were trained and performed 578 NASG interventions, averaging 3.3 interventions per study participant.

Considering the data was only monitored during the study timeframe, the current number of interventions resulting from these trainings is likely significantly higher.

4.5 | Educational, clinical, and epidemiological impact

In 90% ($n = 18$) of studies,[17,20–35] the impact of prehospital HM training on first responder proficiency and patient outcomes was measured. In 47% ($n = 7$) of studies,[16,17,21,25,26,31,35] HM training led to a median knowledge increase of 57% (IQR: 23%, 65%) immediately following the course. Knowledge retention was evaluated at a median of 12 months (IQR: 9, 12) in 50% ($n = 9$) of studies,[17–19,23,24,26,29,30,34] with a median retention of 65% (IQR: 59%, 70%).

Clinical impact was assessed in two traumatic HM and two obstetric HM articles. Traumatic HM training for village healthcare workers in Iran resulted in a 4.3% reduction in mortality in a randomized controlled trial (RCT).[27] Nursing students reported HM survival rates of 98.2% using direct pressure and 100% using tourniquets in 217 total encounters.[30] For obstetric HM, NASG training and application led to 50% less blood loss and a 6% reduction in PPH mortality in an RCT of 578 interventions in Egypt and Nigeria.[20] In another RCT with 1586 women in Ghana, oxytocin training and administration led to a 51% decrease in significant PPH hemorrhage (>500 mL).[32]

Meanwhile, retrospective studies in Botswana and Rwanda highlighted the significant burden of hemorrhage on prehospital care. Traumatic HM was performed in 77% of first responder encounters, the highest among any prehospital intervention category.[22] In Botswana, hemorrhage was responsible for 47% of road traffic deaths in Botswana, with 68% considered preventable.[28]

5 | DISCUSSION

This scoping review sought to describe existing literature on the state of prehospital HM and HM training program outcomes in LMICs to address deficits and inform future interventions in these settings. Our results show that Tier-1 and Tier-2 first responder interventions can play a significant role in reducing the mortality rate from traumatic and obstetric hemorrhage, with interventions showing similarities among training, curricula, supplies, and clinical impact.

Traumatic HM curricula focused on pressure/elevation (88%, $n = 15$), tourniquet tying (88%, $n = 15$), and gauze application (82%, $n = 14$). Both pressure/elevation and gauze application have consistently shown HM benefits,[36,37] but it is crucial to emphasize the use of clean gauze to reduce infection risk. In our review, Merchant et al.[25] found that traditional Mozambican dresses, such as tree leaves and capulanas, were effective for low-resource HM; however, infection rates were not measured.

The benefit of prehospital tourniquets is well-documented. While some researchers only found a difference in all-cause mortality between tourniquets and direct pressure application in military settings,[36] Parvin-Nejat et al.[30] reported 100% survival using tourniquets. Studies have shown that tourniquet usage in rural settings can be beneficial. Tourniquets have equalized rural morbidity and mortality compared to urban settings,[38] though its utility does depend on hospital transfer times not being increased.[39] Most significantly, prior literature has documented significant reductions in civilian mortality (1% and 9%) due to prehospital tourniquet use,[37,40] along with a reductions in limb amputations (8%) and fasciotomies (19%) in an 8-year retrospective study.[41]

Considering the data, prehospital tourniquet education is warranted due to the low risk of adverse events and potential benefits, especially in LMICs where other proven bleeding therapies such as hemostatic agents may be limited.[42–44] Responders should be trained to administer direct pressure/elevation and clean gauze first, while improvising tools such as tree leaves if gauze is not available. If bleeding remains uncontrolled, they should tie a tourniquet if doing so does not delay hospital transport.

In obstetric HM curricula, emphasis was placed on uterine massage (100%, $n = 3$) as a low resource means of HM. A novel 2021 RCT of 176 vaginal deliveries in Turkey found a reduction in PPH within 2 h with uterine massage, the first to find a statistically significant reduction.[45] Considering its low risks, uterine massage should continue to be the first-line treatment of PPH in LMICs. In our review, Stanton et al.[32] demonstrated significantly reduced blood loss with oxytocin administration, effectively applying WHO PPH recommendations to prehospital LMICs.[46] However, misoprostol may be a more effective alternative, as an RCT of 400 vaginal deliveries in Iran found significantly decreased hemorrhage with misoprostol compared to oxytocin.[47] Additionally, misoprostol is cheaper, with manufacturers selling the pill to pharmacies for $0.05, in contrast to the $1.40 per oxytocin dose reported by Stanton and colleagues.

Kausar et al.'s novel RCT showed that the NASG could reduce mortality by 6% and PPH by 50% in prehospital LMIC settings.[20] These outcomes align with NASG benefits observed in LMIC hospital settings, where a 2013 RCT of 880 vaginal births in Zambia and Zimbabwe reported a 46% reduction in mortality.[48] The findings support the use of uterine massage, low-cost medications like misoprostol, and NASG application whenever possible to reduce obstetric hemorrhage and mortality in prehospital LMICs.

Tier-1 responders showed significant educational and clinical impacts following interventions. They experienced a mean increase in HM knowledge of 50% over eight studies, compared to only 17% reported for Tier 2 responders in one study. Tier-1 responders applied HM skills in 64% of encounters, with Parvin and colleagues[30] reporting 100% incident survival with tourniquet application, as mentioned earlier. This data aligns with previous findings,[34,35] demonstrating the potential of Tier 1 responders to grasp, retain, and apply HM skills. Alongside prior research,[49–51] our review further supports the 2004 WHO recommendation to utilize Tier-1 responders as a means of establishing formal EMS in LMICs.

Similar to previous scoping reviews on airway management and spinal cord injury,[52,53] an accessibility

challenge to prehospital HM in LMICs persists. In high-income countries (HICs), effective bioengineered hemostatic agents, such as RickClot Combat Gauze (QCG), Tranexamic Acid (TXA), and RevXSTAT (XSTAT), are first-line agents for life-threatening bleeds not controlled by tourniquets.[54] QCG alleviated 89% of hemorrhage with no adverse effects,[55] TXA further reduced mortality by 17–24% in trauma settings,[56] and XSTAT stopped hemorrhage in 90% of cases of invasive penetrating trauma[57] while also showing promise for PPH.[58]

These tools, along with dedicated EMS systems, contribute to just 7% of road traffic collision deaths occurring in HICs.[4] Although XSTAT and QCG are costly at $85 and $43, respectively, just 5 mg/mL of TXA showed antifibrinolytic benefit,[59] placing its potential per-use cost at just $2.40. This puts it within the scope of the median equipment cost of $6.11 found in our review. Considering the clinical benefits, a thorough cost review of affordable hemostatic agents for LMIC HM is warranted.

Despite preliminary findings in the present study, the present study was not without limitations. Literature on prehospital HM was sparse, suggesting a gap in research on HIC HM compared to LMIC HM. Articles were restricted to those indexed in PMC, MEDLINE, and SCOPUS databases, which may have led to exclusion of pertinent gray literature. Additionally, while many prehospital training programs are described in the scientific literature, the present study does not capture those programs which have not undergone formal study, nor does it capture HM programs within the hospital setting.

While we must not draw broad conclusions given the inclusion of just 20 studies within 16 LMICs, the consistency between our findings and those in supporting literature support a high degree of hemorrhage frequency, a large HM knowledge acquisition, and a significant clinical impact of HM care. Altogether, this supports the need for further research and resources dedicated to prehospital HM training in LMICs to reduce the burden of traumatic and obstetric hemorrhage mortality in the future.

6 | CONCLUSION

To our knowledge, this is the first scoping review of prehospital HM in LMICs. Our review highlights the positive impact of HM training on both Tier-1 and Tier-2 first responders, with at least half of their encounters involving the use of HM skills. These training led to significant knowledge acquisition and low-cost interventions that effectively reduced prehospital deaths from traumatic and obstetric hemorrhage.

Our findings indicate the importance of capacity building for HM training, considering the educational and clinical benefits observed and the frequency of hemorrhage in prehospital care. As LMICs face a disproportionate burden of hemorrhage, investing in HM training will play a crucial role in reducing the global injury burden disparity. Continued efforts need to be greatly expanded, as this will ultimately decrease the large hemorrhage mortality burden in LMICs.

AUTHOR CONTRIBUTIONS

Ashwin J. Kulkarni: study design, literature search, data collection, data analysis, data interpretation, writing, and critical revision. **Amber Batra**: literature search, data collection, critical revision. **Zachary J. Eisner**: data collection, data analysis, data interpretation, and critical revision. **Peter G. Delaney**: data analysis, critical revision. **Haleigh Pine**, **Maxwell C. Klapow**, **Krishnan Raghavendran**: critical revision.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

There were no ethical considerations required for this work.

ORCID

Ashwin J. Kulkarni https://orcid.org/0009-0006-5010-9735

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AUTHOR BIOGRAPHY

Ashwin J. Kulkarni was raised in San Jose, California and is currently a medical student at the University of Michigan. Prior to medical school, he earned his undergraduate degree from Northwestern University, where he studied journalism and neuroscience. He serves as the Outreach Director at LFR International, a nonprofit that develops lay first responder systems in resource-limited communities. His research focuses on increasing surgical care access through his work with the University of Michigan Institute for Healthcare Policy and Innovation. He is also passionate about building efficacious and sustainable emergency medical systems (EMS) in developing countries. In his free time, he plays ice hockey and is working towards obtaining his private pilot's license.

[Correction added on 26-Feb-2024, after first online publication: The first author's biography and photograph have been included in this version.]