



## ORIGINAL ARTICLE

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## ARTICLE INFO

## Keywords:

Essential medicines  
Emergency care  
Africa  
Health system

## ABSTRACT

**Objectives:** Essential medicines lists (EMLs) are efficient means to ensure access to safe and effective medications. The WHO has led this initiative, generating a biannual EML since 1977. Nearly all countries have implemented national EMLs based on the WHO EML. Although EMLs have given careful consideration to many public health priorities, they have yet to comprehensively address the importance of medicines for treating acute illness and injury.

**Methods:** We undertook a multi-step consensus process to establish an EML for emergency care in Africa. After a review of existing literature and international EMLs, we generated a candidate list for emergency care. This list was reviewed by expert clinicians who ranked the medicines for overall inclusion and strength of recommendation. These medications and recommendations were then evaluated by an expert group. Medications that reached consensus in both the online survey and expert review were included in a draft emergency care EML, which underwent a final in-person consensus process.

**Results:** The final emergency care EML included 213 medicines, 25 of which are not in the 2017 WHO EML but were deemed essential for clinical practice by regional emergency providers. The final EML has associated recommendations of desirable or essential, and is subdivided by facility level. Thirty-nine medicines were recommended for basic facilities, an additional 96 for intermediate facilities (e.g. district hospitals), and an additional 78 for advanced facilities (e.g. tertiary centres).

**Conclusion:** The 25 novel medications not currently on the WHO EML should be considered by planners when making rational formularies for developing emergency care systems. It is our hope that these resource-stratified lists will allow for easier implementation, and will be a useful tool for practical expansion of emergency care delivery in Africa.

## African relevance

What is already known about this subject:

- Essential medicines lists are efficient means to ensure access to safe and effective medications.
- Although essential medicines lists have given careful consideration to many public health priorities, they have yet to comprehensively address the importance of medicines for treating acute illness and injury.
- Low-resource settings with underdeveloped emergency care systems are in urgent need of emergency care-specific essential medicines

lists to enhance facility and system planning.

What this study adds:

- This manuscript proposes an emergency care essential medicines lists that includes 213 medicines, 25 of which are not in the 2017 WHO essential medicines lists.
- These medications were selected and agreed upon by expert clinicians practicing emergency care in Africa using a multi-phase consensus process.
- The final essential medicines lists has associated recommendations of desirable or essential, and is subdivided by facility level (basic,

<sup>☆</sup> This article has been co-published in the Emergency Medicine Journal; published Online First: 07 April 2018. Doi: <http://doi.org/10.1136/emered-2017-207396>. Peer review under taken by the Emergency Medicine Journal.

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intermediate, advanced).

## Introduction

Since the introduction of the World Health Organization's (WHO) Model List of Essential Medicines in 1977, essential medicines lists (EMLs) have become a core component of primary healthcare [1]. EMLs have nearly doubled access to essential medicines and are often cited as one of the most cost-effective interventions in modern healthcare [2,3]. By effectively limiting the number of medicines available, EMLs encourage prescription of higher-quality medicines [4], guide proper use and dosage of these medicines, and facilitate clinical education and training [1]. EMLs can also address public health concerns such as antibiotic resistance by promoting responsible use of these medicines [5].

The WHO EML is evidence-based, with medicines being prioritised based on public health relevance, safety, cost-effectiveness, and efficacy to ensure that they can be available in adequate doses at all times [6,7]. Ninety-five percent of countries have national EMLs guided by the WHO EML [4,7]; national EMLs are then used to inform treatment guidelines and allow for mandates surrounding procurement, provision, and training. Aid groups also rely on the WHO EML to create widely-applicable purchase lists and field guidelines [8,9].

From a population perspective, EMLs represent cost-effective interventions directed toward preventing and treating diseases [1]. However, the current WHO list has not been oriented toward a crucial form of secondary prevention – the appropriate treatment of patients with emergent clinical presentations. Emergency care is recognised as an effective means of reducing morbidity and mortality, especially in low-resource settings where the majority of the global burden of injury and illness resides [10–12]. Emergency care remains an underdeveloped aspect of healthcare in much of the world [10,13,14], and the essential medicines necessary for a general approach to treating acute illness and injury across multiple diseases have not been formally specified.

Some countries include medicines lists in their emergency care treatment guidelines, but these lists are not vetted for cost-effectiveness, public health relevance, and evidence of efficacy and safety [7]. The WHO EML itself receives minimal input from emergency care specialists [11]; the resultant list prioritizes vaccines and medications for the chronic treatment of infectious and non-communicable diseases but has notable gaps in vital medications required for emergency care [7]. In high-income countries the current WHO inclusion list is not problematic; systems are able to tailor the WHO EML to their already-functioning emergency units. But low-resource settings where emergency care systems are far less developed lack the capacity to complete such a process, yet are in urgent need of emergency care-specific medication lists to enhance facility and system planning [10,14,15].

More than half of Africans lack access to essential medicines [2] and many are required to pay for medicines prior to receiving care [16]. This is particularly problematic and often grossly unethical in emergency situations when medicines are needed immediately, regardless of ability to pay. A simplified emergency care EML would ensure the safety, efficacy, and availability of life-saving medicines [17]. It would serve to guide an essential component of emergency service delivery, leading to a more reliable drug supply and improved prescribing patterns, likely with improved patient outcomes and cost-effectiveness [4,8].

Over the coming decades, many African countries are expected to develop their emergency care systems. Currently, only one example of a country-level essential emergency medication list exists in Africa [18]. This paper describes a multi-step consensus process which we undertook to establish an EML for emergency care in Africa. We believe that such a list will be a useful tool for practical expansion of emergency care delivery in Africa, and that increasing the availability of essential emergency medicines will ultimately improve outcomes from acute

injury and illness.

## Literature review

A comprehensive literature review of both peer-reviewed publications and grey literature was conducted in late 2015 to identify EMLs specific to emergency care. A list of key search terms surrounding emergency medications and EMLs was devised. PubMed, MEDLINE, and Google Scholar were first searched to identify EMLs specific to emergency care; however, this search only returned one such list, published by the Ethiopian Food, Medicine and Health Care Administration and Control Authority in 2014 [18].

The search was then broadened to look for lists of essential medicines designed for low-resource settings. Although many national- and regional-level EMLs are available online, they are not published in indexed journals, so a detailed search of the grey literature was necessary [19]. Through the use of online search engines and key search terms we were able to identify numerous EMLs on academic, organisational, and government sites, including the 2013 WHO Essential Medicines List, the 2013 Médecins Sans Frontiers Essential Drugs list, and National Medicines Lists from 44 (81%) African countries. There was mention of EMLs for several other African countries, but they were not specific to emergency care and were unable to be obtained online.

The 2013 WHO EML and the 2013 Essential Drugs list from Médecins Sans Frontiers were compared to the retrieved National Medicines lists. We abstracted all medications known to be used in emergency care settings. Drugs used only to treat chronic conditions, such as chemotherapeutics and anti-retroviral medications, were not included. Drugs were also excluded if they were not listed on a majority (> 50%) of identified African EMLs, as this strongly indicated their lack of relevance and/or availability in the African setting.

This initial process generated a candidate list of 250 potential medicines. Drugs were grouped by categories deemed relevant to emergency care in order to facilitate later presentation for consensus gathering. We undertook a year-long, multi-step consensus process to refine the candidate list into a final EML for emergency care in 2015–16 (Fig. 1). The study design did not require our team to seek IRB approval.

## Online survey

The candidate list of medicines was used to generate a survey using an online tool (SurveyMonkey®). In order to capture opinions from the breadth of emergency care systems across Africa, a wide variety of healthcare providers who deliver emergency care in a range of contexts across the continent were sampled via convenience. Survey participants were identified through AFEM's membership pool: members who had been practising emergency care (whether as a specialist or any other level of healthcare provider) for at least one year at any type of facility were targeted. Of these, 109 had current contact details on file and were able to be reached via email to request participation.

The online survey contained 250 total medications, divided into 33 categories. Due to the large francophone population in Africa, it was made available to participants in both English and French. Participants were asked to rank each medicine as “essential”, “desirable”, “not necessary”, or “not applicable” [20,21]. Medicines were also ranked for three levels of facilities (basic, intermediate, advanced) to allow the EML to build upon the previously published African Federation for Emergency Medicine's (AFEM) sub-Saharan African emergency care facility designations [21]. This approach is synergistic with other initiatives for African emergency care development that base recommendations on facility capacity [22].

Respondents were asked to propose other medications and provide commentary. Medication routes were not specified at the time of the survey; however, respondents were informed about the facility level capacity of drug administration (e.g., basic level facilities can

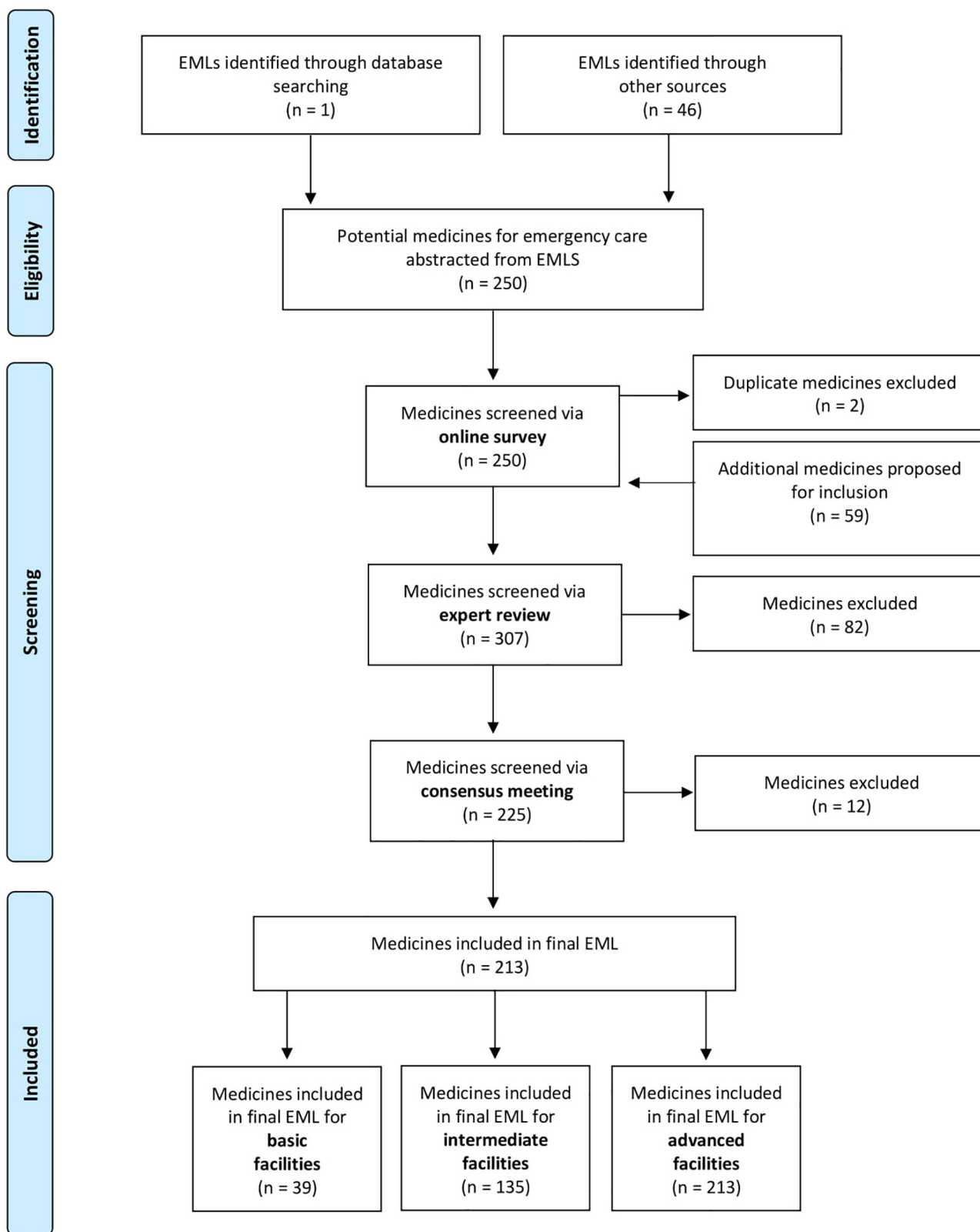


Fig. 1. Multi-step emergency care EML refinement process.

administer PO and IM medications, but not IV).

The survey was completed by 83 (76%) providers. The participant group comprised emergency medicine specialists (43%) and registrars (18%), non-emergency medicine specialist physicians (10%), emergency nurses (11%), and midlevel providers (8%) with collective

experience in 25 countries (22 of which are in Africa). When the data were analysed, it was discovered that the number of respondents completing each section decreased over the course of the survey: in the initial sections, 100% of respondents answered the questions, but by the last section only 64% of respondents replied.

**Table 1**

Essential emergency medicines for basic facilities. Resources available in one category are not repeated in another. The majority of essential medications for trauma presentations are included in categories respiratory failure, shock, altered mental status and severe pain. For a complete listing of drugs by categories, please see [Appendix 2](#).

RESPIRATORY FAILURE	SHOCK	ALTERED MENTAL STATUS	SEVERE PAIN
Ipratropium bromide Oxygen Prednisolone Salbutamol	Adrenaline Oral rehydration salts	Diazepam Oral glucose*	Acetylsalicylic acid Diclofenac* Ibuprofen Lidocaine (local anaesthesia) Paracetamol
ANTIDOTES & VACCINATIONS	ANTIMICROBIALS	OTHER	OPHTHALMOLOGIC DROPS/OINTMENT
Rabies vaccine Tetanus vaccine	Albendazole/Mebendazole Amoxicillin Amoxicillin + clavulanic acid Azithromycin Benzathine benzylpenicillin Ceftriaxone Ciprofloxacin Clindamycin Doxycycline Metronidazole Nystatin Praziquantel Regionally recommended oral antimalarial Sulfamethoxazole + trimethoprim	Chlorhexidine Diphenhydramine* Metformin Metoclopramide Povidone iodine Zinc sulfate	Aciclovir Erythromycin Ofloxacin Tetracaine Tetracycline <b>TOPICAL</b> Hydrocortisone Miconazole Silver sulfadiazine

According to the African Federation for Emergency Medicine's emergency facility designation, a basic level emergency care facility minimally offers oral and IM medications. This differs from standard Basic Emergency Obstetric and Newborn Care capacity facilities, which are considered to be able to give IV medications. Thus, no medicines are recommended in the category of "Maternal Health" at basic facilities [21,25].

\* Not listed on 2017 WHO Model List of Essential Medicines. Recommendation strength: desirable; **essential**.

In order to reduce the potential for weak results for medications near the end of the survey secondary to respondent attrition, we undertook a second expert review prior to the formal consensus meeting. Due to this attrition, no consensus level was defined to exclude medications, and all were considered in the expert review.

### Expert review

The expert review included 307 medications: 2 of the 250 original medications were excluded due to duplication and 59 additional medications were suggested. Survey data were analysed to generate descriptive statistics about responses. For simplicity, the medications from the online survey were regrouped from the initial 33 categories into 11 clinical presentation-based categories. For further context, the survey results were presented along with information on whether or not the medications were currently included on the WHO EML and the newly-released sidHARTE program Emergency Services Resource Assessment Tool (unpublished).

The survey results were presented for online review by expert physicians practicing emergency care in Africa. Recommendations were made for type of medication, location for inclusion (basic, intermediate and advanced) and whether the medication should be essential or desirable. The expert review group was comprised of a smaller cohort of participants who had not participated in the online survey. Fifteen physicians were included: three practicing in each AFEM region (North, South, East, and West) and three international subject matter experts. To be included, physicians were required to be qualified emergency medicine specialists, with experience practising directly in emergency units. Potential experts were identified via AFEM's membership pool, and contacted via email to request participation. The first three respondents to confirm availability to complete the full review process from each region were included.

A threshold of 70% agreement was predetermined for inclusion and the expert review recommended a total of 225 medications: 15 essential and 37 desirable medications at the basic level, 76 essential and 115 desirable medications at the intermediate level, and 154 essential and 71 desirable medications at the advanced level. These results were

combined with the feedback from the online survey and used to create a further-refined emergency care EML to be presented at the consensus meeting.

### Consensus meeting

Of the 307 medicines considered in the expert review, 225 reached consensus and were used as the basis on which to draft a tiered emergency care EML for basic, intermediate, and advanced facility levels. A medication was proposed for a given facility level if it received greater than 70% agreement in the expert review, either as essential or desirable.

A consensus meeting was convened at the 2016 African Conference on Emergency Medicine in Cairo, Egypt to review and provide further refinement of these preliminary EMLs. The consensus panel was composed of 21 clinicians currently practicing emergency care in Africa. These clinicians were selected based on agreement and availability to attend the meeting, longitudinal involvement in emergency care systems development and capacity building, and expertise in the African context. Participants could not have participated in previous reviews of the list. Again, participants were identified via AFEM's membership and contacted via email to request participation.

At the meeting, the draft list for each facility level was presented, and each medication was discussed in depth. Simple majority consensus opinion (> 50% agreement) was sought. Participants also had the opportunity to make comments on paper copies of the lists; these comments were collated for consideration in the final EMLs.

The final emergency care EML contained 213 medicines, grouped into 11 categories reflective of potential emergency presentations; these categories included the six AFEM sentinel conditions (difficulty in breathing, shock, altered mental status, severe pain, trauma, and maternal health) as well as five other categories identified as critical to emergency care. The final EML was further subdivided by facility level (Tables 1–3) to align with other emergency care development tools used in the region [21]. Of the original 250 medications derived from the literature review and proposed in the online survey, 36 medications were excluded as they did not reach consensus (Appendix 1). Most

**Table 2**

Essential emergency medicines for intermediate facilities. Resources available in one category are not repeated in another. The majority of essential medications for trauma presentations are included in categories respiratory failure, shock, altered mental status and severe pain. For a complete listing of drugs by categories, please see [Appendix 2](#).

RESPIRATORY FAILURE	SHOCK	ALTERED MENTAL STATUS	SEVERE PAIN	MATERNAL HEALTH
<b>Adrenaline</b> <b>Dexamethasone</b> <b>Hydrocortisone</b> <b>Ipratropium bromide</b> <b>Oxygen</b> <b>Prednisolone</b> Propofol <b>Salbutamol</b> <b>Suxamethonium</b> <b>Vecuronium</b>	Fresh frozen plasma <b>Oral rehydration salts</b> Phytomenadione (vitamin K) Platelet concentrates <b>Red blood cells (packed)</b> <b>Sodium chloride 0.9%</b> <b>Sodium lactate (Ringer's lactate)</b> <b>Tranexamic acid</b> <b>Whole blood</b>	Chlorpromazine Clozapine <b>Diazepam</b> Glucagon Glucose (10%, 50%) Haloperidol <b>Insulin injection</b> Intermediate-acting insulin Lorazepam <b>Mannitol</b> Midazolam <b>Oral glucose</b> <sup>*</sup> Phenobarbital <b>Phenytoin</b> Thiamine Valproic acid	Bupivacaine <b>Codeine</b> <b>Diclofenac</b> <sup>*</sup> Droperidol Fentanyl <b>Ibuprofen</b> <b>Ketamine</b> <b>Lidocaine (local anaesthesia)</b> <b>Lidocaine + epinephrine</b> <b>Morphine</b> <b>Paracetamol</b> <b>Pethidine</b> <sup>*</sup> <b>Tramadol</b> <sup>*</sup>	<b>Ergometrine</b> <b>Magnesium sulfate</b> Mifepristone Misoprostol <b>Oxytocin</b> Prostaglandin E
ANTIDOTES & VACCINATIONS	ANTIMICROBIALS	CARDIAC	OTHER	OPHTHALMOLOGIC DROPS/OINTMENT
Acetylcysteine <sup>1</sup> <b>Activated charcoal</b> Anti-rabies immunoglobulin <b>Anti-tetanus immunoglobulin</b> Anti-venom immunoglobulin Anti-D immunoglobulin <b>Atropine</b> Calcium gluconate Diphtheria antitoxin Fomepizole <sup>2</sup> Methylthionium chloride (methylene blue) <sup>4*</sup> <b>Naloxone</b> Pyridoxine <b>Rabies vaccine</b> Sodium nitrite + sodium thiosulfate <sup>3</sup> <b>Tetanus vaccine</b>	<b>Aciclovir</b> <b>Albendazole/Mebendazole</b> <b>Amoxicillin</b> <b>Amoxicillin + clavulanic acid</b>  Amphotericin B <b>Ampicillin</b> <b>Artemether</b> <b>Artesunate</b> <b>Azithromycin</b> <b>Benzathine benzylpenicillin</b> <b>Benzylpenicillin</b>  <b>Cefazolin</b> <b>Ceftriaxone/Cefotaxime</b> Chloramphenicol <b>Ciprofloxacin</b>  Clarithromycin Cloxacillin/Dicloxacillin Diethylcarbimazine <b>Doxycycline</b> <b>Fluconazole</b>  Ivermectin  <b>Metronidazole</b>  <b>Nystatin</b> Praziquantel <b>Quinine</b> <b>Regionally recommended oral antimalarial</b> Sulfamethoxazole + trimethoprim	<b>Acetylsalicylic acid</b>  Adenosine <sup>*</sup> Amiodarone <b>Amlodipine</b>  Bisoprolol Captopril <sup>†</sup> Digoxin Diltiazem <sup>*</sup> Dopamine Enalapril Enoxaparin  <b>Furosemide</b> <b>Glyceryl trinitrate</b> <b>Heparin sodium</b> Hydralazine  Hydrochlorothiazide Isosorbide dinitrate Labetalol Lidocaine Methyldopa  <b>Potassium chloride (powder)</b> Potassium chloride (solution) Sodium nitroprusside Spironolactone Verapamil	5% glucose, 0.45% sodium chloride 5% glucose, 0.9% normal saline Acetazolamide Aluminium hydroxide <sup>*</sup>  <b>Chlorhexidine</b> <b>Diphenhydramine</b> <sup>*</sup> <b>Iodine</b> Levothyroxine Loratadine <b>Magnesium hydroxide</b> <sup>*</sup> <b>Metformin</b>  <b>Metoclopramide</b> <b>Omeprazole</b> <b>Ondansetron</b> Potassium iodide  <b>Promethazine</b> <sup>*</sup> Propylthiouracil Pyridoxine <b>Ranitidine</b> Sodium chloride 0.45% <sup>*</sup>  <b>Zinc sulfate</b>	Aciclovir Chlorine Chloramphenicol <sup>†</sup> <b>Erythromycin</b>  Fluorescein Gentamicin Ofloxacin Prednisolone Tetracaine Tetracycline Timolol  Tropicamide <b>TOPICAL</b> Betamethasone Clotrimazole  Ethanol Hydrocortisone Miconazole Mupirocin Potassium permanganate (solution) <b>Povidone iodine</b>  Selenium sulfide  <b>Silver sulfadiazine</b> Terbinafine

\* Not listed on 2017 WHO Model List of Essential Medicines Recommendation strength: desirable; **essential**.

<sup>1</sup> Treatment for paracetamol overdose.

<sup>2</sup> Treatment for methanol or ethylene glycol poisoning.

<sup>3</sup> Treatment for cyanide poisoning.

<sup>4</sup> Treatment for cyanide poisoning and methemoglobinemia.

medicines recommended in the final EML (88%) are included in the current WHO EML. The expert panel acknowledged the robust internationally accepted guidance on regionally appropriate oral anti-malarials and thus deferred specific guidance on this class.

### Limitations of process

Using an online literature review strategy to find emergency care

EMLs will only identify those emergency care EMLs that have been published online. As emergency care is a rapidly developing field, there may be existing emergency care EMLs for low-resource settings that have not yet been published online, and therefore would have been missed by our literature review.

Although we attempted to reach a broad range of emergency care providers across Africa, there was limited input from those in Francophone nations. The online survey was offered in both English

**Table 3**

Essential emergency medicines for advanced facilities. Resources available in one category are not repeated in another. The majority of essential medications for trauma presentations are included in categories respiratory failure, shock, altered mental status and severe pain. For a complete listing of drugs by categories, please see [Appendix 2](#).

RESPIRATORY FAILURE	SHOCK	ALTERED MENTAL STATUS	SEVERE PAIN	MATERNAL HEALTH
<b>Adrenaline</b>	Desmopressin	<b>3% Sodium chloride</b> *	<b>Bupivacaine</b>	<b>Ergometrine</b>
Atracurium	<b>Dobutamine</b> *	<b>Chlorpromazine</b>	<b>Codeine</b>	<b>Magnesium sulfate</b>
<b>Dexamethasone</b>	<b>Factor IX concentrate</b>	Clozapine	<b>Diclofenac</b> *	Mifepristone
<b>Etomidate</b> *	Fludrocortisone	<b>Diazepam</b>	Droperidol	<b>Misoprostol</b>
<b>Hydrocortisone</b>	<b>Fresh frozen plasma</b>	Ethosuximide	<b>Fentanyl</b>	<b>Oxytocin</b>
<b>Ipratropium bromide</b>	Oral rehydration salts	Fluphenazine	<b>Ibuprofen</b>	<b>Prostaglandin E</b>
<b>Methylprednisolone</b>	<b>Phytomenadione (vitamin K)</b>	<b>Glucagon</b>	<b>Ketamine</b>	<b>Surfactant</b>
<b>Oxygen</b>	<b>Platelet concentrates</b>	Glucose (5%, 10%, 50%)	<b>Lidocaine + epinephrine</b>	
<b>Prednisolone</b>	<b>Red blood cells (packed)</b>	<b>Haloperidol</b>	<b>Lidocaine (local anaesthesia)</b>	
Propofol	<b>Sodium chloride 0.9%</b>	<b>Insulin injection</b>	<b>Morphine</b>	
<b>Salbutamol</b>	<b>Sodium lactate (Ringer's lactate)</b>	<b>Intermediate-acting insulin</b>	Nitrous oxide	
		Levetiracetam*	<b>Paracetamol</b>	
<b>Suxamethonium</b>	<b>Tranexamic acid</b>	<b>Lorazepam</b>	<b>Pethidine</b> *	
Thiopental†	<b>Whole blood</b>	<b>Mannitol</b>	<b>Tramadol</b> †	
<b>Vecuronium</b>		<b>Midazolam</b>		
		<b>Oral glucose</b>		
		<b>Phenobarbital</b>		
		<b>Phenytoin</b>		
		<b>Thiamine</b>		
		<b>Valproic acid</b>		
<b>ANTIDOTES &amp; VACCINATIONS</b>	<b>ANTIMICROBIALS</b>	<b>CARDIAC</b>	<b>OTHER</b>	<b>OPHTHALMOLOGIC DROPS/OINTMENT</b>
<b>Acetylcysteine</b> <sup>1</sup>	<b>Aciclovir</b>	<b>Acetylsalicylic acid</b>	5% glucose, 0.45% sodium chloride	<b>Aciclovir</b>
<b>Activated charcoal</b>	<b>Albendazole/Mebendazole</b>	<b>Adenosine</b> *	5% glucose, 0.9% normal saline	<b>Atropine</b>
<b>Anti-D immunoglobulin</b>	<b>Amoxicillin</b>	Amiloride	<b>Acetazolamide</b>	Azithromycin
<b>Anti-rabies immunoglobulin</b>	<b>Amoxicillin + clavulanic acid</b>	<b>Amiodarone</b>	Albumin*	<b>Chloramphenicol</b> †
<b>Anti-tetanus immunoglobulin</b>	Amphotericin B	<b>Amlodipine</b>	Aluminium hydroxide*	<b>Erythromycin</b>
<b>Anti-venom immunoglobulin</b>	<b>Ampicillin</b>	<b>Bisoprolol</b>	<b>Diphenhydramine</b> *	<b>Fluorescein</b>
<b>Atropine</b>	<b>Artemether</b>	<b>Captopril</b> *	<b>Iodine</b>	<b>Gentamicin</b>
Calcium chloride <sup>2*</sup>	Artesunate	<b>Clopidogrel</b>	<b>Levothyroxine</b>	<b>Hydrocortisone</b>
<b>Calcium gluconate</b>	<b>Azithromycin</b>	<b>Digoxin</b>	Loratadine	Latanoprost
Dantrolene	<b>Benzylpenicillin</b>	<b>Diltiazem</b> *	<b>Magnesium hydroxide</b> *	<b>Ofloxacin</b>
<b>Deferoxamine</b> <sup>3</sup>	<b>Benzathine benzylpenicillin</b>	<b>Dopamine</b>	<b>Metformin</b>	<b>Pilocarpine</b>
Dimercaprol <sup>4</sup>	Cefalexin	Enalapril	<b>Metoclopramide</b>	<b>Prednisolone</b>
Diphtheria antitoxin	<b>Cefazolin</b>	<b>Enoxaparin</b>	<b>Omeprazole</b>	<b>Tetracaine</b>
Fomepizole <sup>5</sup>	<b>Ceftriaxone/Cefotaxime/Cefixime/Ceftazidime</b>	<b>Furosemide</b>	<b>Ondansetron</b>	<b>Tetracycline</b>
<b>Hydroxocobalamin</b> <sup>6</sup>	Chloramphenicol	<b>Glyceryl trinitrate</b>	<b>Potassium iodide</b>	<b>Timolol</b>
Intralipid	<b>Ciprofloxacin</b>	<b>Heparin sodium</b>	<b>Promethazine</b> *	Tropicamide
Methylthionium chloride (methylene blue) <sup>9*</sup>	<b>Clarithromycin</b>	<b>Hydralazine</b>	<b>Propylthiouracil</b>	
<b>Naloxone</b>	<b>Clindamycin</b>	<b>Hydrochlorothiazide</b>	<b>Ranitidine</b>	<b>TOPICAL</b>
<b>Pralidoxine</b> <sup>7*</sup>	<b>Cloxacillin/Dicloxacillin</b>	<b>Isosorbide dinitrate</b>	Sodium chloride 0.45%*	Betamethasone
Pyridoxine	Diethylcarbamazine	<b>Labetalol</b> †	Sulfasalazine	<b>Chlorhexidine</b>
<b>Rabies vaccine</b>	<b>Doxycycline</b>	<b>Lidocaine</b>	<b>Zinc sulfate</b>	Clotrimazole
Sodium calcium edetate <sup>8</sup>	<b>Fluconazole</b>	<b>Losartan</b>		<b>Ethanol</b>
<b>Sodium nitrite + sodium thiosulfate</b> <sup>6</sup>	Flucytosine	<b>Methyl dopa</b>		<b>Hydrocortisone</b>
<b>Succimer</b> <sup>8</sup>	<b>Gentamicin</b>	<b>Nifedipine</b>		<b>Miconazole</b>
<b>Tetanus vaccine</b>	<b>Ivermectin</b>	<b>Potassium chloride (powder)</b>		Mupirocin
		<b>Potassium chloride (solution)</b>		Potassium permanganate (solution)
	Levofloxacin	Procainamide*		<b>Povidone iodine</b>
	<b>Metronidazole</b>	<b>Sodium nitroprusside</b>		Selenium sulfide
	<b>Nitrofurantoin</b>	<b>Spirolactone</b>		<b>Silver sulfadiazine</b>
	Nystatin	<b>Streptokinase</b>		Terbinafine
	<b>Pentamidine</b>	Verapamil		
	Praziquantel	Tenecteplase (tPA, metalyse) <sup>10*</sup>		
	<b>Quinine</b>			
	<b>Regionally recommended oral antimalarial</b>			
	<b>Sulfamethoxazole + trimethoprim</b>			

(continued on next page)

Table 3 (continued)

RESPIRATORY FAILURE	SHOCK	ALTERED MENTAL STATUS	SEVERE PAIN	MATERNAL HEALTH
<b>Vancomycin</b>				
* Not listed on 2017 WHO Model List of Essential Medicines Recommendation strength: desirable; <b>essential</b> .				
<sup>1</sup> Treatment for paracetamol overdose.				
<sup>2</sup> Treatment for hypocalcaemia and magnesium sulfate overdose.				
<sup>3</sup> Treatment for iron toxicity.				
<sup>4</sup> Treatment for arsenic, mercury, lead poisoning.				
<sup>5</sup> Treatment for methanol or ethylene glycol poisoning.				
<sup>6</sup> Treatment for cyanide poisoning.				
<sup>7</sup> Treatment for organophosphate poisoning.				
<sup>8</sup> Treatment for lead poisoning.				
<sup>9</sup> Treatment for cyanide poisoning and methemoglobinemia.				
<sup>10</sup> Treatment for massive pulmonary embolism.				

and French, but the expert review and consensus meeting were conducted only in English. In future iterations of the emergency care EML we will work with translators to ensure better engagement of French-speaking emergency care representatives.

Pharmacists bring diverse and indispensable expertise to EMLs. Our process is limited by the fact that we did not engage enough pharmacists throughout the study. There are few, if any, pharmacists in Africa that specialise in emergency care. As such, we could not identify a robust pool of pharmacists that could be considered experts in this field. The consultation of a pharmacist with significant experience providing emergency care in low-resource settings was sought later in the consensus process. Future iterations of the list should include perspectives from a larger group of pharmacists.

A potential limitation of any consensus group discussion is that not all views may end up being included, as some participants conform with the majority opinion. This may have occurred in the consensus meeting; however, we tried to avoid this by allowing participants to also make written comments for later consideration.

## Discussion

The process to generate this emergency care EML was iterative, engaging a diverse group of experienced clinicians practicing at all levels in a range of African settings. In some categories, individuals practicing in tertiary care facilities recommended more specialised drugs (e.g. imipenem), but the multi-stage consensus process appropriately excluded these resource-intensive, likely unrealistic medicines from the EML.

This is the first non-country-specific emergency care EML for low-resource settings. The EML addresses two challenges to implementing emergency care: it identifies context-specific medicines essential to emergency care, and it identifies the appropriate locations for distribution of those medications based on fundamental emergency capacities of facilities [21].

In order to ensure that emergency care EMLs are appropriate for a range of facility levels within countries and regions, we divided the comprehensive list first by facility level and then by strength of recommendation. The three facility levels were defined according to minimum expected emergency capacity via consensus across African emergency care experts in 2013 [21]. Medication recommendations for each level were matched to expected performance of emergency service delivery.

Certain medications are notably absent from the emergency care EML. These were excluded specifically because of lack of data concerning their efficacy in resource limited settings (e.g., tissue plasminogen activator for cerebral vascular accident [23]) or lack of evidence to show significant improvement in mortality, morbidity, or patient-centred outcomes in the first 24 h of care (e.g., anti-tuberculosis medications). Instead, experts recommended additional medications

deemed essential for treating emergent conditions, yet were absent from the WHO EML. Some examples include etomidate, a hemodynamically neutral induction agent for rapid sequence intubation; labetalol and diltiazem, both used for immediate rate control in supraventricular tachycardias and for blood pressure reduction; dobutamine for cardiogenic shock, and diphenhydramine for allergic reactions.

Medications were stratified as being either essential or desirable; this terminology is modelled off of prior WHO checklists [24]. Essential and desirable were used in place of WHO's 'core' and 'complementary' recommendation levels, respectively, because these terms have previously been used to define capacity in the African setting [21]. *Essential* medicines should be available at all facilities of a given level at all times, while the availability and use of *desirable* medicines might vary based on availability of clinical expertise and resource constraints at a facility. Of note, processes should be in place at health care facilities to ensure timely access by health care providers to essential medications; for example, drugs required for emergent airway management should not exclusively be stocked in the operating theatre, far from the emergency unit.

Prior to completing this process, it was anecdotally held that most medicines sufficient to treat emergencies in Africa were contained in the WHO EML. In fact, 88% of medicines included in the final emergency care EML are listed on the WHO EML. Since national EMLs are typically based off of the WHO list, this implies that most emergency medicines would also already be included at the national level, and that dosage and administration route guidance provided in the WHO EML will be well known. However, of the 213 medicines ultimately recommended for inclusion, 25 were not included on the 2017 WHO EML. This highlights a potential gap, and suggests that the WHO EML is missing medications important for emergency care in Africa. It is our hope that these resource-stratified lists will allow for easier implementation in countries, while maintaining the rigorous recommendations necessary to improve availability of essential emergency medications.

## Authors' contributions

MCB, LAW, and EJCH conceived and designed the study. All authors contributed substantially to the EML refinement process. MCB, JLP, LAW, and EJCH drafted the manuscript. All the authors contributed to the manuscript's revision.

## Acknowledgements

The authors and the AFEM Scientific Committee would like to thank the 83 participants of the online survey. We would also like to thank the 15 physicians who completed expert review:

AFEM East: S Kassamali, S Kilindimo, A Alenylo Ngabirano.

AFEM South: M Botha, K Diango, K Sikuvi.

AFEM West: J Jeong, E Ami Momade, C Kwaku Oppong,

AFEM North: H Benmasaud, S Helmy, H Zaki.

International: H Harrison, A Levine, C Taubman.

*Consensus panel:* J Becker, M Bizanso, C Chang, K Diango, J Dixon, S Dunlop, A Hankin-Wei, S Helmy, S Kassamali, J Lin, G Mbanjumucyo, J Mfinanga, N Mould-Millman, M Mutendi Muller, H Sawe, H Zaki.

*The following countries (number of participants) were represented throughout the process— some participated in more than one phase:* Botswana (3), Cameroon (2), DR Congo (2), Egypt (3), Ethiopia (2), Ghana (6), Kenya (1), Libya (1), Madagascar (5), Malawi (1), Namibia (2), Netherlands (1), Nigeria (2), Rwanda (5), Saudi Arabia (1), Sierra Leone (1), Somalia (3), South Africa (15), Sudan (6), Tanzania (11), U.A.E (1), Uganda (2), U.K. (1), U.S.A. (4), Zambia (2).

The authors are grateful for the pharmacological expertise of Dr Lance Ray and the extensive contributions of Dr Teri Reynolds.

### Conflicts of interest

The authors declare no conflict of interest.

### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.afjem.2018.05.002>.

### References

- [1] Executive Summary: The Selection and Use of Essential Medicines Geneva; 2017.
- [2] Equitable access to essential medicines – a framework for collective action. WHO Policy Perspectives on Medicines Geneva; 2004.
- [3] Bansal D, Purohit VK. Accessibility and the use of essential medicines in health care: Current progress and challenges in India. *J Pharmacol Pharmacother* 2013;4(1):13–8. <http://dx.doi.org/10.4103/0976-500X.107642>.
- [4] The Selection of Essential Medicines WHO Policy Perspective on Medicines Geneva; 2002.
- [5] Gulland A. WHO targets antimicrobial resistance in new essential medicines list. *BMJ* 2017;357:j2809. <http://dx.doi.org/10.1136/bmj.j2809>.
- [6] Laing R, Waning B, Gray A, et al. 25 years of the WHO essential medicines lists: progress and challenges. *Lancet* 2003;361(9370):1723–9. [http://dx.doi.org/10.1016/S0140-6736\(03\)13375-2](http://dx.doi.org/10.1016/S0140-6736(03)13375-2).
- [7] Understanding the Role and Use of Essential Medicines Lists; 2015.
- [8] UNHCR's Essential Medicines and Medical Supplies: Policy and Guidance 2011. Geneva; 2011.
- [9] Pilon S. Essential Drugs: 2016 Edition Medicins Sans Frontieres; 2016.
- [10] Reynolds TA, Mfinanga JA, Sawe HR, et al. Emergency care capacity in Africa: a clinical and educational initiative in Tanzania. *J Public Health Policy* 2012;33(Suppl 1):S126–37. <http://dx.doi.org/10.1057/jphp.2012.41>.
- [11] Thind A, Hsia R, Mabweijano JR, et al. Essential Surgery. *Disease Control Priorities in Developing Countries*. 3 ed; 2015:246.
- [12] Wang HNM, Allen C, Barber R, Bhutta Z, Carter A, Casey D, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1459–544. [http://dx.doi.org/10.1016/S0140-6736\(16\)31012-1](http://dx.doi.org/10.1016/S0140-6736(16)31012-1).
- [13] Hamedani AG, Wears RL. Anyone, anything, anytime...All the time. *Ann Emerg Med* 2009;53(6):724–6. <http://dx.doi.org/10.1016/j.annemergmed.2008.12.002>.
- [14] Nowacki AK, Landes M, Azazh A, et al. A review of published literature on emergency medicine training programs in low- and middle-income countries. *Int J Emerg Med* 2013;6(1):26. <http://dx.doi.org/10.1186/1865-1380-6-26>.
- [15] Tumuslime P, Gonani A, Walker O, et al. Health systems in sub-Saharan Africa: What is their status and role in meeting the health Millennium Development Goals? *Afr Health Monitor* 2012;14.
- [16] Leive A, Xu K. Coping with out-of-pocket health payments: empirical evidence from 15 African countries. *Bull World Health Org* 2008;86(11):849–56.
- [17] Hutchings J, Neroutsos K, Donnelly K. Making the list: the role of essential medicines lists in reproductive health. *Int Perspect Sex Reprod Health* 2010;36(4):205–8. <http://dx.doi.org/10.1363/3620510>.
- [18] Emergency Medicines List 1ed. Addis Ababa; 2014.
- [19] Saleh AA, Ratajeski MA, Bertolet M. Grey literature searching for health sciences systematic reviews: a prospective study of time spent and resources utilized. *Evid Based Libr Inf Pract* 2014;9(3):29–50.
- [20] Germa F, Bayleyegn T, Kebede T, et al. Emergency medicine development in Ethiopia: Challenges, progress and possibilities. *Afr J Emerg Med* 2013;3:3–9.
- [21] Calvello EJ, Tenner AG, Broccoli MC, et al. Operationalising emergency care delivery in sub-Saharan Africa: consensus-based recommendations for healthcare facilities. *Emerg Med J* 2016;33(8):573–80. <http://dx.doi.org/10.1136/emered-2015-204994>.
- [22] Wallis LA, Reynolds TR. AFEM handbook of acute and emergency care. Oxford University Press; 2014.
- [23] Aaron L, Berkowitz AL, Mittal MK, McLane HC, et al. Worldwide reported use of IV tissue plasminogen activator for acute ischemic stroke. *Int J Stroke* 2014;9:349–55.
- [24] World Health Organization and International Association for the Surgery of Trauma and Surgical Intensive Care (IATSIC). Essential trauma care project: checklists for surveys of trauma care capabilities. Geneva: World Health Organization; 2004. [http://www.who.int/emergencycare/trauma/essential-care/estc\\_checklist.pdf?ua=1](http://www.who.int/emergencycare/trauma/essential-care/estc_checklist.pdf?ua=1).
- [25] Bailey P, Lobis S, Maine D, et al. Monitoring emergency obstetric care: a handbook. Geneva: World Health Organization; 2009.