TRIAGE OF ILL CHILDREN IN TANZANIA

Recommendations for a paediatric triage tool in primary health care settings

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Triage of ill children in Tanzania

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by

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Declaration:
Where other people's work has been used (either from a printed source, internet or any other source) this has been carefully acknowledged and referenced in accordance with departmental requirements.
The thesis **Triage of ill children in Tanzania** is my own work.

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Table of Contents

List of tables, figures and abbreviations

Tables

Figures

Abbreviations

ABCD	Airway, Breathing, Circulation, Disability
AUC	Area under the receiver-operating-curve
AVPU	Alert, Verbal, Pain, Unresponsive
CPETS	Chinese Paediatric Emergency Triage System
CTAS	Canadian Triage and Acuity Scale
DALY	Disability Adjusted Life Year
ED	Emergency Department
ESI	Emergency Severity Index
ETAT	Emergency Triage and Treatment
GDP	Gross Domestic Product
HR	Heart Rate
IMCI	Integrated Management of Childhood Illness
LMIC	Low and Middle Income Country
LTS	Local Triage System
MD	Medical Doctor
MDG	Millenium Development Goal
MTS	Manchester Triage System
MUAC	Mid Upper Arm Circumference
OTT	One-two-triage
PEWS	Paediatric Early Warning Score
PHC	Primary Health Care
RDT	Rapid Diagnostic Test
REC	Research Ethics Committee
RR	Respiratory Rate
SATS	South African Triage Scale
Se	Sensitivity
SITS	Solomon Islands Triage Scale
Sp	Specificity
SpO2	Oxygen saturation
TOPRS	TOPRS – Temperature, Oxygen saturation, Pulse rate, Respiratory rate, Sensorium - seizures
WHO	World Health Organization

Abstract

Introduction
A key challenge in Tanzanian paediatric care is limited availability and quality of primary health care (PHC). Introducing a triage system to prioritize children with urgent illness may improve its efficiency and effectiveness. This study aims to identify available paediatric triage tools for low and middle income countries (LMIC) and to evaluate their feasibility for use in the Tanzanian PHC.

Methods
A literature review identified the available paediatric triage tools in LMIC. We evaluated them for their intended use, stage of validation, validity and reliability. Next, we performed a one-round Delphi survey among healthcare providers in the Tanzanian PHC. For all items of the identified triage tools we ranked the reliability of measurement, frequency of finding an abnormal value and required resources in PHC settings.

Results
We identified thirteen paediatric triage tools for LMIC. One was intended to be used in primary care (SCREEN). Two were evaluated broadly in the African setting (Emergency Triage and Treatment (ETAT) and South African Triage Scale (SATS)). The Delphi survey (n=30) showed that clinical signs and symptoms were likely to be feasible for triage in Tanzanian PHC, in contrast to vital sign measurements due to lack of resources and need for training.

Discussion
The SCREEN triage tool and an adapted version of ETAT/SATS seem feasible for use in the Tanzanian PHC setting. Validation and evaluation of clinical efficacy and effectiveness need to be performed to measure its impact on the health system and on child health.

Keywords: triage, primary health care, pediatrics, Tanzania, health resources, delivery of health care
Word count: 8832

Introduction

Background
My name is Josephine van de Maat. I am a medical doctor from The Netherlands. During medical school at Leiden University I took courses in tropical medicine and in African and Latin American studies. After my graduation in 2012 I worked as a doctor in clinical care until 2014, in the departments of internal medicine and emergency care in The Hague and Zoetermeer (NL). In 2015, I followed the Netherlands Course in Tropical Medicine (NTC) at the Royal Tropical Institute (KIT) in Amsterdam, as the start of my master in International Health. After this, I spent three months working in the north of Malawi as a general doctor in Ekwendeni Mission Hospital. Coming back to The Netherlands, I worked for six months at the paediatric intensive care unit (PICU) of Leiden University Medical Centre, before I started my PhD in epidemiology at the department of general paediatrics of the Sophia Children's Hospital in Rotterdam.

Topic of this thesis
The main topic of this thesis is triage of children in Primary Health Care (PHC) in Tanzania. Triage is the process of prioritization of patients that most urgently need medical attention. This is common in many emergency departments (ED) around the world, but is not always carried out systematically in the Tanzanian PHC system. Absence of patient triage can result in long waiting times for ill children requiring urgent medical attention and may delay treatment and/or referral. Several paediatric triage tools are available for low-and-middle-income countries (LMIC), but it is unknown which tool would be suitable for the PHC setting in Tanzania. In this thesis I evaluate the evidence and applicability of existing paediatric triage tools and make recommendations for a triage tool in primary care in Tanzania, against the background of the local organization of care, epidemiology of disease and available resources.

Why this topic?
During my PhD research, I found out that a Swiss/Tanzanian research group was performing similar studies as I performed in The Netherlands. The main project of my PhD thesis was the Study To Reduce Antibiotic prescription in childhood Pneumonia (STRAP). In this trial we aimed to reduce antibiotics in children under five with respiratory tract infections by implementing a clinical decision rule in the emergency department. The researchers at the Swiss Tropical Institute (Principal Investigator Dr. Kristina Keitel, paediatrician) had performed the ePOCT trial: implementation of a diagnosis and treatment algorithm to improve management of febrile children under five in the Tanzanian primary care setting. This inspired me to contact the researchers, which led to a collaboration and the topic of this thesis. The Swiss TPH is preparing a large-scale follow-up trial in collaboration with Ifakara Health Institute Tanzania, to implement an updated diagnosis and treatment algorithm for children in primary care (DYNAMIC trial). At the time of this thesis, no content was available for a triage algorithm.

What do I hope to achieve?
I hope to provide evidence-based recommendations for a paediatric triage tool that is of the best quality and applicability for the Tanzanian PHC setting. This triage tool will be incorporated in the clinical algorithms in the DYNAMIC study, starting in Tanzania in 2020.

Background

Health care and burden of disease in Tanzania

General introduction of Tanzania

The United Republic of Tanzania is located in the east of Africa, consisting of the mainland and the semi-autonomous island of Zanzibar. Tanzania has a total population of 57 million people (with an annual population growth of 3%), of which almost half is under 15 years old. The majority of the population (71%) live in rural areas.(1) Tanzania's gross domestic product (GDP) is 52 billion US$ (936 US$ per capita), and the main economic sectors are agriculture, industry, mining and construction. Life expectancy has increased steadily over the past 20 years, and is currently 65 and 69 years at birth (males versus females). Though under-five mortality has decreased in the past years, approximately one of 16 children die before the age of five (compared to 1 in 250 children in The Netherlands. Most mortality is caused by infectious diseases, whereas non-communicable diseases cause a significant share of the country's disability.(2-5)

Organization of health system

Healthcare in Tanzania is provided by public and private providers, but the largest share is provided by the public sector.(6) This public sector also includes a large proportion of faith-based organizations. The primary health care (PHC) level consists of the three lowest layers of Figure 1: outreach and community healthcare at the community level, dispensaries at the village level and rural health centres at the ward level. Patients are expected to be seen at a PHC facility for their illness. At dispensaries patients can be observed for some hours, but inpatient care starts at the health centre level. Patients can be referred from dispensaries to health centres for basic inpatient care, or, if needed, to higher levels of care in district hospitals or regional referral hospitals. Specialist care is provided at the regional level. Zonal and national level hospitals provide advanced care and training of doctors and nurses.(6)

Public health needs and national health policy

Even though the number of healthcare facilities is increasing, a major challenge in Tanzania is the availability and quality of primary care, particularly in rural areas. This is directly related to challenges in human and financial resources as well as governance. The WHO mentions the inefficiency of human resources and the de-motivation of staff.(5) Major human resource challenges for primary care are the attraction of qualified staff to live in rural areas, and the retention of qualified staff (personal communication). Given the history of communicable diseases, a strong focus has been on disease-specific programmes. Even though these programmes have been successful in early detection and treatment of diseases of focus, it also resulted in fragmented healthcare (and financing). Reproductive, maternal, child and adolescent healthcare are underperforming, so a major challenge is to improve the care for these groups and to harmonize different programmes.(6) To improve the availability, accessibility and quality of services, the first strategic objective of the Tanzanian government is to improve the quality of primary healthcare services. This entails the provision of a package of essential health services including preventive as well as curative care for communicable and non-communicable diseases, and a strong focus on maternal and child care.(6, 7)

Tanzania reached the Millennium Development Goal (MDG) 4 for child survival, mostly due to increased vaccination coverage and specific high-impact interventions. However, less progress is made in curative care, and large disparities exist between rural and urban areas.(8)

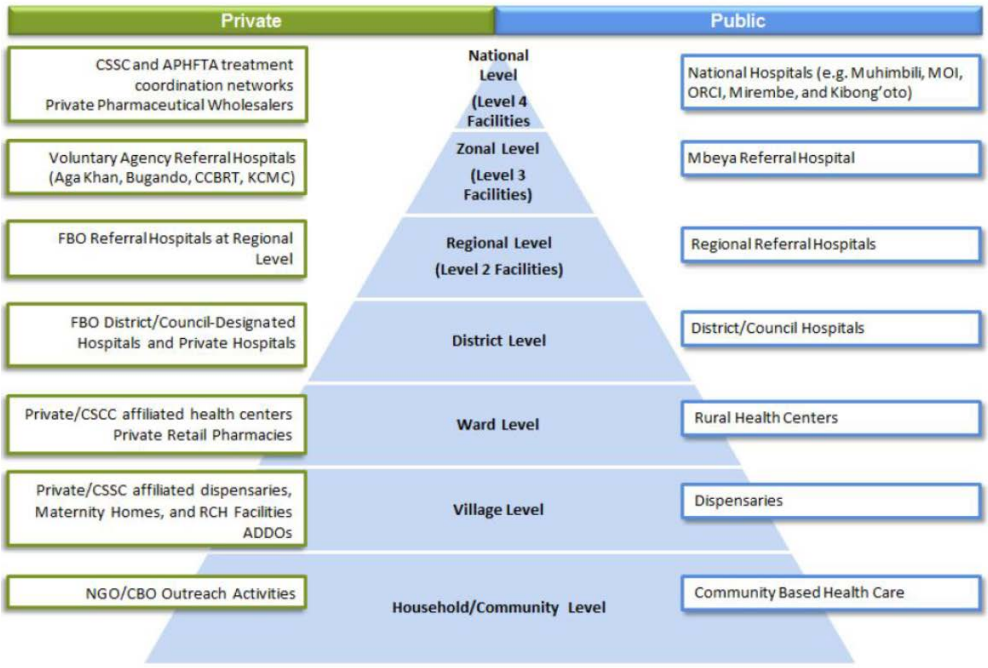


Figure 1. Organization of the healthcare system in Tanzania (6)

Child health in Tanzania

Burden of disease

The general pattern of diseases in Tanzania is similar to other sub-Saharan countries and consists of the double burden disease: communicable diseases are still widely present, while non-communicable diseases are on the rise. Also in children, the burden of disease is shifting: in 1990, the two most important causes of death and DALYs lost in children under five in Tanzania were respiratory infections and malaria, whereas in 2017 these were neonatal and 'other non-communicable' diseases (including congenital defects).(9) However, after the neonatal period the main causes of death and disability are still infectious diseases: respiratory infections, malaria and diarrhoea account for more than half of under-5 child deaths.(8, 9)

Providers of paediatric care

In Tanzania, paediatric care is provided by different healthcare professionals, depending on the level of care.(10) At hospital level, paediatric care is provided by nurses, medical officers (MD) and by paediatricians. In primary care, all patients (adults and children) are seen by nursing staff and clinicians, depending on the size of the facility. At dispensary level, the staff usually consists of nurses. At health centres, in addition to nurses, clinicians are available (this can be clinical officers, assistant medical officers or medical officers), and basic medical and surgical care can be provided. The number of providers in PHC may vary greatly between rural and urban areas and between richer or poorer regions.(6, 10) Dispensaries usually have 3-5 providers in total, and health centres 5-15 (including in-patient staff, staff shifts etc.) (based on personal communication).

Integrated management of childhood illnesses

Primary care to children in Tanzania is provided following the WHO Integrated Management of Childhood Illnesses (IMCI) strategy and other strategic documents or treatment guidelines. IMCI aims to integrate vertical disease programs into a single, integrated strategy to reduce childhood mortality, including training, vaccines and guidelines. Tanzania has adopted the IMCI strategy from the beginning, and implemented this in 2000 throughout the country.(8) In 2017, a global survey of the WHO showed that Tanzania was among the 'full implementer' countries, meaning that in >90% of the districts the IMCI strategy was implemented.(11)

Guidelines for paediatric primary care

Part of the IMCI strategy is the IMCI chart booklet. This case management guideline is a syndrome-based approach for the care of children under five, focusing on the most prevalent diseases in this group and recognizing that children often present with multiple conditions.(12) The chart booklet provides guidance for diagnosis and treatment of children in low-resource settings. Examples of included syndromes are fever, cough

or dyspnoea or diarrhoea. Based on clinical signs and symptoms, the condition of the child is classified as severe (red, needs urgent treatment and/or referral to hospital), moderately severe (yellow, needs urgent treatment) or not severe (green). Next to this chart booklet, the 'Standard treatment guidelines and essential medicines list' is available from the Tanzanian ministry of health, including national recommendations for indications and dosing of medications for adults as well as children.(13)

Decision algorithms for the management of febrile children

IMCI provides global, standardized recommendations for the management of childhood illness and has had a great impact in many settings in improving child health.(14) Though country adaptations of IMCI are performed, the IMCI chart booklet remains generic and inadequately tailored to the local prevalence of disease and availability of resources. Over the past years, a Swiss/Tanzanian research group has aimed to improve the management of sick children by developing electronic algorithms that are based on IMCI, but adjusted to the most recent scientific evidence and to the Tanzanian epidemiology of disease and availability of resources. The first algorithm was 'ALMANACH', in which the IMCI recommendations were adjusted against the background of declining malaria prevalence and increased availability of malaria rapid diagnostic tests (RDT) in Tanzania.(15) In a research study the implementation of this algorithm in 2011 led to better clinical outcomes and a reduction in antibiotic prescription of 80%.(16) After these promising results, the algorithm has been updated, resulting in ePOCT: a decision algorithm that not only includes clinical signs and symptoms, but has also incorporated point-of-care tests (POCT, for example haemoglobin and C-reactive protein) to improve the recognition and treatment of serious illness.(17) The impact of this ePOCT algorithm was studied a controlled, randomized study in Tanzanian health centres and outpatient clinics for the management of children under five, presenting with a (history of) fever. Compared to the ALMANACH algorithm, ePOCT resulted in improved clinical outcomes and a reduction in antibiotic prescription in this study.(17) Currently, the ePOCT algorithm is being further developed into ePOCT+ and will undergo a larger effectiveness evaluation in routine conditions. The aim is to extend the algorithm to the whole spectrum of disease, to cover all age groups and to include a pre-consultation triage algorithm. This content extension is necessary to assure that ePOCT+ can be used for all patients presenting to the health facility.

Problem statement and justification

One of the key challenges in the Tanzanian health system is the limited availability and quality of primary care, while this is the level of care that serves by far the largest share of the population.(6, 10) In order to improve health of the population, improving primary care should be and is a high priority for the Tanzanian government. Since disease-specific programmes increase fragmentation, attention should be given to interventions that target the whole spectrum of disease. Given the scarcity of resources, one way to strengthen primary health care is to improve efficiency and effectiveness of the system.(18)

Triage of patients is a common and important way of improving efficiency and quality of emergency care settings. Triage is the prioritization of patients that most urgently need medical attention.(18) During triage, patients are categorized into different levels of urgency based on a quick assessment by a nurse, before the actual medical consultation by a physician. Adequate triage serves two goals. First, it improves the quality of care, by ensuring that patients who need urgent treatment are seen and treated first.(19, 20) Early identification of urgent illness thereby improves clinical outcomes. Second, it improves the efficiency of the ED, by shifting tasks from physicians to nurses or less-trained providers and thereby making optimal use of the human resources.(21) Both goals have benefits especially in crowded health care settings where waiting times are long. Regarding triage of children, many paediatric triage tools are available and several have been developed or validated in low-and-middle-income countries (LMIC).(22)

Most of the paediatric triage tools have been developed in the hospital ED setting, but less is known about triage in the primary health care setting. Also in Tanzania, triage of children is performed in some hospitals,(23) but is not formally carried out in primary care, even though crowding and scarcity of resources are common. Triage tools that are developed for a hospital setting may not be directly applicable to primary care settings. First, triage in primary care settings requires different levels of urgency, since children with acute life-threatening illness that require immediate resuscitation are less prevalent.(24) A greater risk may be to miss children with illness of intermediate urgency, who deteriorate during long waiting times and may develop life-threatening illness. Another important difference is that primary care centres often have less qualified staff, and it is unknown what type of task-shifting can be done in these settings.

Triage in primary care settings can be performed in two ways. First, a triage tool can be used to decide whether a patients needs urgent referral and pre-referral treatment. Another form of triage is more similar to the emergency care settings, namely the prioritization of patients in the waiting area within the primary care facility. The different forms of primary care triage are depicted graphically in Figure 2. The currently used IMCI guidelines provide guidance prioritizing children that need urgent referral to a higher level of care, based on danger and priority signs (B in Figure 2).(12) This evaluation of danger signs is done during the medical

consultation, and not as a triage tool to prioritize children before consultation (A in Figure 2). Therefore, IMCI does not identify potential deterioration of the child's illness while he or she is in the waiting area. In this form, no task-shifting is performed, and all care is provided by the same health care professional, in Tanzania mostly a nurse or physician.

As mentioned previously, a Swiss/Tanzanian research team has developed and implemented electronic algorithms to improve management of children in outpatient care in different clinical trials. In a subsequent trial (DYNAMIC), an updated version of the ePOCT algorithm (ePOCT+) will be implemented at a larger scale, in different geographical regions, will include more diseases and age groups, and will also include a triage algorithm. However, two important knowledge gaps exist. First, it is unknown what the latest evidence for paediatric triage tools is in primary care settings in LMIC in general. Second, it is unknown what the feasibility is of introducing a paediatric triage tools in the primary care setting in Tanzania, taking the local clinical practice and availability of resources into account.

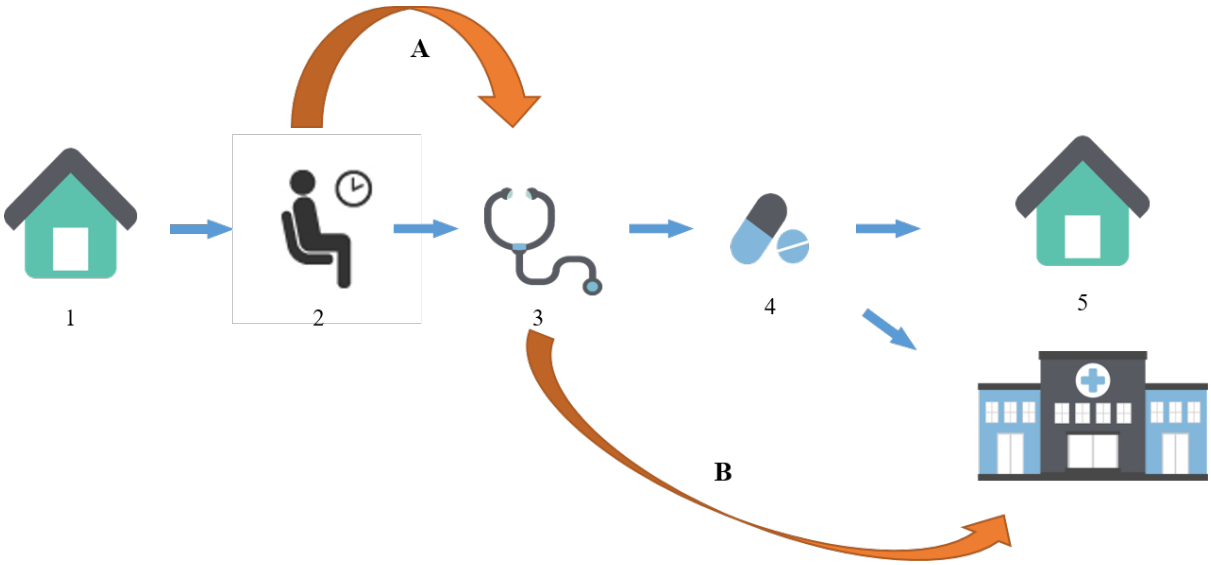


Figure 2. Forms of triage in primary health care facility.
Legend: 1: patient comes from home, 2: patient in waiting area of the facility. 3: medical consultation by nurse or physician. 4: treatment. 5: discharge home or referral to higher level of care.
A: Within-facility triage: prioritizing patients for medical consultation in waiting area
B: Between-facility triage: prioritize patients during medical consultation for urgent referral to higher level of care.

Objectives

The overall objective of this thesis is to review the current evidence of existing triage tools for children in LMIC and to evaluate their feasibility for the Tanzanian primary care setting.

Specific objectives:

1. To identify all paediatric triage tools that are currently available in the literature for LMIC.
2. To review the reliability and validity of the identified paediatric triage tools.
3. To evaluate the stage of validation of the identified paediatric triage tools.
4. To assess the intended level of care of the identified paediatric triage tools.
5. To investigate which triage tools are feasible and applicable in Tanzanian primary care.
6. To provide recommendations for the introduction of a triage tool in the Tanzanian primary care settings, taking into account the level of evidence and local clinical practice.

Methods

Study design

In order to meet the objectives of the thesis, this study consists of 2 phases. First, we performed a structured literature review and evaluation of paediatric triage tools for low-resource settings, in order to provide answers to the objectives 1-4. Next, we performed a 1-stage Delphi study to evaluate the feasibility and applicability of the triage tools in the Tanzanian primary care setting (objective number 5). Based on the results of both phases, we provided recommendations for the introduction of a paediatric triage tool in Tanzanian primary care (objective 6). The study design is shown graphically in Figure 3.

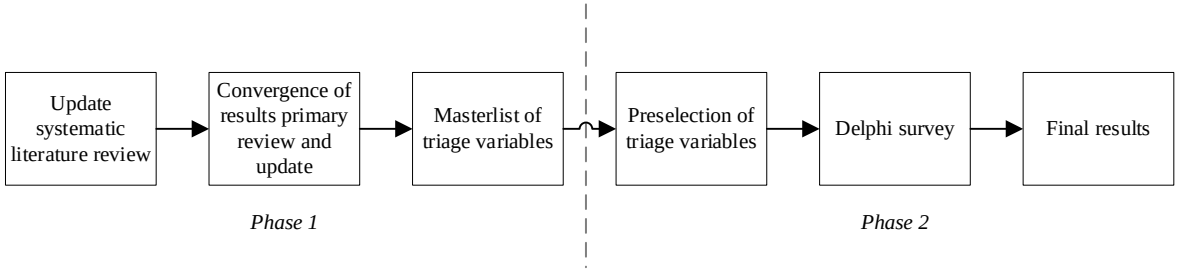


Figure 3. Study design.

Analytical framework

For the evaluation of the triage tools that were identified in the review, we used the analytical framework for electronic decision algorithms, published by Keitel and D'Acremont.(25) This framework describes the different stages that are needed in the development of clinical decision algorithms (Figure 4 and Table 1). Central to all these stages is that the algorithm should be tailored to the clinical and epidemiological context, and that user and patient perception should be taken into account. We have used this framework as well to formulate our recommendations.

Figure 4. Analytical framework for electronic decision algorithms(25)

Table 1. Stages of validation of identified triage tools.(25)

Stage of validation	Definition
1. Development	Development of the content of the algorithm, based on evidence. If evidence is insufficient, consensus from experts should be sought. Publication of details of the algorithm, and internal validation of the algorithm.

2. Clinical efficacy	Evaluation of the algorithm for its ability to improve outcomes under controlled conditions.
3. Clinical effectiveness	Evaluation of the algorithm for its ability to improve outcomes under routine conditions.
4. Impact	Impact analysis, evaluating the impact of large-scale implementation on the health system, including impact on costs.
5. Responsiveness	Improvement of the algorithm, based on data on local epidemiology, collected through the use of the algorithm

Literature review

Search strategy

In 2017, Hansoti et al published a systematic review about the 'reliability and validity of paediatric triage tools evaluated in low resources settings'.(22) These authors performed a systematic search on literature published between January 2000 and July 2015. For the current thesis, we have updated this review, to include newly developed or validated paediatric triage tools. We performed the literature search in PubMed on 24 September 2019, including studies published from January 2015 to September 2019. For time restrains, we did not search other databases. We included studies describing the reliability or validity of paediatric triage tools and IMCI. We excluded studies in adult populations, in high-income countries, non-English studies, non-validation studies, studies on tools that do not influence patient care (for example trauma scales) or tools for specific diseases only. The complete search strategy is attached in Appendix I. We checked references for relevant articles that were not obtained in our literature search. For country income-level we used the World Bank country classification of 2015 – 2019.(26)

Evaluation of identified triage tools

Quality assessment of primary studies

We evaluated the quality of all included primary studies of the literature update using the QUADAS-2 for diagnostic studies.(27) This tool scores the quality of diagnostic studies in two domains: 1) risk of bias and 2) concerns about applicability, as either low, some or high risk or concerns. Both domains are scored for patient selection, index test and reference standard. Risk of bias is also evaluated for patient flow and timing.

Stage of validation and intended use

We identified the stage of validation for each of the available triage tools, according to the five stages of the analytical framework (Table 1). In addition, we reported the intended use of the different tools: what was the intended level of care and what is the intended guidance for clinical decisions?

Reliability and validity of triage tools

For all available paediatric triage tools (from the review by Hansoti et al. as well as from our literature search) we assessed their performance in terms of reliability and validity. Reliability was defined as inter-rater agreement and was expressed in kappa; validity in either sensitivity and specificity (for categorical outcomes) or area under the receiver-operating-curve (AUC, for continuous outcomes).

Delphi study

A Delphi method is often used to reach consensus in different areas in health care: for priority-setting in research, for development of quality indicators, or for evaluating feasibility of interventions.(28-30) We chose a Delphi method, because it is an efficient way to consult experts. Moreover, to evaluate feasibility we specifically wanted to consult future users of the triage tools, in addition to general scientific evidence that can be obtained from the literature. Although a Delphi study generally is an iterative process with multiple rounds of consultation, we only performed one round due to time constrains.

Survey

Based on the complete systematic literature review (Hansoti et al. plus the update) we composed a list of all unique variables that were included in the reviewed triage tools. We made a pre-selection of variables, excluding variables a) whose quality or predictive value was insufficient based on previous research,(31) b) that are collected anyway during registration of the patient or c) that were known to be unfeasible for triage in Tanzanian primary care beforehand (for example laboratory tests). The final list of variables included in the survey was decided upon consensus within the research team (JvdM, KK, IM. LL). We included questions per variable on three domains: 1. Reliability of measurement of the variable, 2. Frequency of finding an abnormal value, and 3. Level of training required to collect this variable. Domains one and two were asked for dispensary

and health centre level separately, given the difference in available resources and presenting problems. Domains one and three evaluate the feasibility of collecting this variable at triage, domain two evaluates applicability of the variable. For vital signs a question was added on the availability of instruments required for measuring these variables. In addition, participants were asked if they foresaw any challenges in collecting each variable. The complete questionnaire is included in Appendix II. The answers were classified using a 5-point Likert scale: minimal, moderate, high, not applicable, I don't know. The answer options for the availability of vital sign instruments were yes/no/I don't know. We also collected data on the professional background and expertise of the participants. The format of the survey was based on a recently published Delphi study on predictors of sepsis in children under five by Fung et al.(31)

Participants and data collection

As our aim was to evaluate the feasibility and applicability (and not the accuracy) of the triage items, we included future users to participate: a) with at least one year of experience in Tanzanian primary care, b) of various roles and professional backgrounds and c) with work experience in rural context. We included medical doctors, nurses, medical officers at different levels of care. We targeted at 15 participants. Assuming a response rate of 50%, we invited 30 people to participate in the survey. Because not all target participants could be reached by email, and to ensure high quality data within a limited timeframe, a local researcher (LL) performed the survey face-to-face in the health facilities in two areas of Tanzania: in Ikwiriri (Rufiji District) and in Ifakara (Kilombero District). We created a digital version of the survey using open data kit (https://opendatakit.org/xlsform/), filled out on a tablet.

Analysis

We analysed the results of the Delphi study according to the three domains: 1. Reliability of measurement, 2. Frequency of abnormal value, 3. Level of training required. The answers were classified into a score 0-3: 0 = not applicable, and 1 – 3 for increasing strength of the answer. We calculated the total score of all participants per variable for each domain, resulting in a sum score of 0 - 90, stratified per level of care (dispensary or health centre). We also calculated the maximum score per variable, excluding the participants who answered 'I don't know' to that particular variable. To facilitate comparison across items, we calculated the sum score as a percentage of the maximum score. We also created a composite sum score per item: sum score of domain 1 + score domain 2 – score domain 3, divided by the sum of max scores of all three domains. separate for dispensary and health centre. We did not predefine a threshold for inclusion in the final proposed triage tool. Analyses were performed in SPSS (version 25.0).

Ethics statement

This study was evaluated by the Research Ethics Committee (REC) of the Royal Tropical Institute (KIT) in Amsterdam, who waived the need for full ethical review (document S-113).

Results

Literature review

Inclusion of articles and quality assessment

We identified 806 articles in our literature search. Based on title and abstract 734 could be excluded, 45 were excluded after full-text screening. Reasons for exclusion are presented in Figure 5. In total, 29 articles were included, of which 9 studies on newly developed triage tools, 9 validation studies of already existing triage tools and 4 literature reviews. The 9 included studies on new triage tools described seven different tools. The seven primary validation studies are listed in Table 2. The other two studies included the description of the development steps of CLARIPED triage tool (32) or was a pilot impact study of the SCREEN triage tool.(33) One of the seven development studies also included validations of existing triage tools.(23) The primary validation studies had a high variability in risk of bias and concerns regarding applicability (Table 2). The risk of bias in the reference standard was unclear for all studies, since there is no good reference standard for disease urgency.

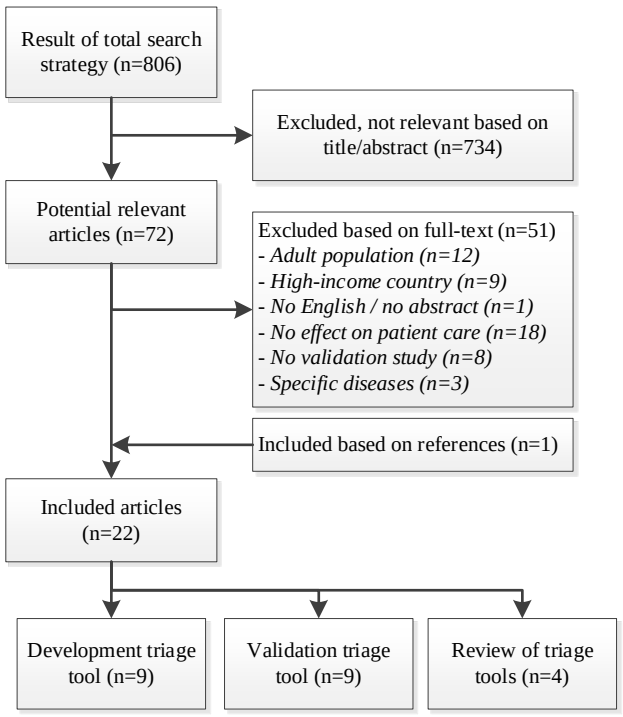


Figure 5. Flowchart of inclusion of articles

Table 2. Quality assessment of primary validation studies of new triage tools (n=7)

Study (year)[ref]	*Triage tool*	*Country (income level)*	*Risk of bias*	*Concerns regarding applicability*
Hansoti (2018)	SCREEN	South Africa (upper middle)	Low for patient selection, index test and patient flow; unclear for reference standard	Low for all three items
Khan (2016)	One-two-triage (OTT)	Cambodia; US (lower middle; high)	Low for patient selection and index test; unclear for reference standard and patient flow	High for patient selection and reference standard; low for index test
Lin (2016)	Chinese Pediatric Emergency Triage System (CPETS)	China (upper middle)	Low for patient selection, index test and patient flow; high for reference standard	Low for patient selection and index test; high for reference standard
Magalhaes-Barbosa (2017)	CLARIPED	Brazil (upper middle)	Low for patient selection, index test and patient flow; unclear for reference standard	Low for all three items
Finette (2019)	MEDSINC	Burkina Faso; Ecuador; Bangladesh (low; upper middle; lower middle)	Low for patient selection, index test and patient flow; unclear for reference standard	Low for patient selection and reference standard, unclear for index test.
Marombwa (2019)	Local Triage System (LTS)	Tanzania (low)	Low for patient selection and patient flow; unclear for index test and reference test	High for patient selection and reference standard, unclear for index test
Wanefalea (2019)	Solomon Islands Triage Scale (SITS)	Solomon Islands (lower middle)	Low for patient selection, index test and patient flow; unclear for reference standard	High for patient selection and reference standard; high for index test

Evaluation of triage tools

Table 3 provides a summary of all available different paediatric triage tools, including a general description, the type of outcome or advice, the stage of validation, methods of development and target use. The original review included: 1) IMCI, 2) ESI – Emergency Severity Index, 3) TOPRS – Temperature, Oxygen saturation, Pulse rate, Respiratory rate, Sensorium - seizures, 4) ETAT – Emergency Triage and Treatment, 5) SATS – South African Triage Scale and 6) PEWS – Paediatric Early Warning Score. The literature update identified 1) SCREEN, 2) OTT – One-two-triage, 3) CPETS – Chinese Paediatric Emergency Triage System, 4) CLARIPED, 5) MEDSINC, 6) LTS – Local Triage System and 7) SITS – Solomon Islands Triage Scale, resulting in 13 triage tools in total.

Content and format
Eight tools were designed as a list of signs and symptoms, two had the format of a flowchart. Most triage tools followed the ABCD system, and consist of a combination of clinical variables or discriminators with vital sign measurements. IMCI, ETAT and SCREEN relied almost exclusively on clinical symptoms, whereas ESI, TOPRS, and PEWS were mostly based on vital sign measurements. The remaining SATS, OTT, CPETS, CLARIPED and SITS used both types of information, of which CLARIPED is the only tool that starts with vital sign measurements. The exact format and content of two tools was not published (MEDSINC and LTS). The comprehensiveness of the tools varied widely, from short lists of 6-7 variables (TOPRS, PEWS and SCREEN) to extensive lists of discriminators, depending on presenting complaint (OTT, CLARIPED).

Intended use and stage of validation
SCREEN was the only triage tool that was explicitly developed to be performed by a lay person in primary health centres. MEDSINC was developed for frontline health workers in different primary care settings: home visits, rural clinics or urban clinics. The other tools were developed for the hospital setting. Various risk classifications were used, varying from two to five different risk groups (Table 3). For TOPRS no clinical advice was provided, all other tools provided advice on how soon the patient should be seen. where the patient should be seen, or both. Most triage tools were developed based on expert opinion. Six of the newly identified tools were based on already existing triage tools, one was developed from scratch (OTT). For CLARIPED the development process was published in detail in a separate publication,(32) for the other tools the development was shortly described in the validation or implementation study,(33-36) or no details on the development were provided.(23, 37) Most triage tools were evaluated for their clinical efficacy. Four tools were evaluated under routine conditions: ETAT, SATS, SCREEN and CPETS. The latter two also underwent narrow impact analysis, reporting the impact on waiting times (both) and patient satisfaction (CPETS).

Validity of paediatric triage tools
Table 4 summarizes the validity of the triage tools, as presented in all studies of the literature review (original review and update), including 18 publications. Since IMCI is not intended for within-facility triage (Figure 2a), we left it out of this table. For MEDSINC the triage component was unclear and no performance measures were available, so this is also left out of Table 4. The table includes the country, population and setting where the tools were evaluated, their performance and the reference standard that was used to measure this performance. Overall, the tools that are most widely studied were ESI, ETAT and SATS. ETAT, SATS and SCREEN were studied in African countries, whereas CLARIPED was only studied in Brazil, ESI in Iran, TOPRS in India, CPETS in China, PEWS in Thailand and SITS in the Solomon Islands.

Different reference standards and performance measures were used to report the validity of the triage tools. Often used reference standards were admission (n=11 studies), mortality (n=4) or physician-based or expert-based judgment of acuity (n=3). One study used other triage tools as a reference standard.(38) One group developed a combined reference standard, including various aspects of acuity, like vital sign changes, life-threatening clinical conditions, lab tests and disposition.(39) To calculate the validity of the triage tool, most studies reported sensitivity and specificity (n=13), but also kappa (n=2), percentage accurate triage (n=2) and correlation (n=2) were presented, or the distribution of triage levels in the population (n=3). If possible, the sensitivity and specificity of the tools were calculated if not already presented in the article. Therefore we used a cut-off proposed by the authors, or one comparable to other publications.

Reference standard: admission
For ESI, ETAT, SATS, PEWS, LTS and SITS the accuracy in predicting admission was reported. High sensitivity and specificities were reported for ESI in Iran, although exact distribution of patients was not provided. ETAT performed well in Malawi in predicting admission (sensitivity 86% and specificity 75%) and was also studied in South Africa, but no performance measures were reported in the South African article.(40, 41) SATS was validated in many different settings, consistently showing specificity of >80%, at varying sensitivity levels (28% - 74%), when a cut-off of level 1/2 versus level 3-4 was used to predict hospital admission.(23, 42-46) PEWS showed moderate accuracy in predicting overall admission in a tertiary hospital in Thailand (Se 78%, Sp 60%). Prediction of ICU-admission was more accurate than ward admission, although different PEWS cut-off was used for these estimations. LTS was highly specific, but not sensitive for admission (Se 27%, Sp 98%). For SITS the admission rates per triage level were presented graphically, showing that admission is more likely in the higher urgency levels.

Reference standard: mortality
ESI, TOPRS, SATS, LTS and SITS were evaluated for predicting mortality. For ESI it was only stated that all 10 deaths were in triage level 1 or 2, without providing performance measures. For TOPRS in India high

sensitivities and specificities were reported for a cut-off of score 2.5, but exact numbers were not provided for this cut-off. When calculating the Se and Sp for cut-off 2 and 3 (for which a distribution was available), specificity was high (>95%), but sensitivity low (<35%). In Tanzania, SATS and LTS were evaluated to predict mortality, both performing well, although numbers of mortality were very low (5/384, 1%). SITS performed best for this outcome (Se 90%, Sp 99%) at a mortality prevalence of 30/10905 (0.3%).

Reference standard: physician-based acuity
For ESI, OTT and CPETS the association with physician-based acuity was presented. OTT and ESI were validated for this outcome in a high-income setting (US) only, showing fair performance (expert-weighted kappa OTT 0.58, ESI 0.47).(34) For CPETS only the percentage accurate triage was presented. This percentage was higher than in the reported control period (96% versus 85%), in which a two-level triage system was used (content unclear).(37)

Other reference standards
SCREEN was validated against a reference standard of four other triage tools, showing overall high sensitivity (99-100%), but moderate specificity (59-64%). It performed better in primary care than in the hospital setting. CLARIPED showed good validity in Brazil using a combined reference standard.(39) However, overall agreement of CLARIPED with the reference standard was only 34%, mainly due to overtriage of the non-urgent blue cases (541/572, 95%). Undertriage was present in 7% of cases (104/1416). For MEDSINC no performance measures were reported for the triage part of the algorithm. It is shown graphically that community health workers using MEDSINC mostly triaged patients similar as the physicians who did not use MEDSINC.(35)

Impact on clinical practice
SCREEN and CPETS were the only triage tools that underwent impact analyses. SCREEN reduced waiting times significantly from 165 to 72 minutes in a pilot study in 4 primary health centres in Cape Town, South Africa.(33) CPETS reduced overall waiting time from 41.6 to 37.3 minutes ($p<0.001$), waiting time for severe patients from 3.23 to 2.07 minutes ($p=0.04$) and improved family satisfaction rates from 92 to 94% ($p<0.001$).(37)

Reliability of triage tools
Reliability or inter-rater agreement was not published for all triage tools, but the available measures are presented in Table 4a. Eleven studies reported inter-rater agreement of five triage tools (ESI, SATS, OTT, CLARIPED and SITS), expressed as kappa and/or % agreement. Reliability was evaluated based on either paper-based scenarios (n=7), real-life patients (n=2) or medical records (n=2). ESI showed moderate to good agreement (kappa 0.45 to 0.84), SATS moderate (kappa 0.59 to 0.63). OTT showed good agreement in the US (kappa 0.71) but poor agreement in Cambodia (0.27 and 0.33).

Table 3. Description of triage tools

Triage tool	Content and type of predictors	Classification and triage advice or target time to consultation	Target use level of care	Stage of validation	Method of development	Remark
From Hansoti review (until 2015)						
IMCI – Integrated Management of Childhood Illnesses	List of general danger signs and flowcharts including danger signs per presenting complaint, based on presenting clinical signs and symptoms and some vital signs.	Red: very severe disease, urgent referral to hospital. Yellow: sick, treatment and observation in clinic. Green: well, no active treatment	Hospital	Impact	Expert opinion	
ESI – Emergency Severity Index	Flowchart, based on vital signs and number of resources needed	l. Immediate life-saving intervention; 2. High risk, <15minutes; 3. Multiple resources needed; 4. One resource needed; 5. No resources needed	Hospital	Clinical efficacy	Expert opinion	
TOPRS – Temperature, Oxygen saturation, Pulse rate, Respiratory rate, Sensorium - seizures	List, based on 6 vital signs, each score 0-1	Score 0 - 6; cut-off 2.5 used to predict mortality	Hospital	Clinical efficacy	Expert opinion	
ETAT – Emergency Triage and Treatment	List of ABCD emergency signs and list of priority signs, based on clinical signs and symptoms	Emergency: immediate consultation. Priority: front of queue.	Hospital	Clinical effectiveness	Expert opinion	
Pediatric SATS – South African Triage Scale	Flowchart, based on ABCD emergency signs, lists of very urgent and urgent signs and vital signs (Triage Early Warning Score)	Red: emergency, resus for immediate treatment. Orange: very urgent, <10min. Yellow: urgent, <1h. Green: routine, <4h. Blue: deceased, certification <2h.	Hospital	Clinical effectiveness	Expert opinion	
PEWS – Pediatric Early Warning Score	List, based on 7 vital signs, each score 0 - 3	Score 0 - 21; cut-off ≥1 used to predict general admission, ≥3 to predict ICU admission	Hospital	Clinical efficacy	Expert opinion	
From literature update (2015 - 2019)						
SCREEN	List, based on 6 questions on clinical signs and symptoms, asked by lay person / queue marshall	If yes to any: priority nurse evaluation.	Primary care	Clinical effectiveness, narrow impact analysis	Expert opinion (PHC providers, PED experts, healthcare management)	Based on IMCI
OTT – One-two-triage	1. Red/orange signs: list, based on clinical signs and symptoms 2. Yellow/green signs: list, based on vital signs and clinical signs and symptoms per chief complaint	Red: resuscitation room. Orange: ER. Yellow: urgent. Green: non-urgent	Hospital	Clinical efficacy (in high-income setting, US)	Expert opinion (US)	Newly developed
CPETS – Chinese Pediatric Emergency Triage System	List of discriminators per organ system. First assessment for level 1, 2 or 5 patients based on clinical signs and symptoms; then further assessment of level 3 or 4 patients, based on vital signs	Level 1: resuscitation, 0 minutes. Level 2: severe, <15 minutes. Level 3: emergency, <1h. Level 4: urgent, <2h. Level 5: not-urgent, >2h.	Hospital	Clinical effectiveness, narrow impact analysis	Unknown	Based on the CTAS (Canadian Triage and Acuity Scale)
CLARIPED	1. List of 6 questions on history + vital signs (VIPE score = *VI*tal signs in *PE*diatrics) 2. List of discriminators, based on clinical signs and symptoms a) General for all patients, and b) specific per organ system, depending on presenting complaint	Red: emergency, 0 min. Orange: very urgent, 10min. Yellow: urgent, 30min Green: little urgent, 90min. Blue: not urgent, 180min	Hospital	Clinical efficacy	Expert opinion and adjustment after reliability and validity pre-testing	Loosely based on SATS.

MEDSINC	Integrated in comprehensive algorithm including risk assessment, triage, treatment and follow-up recommendations. Combination of clinical signs and symptoms and vital signs;	Standard, immediate and urgent care	Primary care	Clinical efficacy	Bayesian pattern recognition logic	Based on IMCI-iCCM and other evidence. Exact content not published
LTS – Local Triage System	Based on presenting complaint, symptoms and signs.	Emergency, priority, queue	Hospital	Clinical efficacy	Unknown	Based on ESI Exact content not published.
SITS – Solomon Islands Triage Scale	Flowchart, based on emergency signs and list of priority signs and vital signs.	Red: emergency, to resuscitation room. Yellow: priority, front of queue. Green: non-urgent, sub-acute area	Hospital	Clinical efficacy	Expert opinion (after observation ED and consultation local staff)	Based on SATS and ETAT

Table 4a. Validity of triage tools

Triage tool	Study (ref)	Country (Income level)	Population, n	Setting	Reference standard	TP	FP	FN	TN	Se	Sp	AUC	kappa	accurate triage	Remark
ESI	Jafari-Rouhi 2013 (47)	Iran (UM)	<18y, n=1104	Hospital	Admission										Spearman correlation 0.35 (nurses) and 0.41 (physicians); 90/104 (87%) admissions in level 1-2
					ICU admission or death										No cut-off chosen, all outcomes (10, 0.9%) in level 1/2
	Khan 2016 (34)	US (H)†	All patients, median 36y, n=472	Hospital	Physician-based acuity								0.41 (0.35-0.48) triage weighted; 0.47 (0.40-0.53) expert-weighted		
	Ghafarypour-Jahrom 2018 (48)	Iran (UM)	<15y with medical symptom, n=1300	Hospital	Admission (cutoff all 5 levels)					81-95%	74-90%	0.88			Se and Sp provided for all 5 levels, no exact nrs provided, ranges reported
TOPRS	Bains 2012 (49)	India (L)	Children (ns), n=777	Hospital	Mortality (cutoff 2.5)					80%	74%	0.82			no exact nrs reported for cutoff 2.5; score based on regression coefficients?
					Mortality (cutoff >2)*	39	22	88	628	31%	97%				inconsistent with reported Se/Sp of cutoff 2.5
					Mortality (cutoff >3)*	15	6	112	644	12%	99%				
ETAT	Buys 2012 (41)	South Africa (UM)	<16y, n=407	Hospital	Admission										Distribution provided, no exact nrs to calculate performance measures; original article unavailable
	Robertson 2001 (50)	Malawi (L)	<5y, excluding trauma, n=2281	Hospital OPD	Admission (level 1/2 vs3)*	153	220	24	672	86%	75%				No cutoff provided in article

(p)SATS	Twomey 2013 (42)	South Africa (UM)	<13y, n=2014	Hospitals	Admission (level 1/2 vs 3/4)					91%	55%				No exact nrs presented, original article unavailable
	Marombwa 2019 (23)	Tanzania (L)	<5y, excluding trauma, n=384	Urban hospital	Admission (level 1/2 vs 3/4)	65	7	164	146	28%	95%	0.62-0.63			
					24 hour mortality (level 1 vs 2-3)	5	na	0	na	100%	80%	0.90-0.91			
	Dalwai 2017 (43)	Afghanistan (L)	All ages, median 34, n=17626	Trauma hospital	Admission (level 1/2 vs 3/4)*	1737	2213	861	12803	67%	80%				Distribution provided, no cutoff specified, nrs of original aritcle used for Se/Sp
		Haiti (L)	All ages, median 44, n=7420	Trauma hospital	Admission (level 1/2 vs 3/4)*	1326	1591	478	3021	74%	80%				
		Haiti (L)	All ages, median 45, n=54731	Hospital	Admission (level 1/2 vs 3/4)*	263	8160	186	46100	59%	80%				
		Sierra Leone (L)	<15y, n=7889	Hospital	Admission (level 1/2 vs 3/4)*	4983	277	2032	489	71%	80%				
	Wangara 2019 (44)	Kenya (LM)	<12y, n=118	Hospital	Admission (level 1/2 vs 3/4)*	24	13	15	55	62%	80%				
					Admission (level 1 vs 2-4)	8	0	31	68	21%	80%				This cutoff mentioned in article
	Gyedu 2016 (45)	Ghana (LM)	Vignettes of all ages, n=25	Hospital	Expert panel triage					42-74%	75-91%				Se and Sp range using cutoffs at all triage levels, by medical students and house officers
	Meyer 2018 (46)	South Africa (UM)	All ages, children <12 reported separately, n=753	Hospital	Admission (level 1/2 vs 3/4)*	73	46	144	490	34%	80%				No cutoff mentioned in article, only correlation (0.37); nrs of article used for Se/Sp
PEWS	Chaiyakulsil 2015 (51)	Thailand (UM)	<15y, n=1136	Tertiary hospital	Admission (overall) (cutoff ≥1)					78%	60%	0.73			No exact nrs presented
					ICU admission (cutoff ≥3)					100%	91%	0.97			
					Ward admission (cutoff ≥1)					77%	59%	0.71			
OTT	Khan 2016 (34)	US (H)†	All patients, median 36y, n=482	Hospital	Physician-based acuity								0.31 (0.25-0.38) triage weighted; 0.58 (0.52-0.65) expert-weighted		
CPETS	Lin 2016 (37)	China (UM)	Children (ns), n=9679	Hospital	Physician triage urgency									9323/9679 (96%)	
CLARIPED	Magalhaes-Barbosa 2018 (39)	Brazil (UM)	Children (ns), n=1416	Hospital	Combined reference standard (red/orange vs yellow/green/blue)	55	29	7	1325	89%	98%			475/1416 (34%)	
SCREEN	Hansoti 2017 (38)	South Africa	<15y, n=461	Primary health centre	IMCI (red)	16	103	1	341	94%	77%				

					ETAT (emergency signs)	8	111	1	341	89%	75%				
					PSATS (emergency)	11	108	1	341	92%	76%				
					PEWS (emergency)	1	118	0	342	100%	74%				
			<15y, n=500	District hospital	IMCI (red)	68	212	0	220	100%	51%				
					ETAT (emergency signs)	81	199	0	220	100%	53%				
					PSATS (emergency)	67	213	0	220	100%	51%				
					PEWS (emergency)	9	271	0	220	100%	45%				
			<15y, n=961	Overall	IMCI (red)	84	315	1	561	99%	64%				
					ETAT (emergency signs)	89	310	1	561	99%	64%				
					PSATS (emergency)	78	321	1	561	99%	64%				
					PEWS (emergency)	10	389	0	562	100%	59%				
LTS	Marombwa 2019 (23)	Tanzania (LM)	<5y, excluding trauma, n=384	Urban hospital	Admission (level 1 vs 2-3)	62	3	167	150	27%	98%	0.62-0.63			
					24 hour mortality (level 1 vs 2-3)	4	na	1	na	80%	81%	0.81			
SITS	Wanefalea 2019 (36)	Solomon Islands	All ages, 40% children, n=10905	Hospital	Admission										Distribution pt per triage level shown graphically, no exact nrs
					Mortality (level 1/2 vs 3)	27	68	3	10478	90%	99%				

Footnotes:
Income levels: L=low; LM=lower middle; UM=upper middle; H=high.
TP = true positive; FP = false positive; FN = false negative; TN = true negative; Se = sensitivity; Sp = specificity.
Ns = not specified further
* Se en Sp were not calculated for this cut-off in the original article, but calculated based on reported numbers for comparison to other studies.
† included because reliability was also reported for low-income setting;

Table 4b. Inter-rater agreement of triage tools

Triage tool	Study	Country	Population	Setting, n patients	Raters	Kappa	Agreement
ESI	Jafari-Rouhi 2013 (47)	Iran (UM)	<18y, n=1104 (a)	Hospital	Nurses (n=?)	0.84	
					Nurses compared to physicians (n=?)	0.82	87%
	Ghafarypour-Jahrom 2018 (48)	Iran (UM)	<15y with medical symptoms, n=1300 (b)	Hospital	Nurses and pediatric residents, comparison unclear (n=?)	0.65-0.92 across ESI levels	
	Mirhaghi 2015 (52)	Iran (UM)	All ages (a)	Hospital	Nurses (n=?)	0.54	79%
					Physicians (n=?)	0.45	71%
					Experts (n=?)	0.81	85%
	Mistry 2018 (53)	Brazil (UM)	Children, n=9 (a)	Hospital	Nurses compared to AHRQ key of scenarios, n=87	0.73 alpha	42%
		United Arab Emirates (H)					49%
		US (H)					51%
pSATS	Dalwai 2018 (54)	Haiti (L)	All ages, n=10 (a)	Hospital	Nurses (n=39)	0.59-0.61 (QW)	
		Afghanistan (L)			Nurses (n=28)	0.59-0.62	
	Gyedu 2016 (45)	Ghana (LM)	All ages, n=25 (a)	Hospital	Medical students (n=59)	0.59 (QW)	77%
					House officers (n=43)	0.60 (QW)	74%
	Tshitenge 2016 (55)	Botswana (UM)	All ages, n=315 [c]	Hospital	Expert panel compared to original assigned level by nurse	0.4	64%
	Wangara 2019 (44)	Kenya (LM)	<12y, n=25 (a)	Hospital	Trained ED staff (n=166) compared to expert	0.63 (F, QW)	64%
OTT	Khan 2016 (34)	US (H)	All ages, n=28/63 pediatric cases (a)	Urban hospital	Nurses (n=8)	0.71 (F)	
		Cambodia (LM)		Urban hospital	Nurses (n=23)	0.33 (F)	
		Cambodia (LM)		Rural hospital	Nurses (n=21)	0.27 (F)	
CLARIPED	Magalhaes-Barbosa 2018 (39)	Brazil (UM)	Children, n=179 (b)	Hospital	Nurses (n=15)	0.75 (QW)	69%
SITS	Wanefalea 2019 (36)	Solomon Islands (LM)	All ages, 40% children, n=86 [c]	Hospital	Independent nurse (n=1), compared to original assigned triage level		88%

Footnotes: (a) paper-based scenarios; (b) real-life patients; (c) medical records. F = Fleiss kappa; QW = quadratic weighted kappa.

Delphi survey

Participants

We invited 30 participants for our survey, and all agreed participation. Baseline characteristics are provided below in Table 5. Most participants were affiliated to primary care (24/30, 80%), 18/30 (60%) were nurses or medical officers, and most participants were experienced in nursing or general medicine.

Table 5. Baseline characteristics of participants

	n (%) / median (IQR)		n (%) / median (IQR)
Sex (female)	17 (57%)	Area of expertise (multiple possible)	
Years of experience	5 (2 - 17)	Nursing	16 (53%)
Primary affiliation		General medicine	13 (43%)
Dispensary	12 (40%)	Pediatrics	1 (3%)
Health centre	12 (40%)	Infectious diseases	1 (3%)
Regional referral hospital	6 (20%)	Epidemiology	1 (3%)
Role		Other, namely:	1 (3%)
Nurse	11 (37%)	HIV	1 (3%)
Medical officer (MD)	7 (23%)	Obstetrics and gynaecology	1 (3%)
Medical attendant / nurse attendant	5 (17%)	Midwifery	1 (3%)
Clinical officer	3 (10%)	Pediatric HIV/TB	1 (3%)
Assistant medical officer	2 (7%)		
Assistant clinical officer	1 (3%)		
Other	1 (3%)		

Survey

Table 6 shows the crude sum scores of the separate questions of the different domains per triage variable. Per column the percentage of the maximum score is coloured by a heat map, ranging from lowest % of maximum score to the highest % of maximum score, where blue is below average and red is above average.

Reliability of measurement of triage variables

All questions on reliability were answered by at least 21 participants: the maximum score was 63 or higher for all variables. The average reliability score across all items was 76% for dispensary level and 79% for health centre level. For the separate variables the % scores at dispensary and health centre level were comparable. Scores at dispensary level ranged from 22/66 (33%) for pain score to 79/81 (98%) for duration of illness and 78/78 (100%) for reported fever. At health centre level the range was 21/63 (33%) for pain score to 76/78 (97%) for duration of illness and 75/75 (100%) for reported fever. Pain score (0-10) scored low on reliability (33%), but ‘severe pain’ scored high (93% at dispensary and 97% at health centre). Overall, vital sign measurements scored lowest on reliability of measurement, especially oxygen saturation (33% at dispensary and 45% at health centre), pain score (33% and 33%), capillary refill time (46% and 49%) and MUAC (47% and 56%).

Frequency of abnormal value

The frequency of finding an abnormal value or symptom was less often known by the participants. At dispensary level, the maximum score ranged from 9 (3 replies, the rest replied ‘I don’t know’) for oxygen saturation to 78 (26 replies) for difficulty breathing and for convulsing now. Average score for this domain was 46% at dispensary level (range 0-86%) and 40% at health centre level (range 0-69%). The overall pattern of frequency of finding an abnormal value at dispensary level was similar to health centre level. However, for 8 variables the frequency of abnormal findings was reported to be higher (score difference of >10%-point) at dispensary level: temperature, pain score, capillary refill time, weak and fast pulse, mobility, reduced urine production, fever and trauma. Trauma, burns and poisoning scored low on frequency of abnormal findings (below 40%), whereas fever, irritability, not able to drink or feed, vomiting and reduced urine production and severe pain scored above 50%.

Level of training and/or resources required

For all triage variables relatively low level of training was required, at an average score of 36% (range 33-41%). Items on past medical history all scored above average. The vital signs MUAC, oxygen saturation and capillary refill time required most training, scoring 40-41%. For MUAC, oxygen saturation, heart rate and pain score the participants frequently responded that the instruments are not available at both levels of care.

Reported challenges
Most challenges were foreseen in collecting information on the past medical history and in measuring vital signs (Table 6). Regarding past medical history, challenges in 'getting the right answers' and 'illiteracy' were mentioned. Frequently mentioned challenges for all vital signs were 'lack of instruments' and 'lack of knowledge or training'. Need for training in collecting the information was mentioned as a challenge across all categories. Lack of personnel was also mentioned. For pain score participants stated that the score is not used in practice.

Combined score
When all three domains are taken into account in the combined score, the average score is 24% (range -6% to 44%) for dispensaries and average 23% (range -5% to 40%) for health centres (Table 7). For oxygen saturation the largest difference in % was observed: score -6% for dispensary, and 4% for health centres. For all other variables the difference was <5%. Of all vital signs, temperature and weight scored highest, whereas oxygen and pains score scored lowest. Difficulty breathing and fast breathing scored highest on the Airway/breathing section. For circulation pallor had the highest score. On the neurology section, all but mobility scored on or above average. Sunken eyes scored better than reduced urine production for the assessment of dehydration. For trauma, only severe pain scored above average.

Table 6. Score on different domains per triage item

	1. Reliability of measurement				2. Frequency of abnormal value				3. Level of training required		Instruments available		Challenges foreseen
	Dispensary		Health centre		Dispensary		Health centre				Dispensary	Health centre	
	*Sum/Max score**	*% of max score*	*Sum/Max score*	*% of max score*	*Sum/Max score*	*% of max score*	*Sum/Max score*	*% of max score*	*Sum/Max score*	*% of max score*	*n/N (%)*		
General / past medical history													
Duration of illness/sign/symptom	79/81	98%	76/78	97%					33/87	38%			4/30 (13%)
Number of previous hospital admissions	56/75	75%	52/72	72%					34/90	38%			3/30 (10%)
Admitted to hospital/clinic in past 2 days	51/75	68%	47/72	65%					33/90	37%			2/30 (7%)
Urgent referral status	47/72	65%	49/72	68%	28/57	49%	36/72	50%	32/87	37%			5/30 (17%)
Does child have HIV / sickle cell disease / cerebral palsy?	**		**		21/66	32%	21/75	28%	33/90	37%			15/30 (50%)
Measurements / vital signs													
MUAC (mm)	34/72	47%	37/66	56%	9/33	27%	15/51	29%	36/90	40%	12/23 (52%)	11/20 (55%)	15/30 (50%)
Temperature	68/78	87%	67/78	86%	51/69	74%	45/75	60%	31/90	34%	25/26 (96%)	25/26 (96%)	3/30 (10%)
Heart rate (HR)	42/66	64%	43/69	62%	13/39	33%	11/45	24%	31/84	37%	12/23 (52%)	12/21 (57%)	8/30 (27%)
Respiratory rate (RR)	51/75	68%	50/69	72%	25/54	46%	23/63	37%	30/87	34%	17/24 (71%)	17/23 (74%)	7/30 (23%)
Oxygen saturation (SpO2)	23/69	33%	31/69	45%	0/9	0%	9/24	38%	33/81	41%	0/21 (0%)	5/19 (26%)	15/30 (50%)
Pain score (0 - 10)	22/66	33%	21/63	33%	2/12	17%	0/18	0%	28/72	39%	0/17 (0%)	0/18 (0%)	16/30 (53%)
Weight	71/78	91%	69/75	92%	37/69	54%	33/72	46%	29/87	33%	25/26 (96%)	23/23 (100%)	3/30 (10%)
Capillary Refill Time	29/63	46%	31/63	49%	12/24	50%	12/42	29%	31/75	41%			13/30 (43%)
Airway / breathing													
Central cyanosis / is the child blue?	57/69	83%	57/66	86%	24/60	40%	24/72	33%	29/87	33%			2/30 (7%)
Apnea (observed or reported)	60/75	80%	63/72	88%	28/63	44%	25/69	36%	34/90	38%			1/30 (3%)
Difficulty breathing (reported)	67/78	86%	69/75	92%	38/72	53%	40/84	48%	32/90	36%			0/30 (0%)
Difficulty breathing (observed: chest indrawing, grunting, nasal flaring)	71/78	91%	67/75	89%	34/78	44%	32/84	38%	32/90	36%			1/30 (3%)
Fast breathing (reported)	72/78	92%	71/75	95%	37/72	51%	34/78	44%	30/90	33%			0/30 (0%)
Circulation													
Skin cold (cool peripheries)	43/72	60%	44/69	64%	18/51	35%	20/72	28%	30/84	36%			3/30 (10%)
Weak and fast pulse	49/78	63%	42/69	61%	23/51	45%	20/57	35%	32/87	37%			5/30 (17%)
Pallor - palmar, oral, conjunctival	72/78	92%	70/75	93%	35/69	51%	35/75	47%	30/90	33%			2/30 (7%)
Neurological													

Irritability, restlessness	74/78	95%	74/75	99%	45/72	63%	42/78	54%	32/87	37%	0/30 (0%)
Convulsions (reported, history of)	73/78	94%	70/75	93%	37/75	49%	36/84	43%	33/90	37%	2/30 (7%)
Convulsing now, actively	76/78	97%	72/72	100%	39/78	50%	37/84	44%	29/87	33%	0/30 (0%)
Not able to drink or feed anything	70/78	90%	70/75	93%	45/75	60%	42/81	52%	31/90	34%	1/30 (3%)
Lethargy (AVPU)	54/69	78%	57/69	83%	27/66	41%	27/78	35%	31/84	37%	3/30 (10%)
Mobility - unable to move as normal	50/78	64%	49/72	68%	23/54	43%	20/60	33%	32/90	36%	0/30 (0%)
Dehydration											
Sunken eyes	73/81	90%	67/75	89%	34/72	47%	31/75	41%	30/90	33%	0/30 (0%)
Reduced urine production	48/78	62%	44/69	64%	30/45	67%	30/54	56%	31/87	36%	3/30 (10%)
Infection											
Fever (reported)	78/78	100%	75/75	100%	57/66	86%	52/75	69%	32/90	36%	0/30 (0%)
Gastrointestinal											
Diarrhea	73/75	97%	73/75	97%	33/72	46%	34/75	45%	31/90	34%	0/30 (0%)
Vomiting everything	77/78	99%	72/75	96%	40/72	56%	39/75	52%	30/90	33%	0/30 (0%)
Trauma											
Significant trauma or other urgent surgical condition	43/72	60%	41/72	57%	17/45	38%	15/54	28%	34/90	38%	2/30 (7%)
Burns	49/72	68%	60/75	80%	19/57	33%	20/69	29%	33/87	38%	2/30 (7%)
Poisoning	43/69	62%	43/66	65%	22/66	33%	20/72	28%	26/78	33%	0/30 (0%)
Severe pain	75/81	93%	70/72	97%	36/63	57%	35/66	53%	30/90	33%	0/30 (0%)
Average score overall		76%		79%		46%		40%		36%	

Footnotes:

Low score = low reliability of measurement / low frequency of abnormality / low level of training required. Empty cell = question not applicable.

Colours = heat map per domain, ranged from lowest % of maximum score to highest % of maximum score. Given the nature of the data different colour schemes are used for domains 1 and 2 (where high = better) versus domain 3 (where low = better). For domains 1 and 2: blue = above average and red = below average. Domain 3: red = above average and green = below average. In domains: white = average.

* Max score = number of respondents per question*3 (leaving out the answers ‘I don’t know’)

** May have been applicable, but asked in different way: can it be measured instead of reliability of collecting information

Table 7. Composite score on different domains per triage item

	Combined score dispensary			Combined score health centre		
	combined sum (domain 1+2-3)	*combined max (domain 1+2+3)*	*%*	*combined sum (domain 1+2-3)*	*combined max (domain 1+2+3)*	*%*
General / past medical history*						
Urgent referral status	43	216	20%	53	231	23%
Measurements / vital signs						
MUAC (mm)	7	195	4%	16	207	8%
Temperature	88	237	37%	81	243	33%
Heart rate (HR)	24	189	13%	23	198	12%
Respiratory rate (RR)	46	216	21%	43	219	20%
Oxygen saturation (SpO2)	-10	159	-6%	7	174	4%
Pain score (0 - 10)	-4	150	-3%	-7	153	-5%
Weight	80	234	34%	73	234	31%
Capillary Refill Time	10	162	6%	12	180	7%
Airway / breathing						
Central cyanosis / is the child blue?	52	216	24%	52	225	23%
Apnea (observed or reported)	54	228	24%	54	231	23%
Difficulty breathing (reported)	73	240	30%	77	249	31%
Difficulty breathing (observed: chest indrawing, grunting, nasal flaring)	73	246	30%	67	249	27%
Fast breathing (reported)	79	240	33%	75	243	31%
Circulation						
Skin cold (cool peripheries)	31	207	15%	34	225	15%
Weak and fast pulse	40	216	19%	30	213	14%
Pallor - palmar, oral, conjunctival	77	237	32%	75	240	31%
Neurological						
Irritability, restlessness	87	237	37%	84	240	35%
Convulsions (reported, history of)	77	243	32%	73	249	29%
Convulsing now, actively	86	243	35%	80	243	33%
Not able to drink or feed anything	84	243	35%	81	246	33%
Lethargy (AVPU)	50	219	23%	53	231	23%
Mobility - unable to move as normal	41	222	18%	37	222	17%
Dehydration						
Sunken eyes	77	243	32%	68	240	28%
Reduced urine production	47	210	22%	43	210	20%
Infection						
Fever (reported)	103	234	44%	95	240	40%
Gastrointestinal						
Diarrhea	75	237	32%	76	240	32%
Vomiting everything	87	240	36%	81	240	34%
Trauma						
Significant trauma or other urgent surgical condition	26	207	13%	22	216	10%
Burns	35	216	16%	47	231	20%
Poisoning	39	213	18%	37	216	17%
Severe pain	81	234	35%	75	228	33%
Average score overall			**24%**			**23%**

Footnote:
Colours = heat map per level of care, ranged from lowest % of maximum score to highest % of maximum score. Green = above average, red = below average, white = average.
*For duration of illness, number of previous admissions, admitted in past 2 days and history of HIV/sickle cell/palsy information was not available for all domains, so there were left out of the composite score.

Discussion

Main findings

For low-and-middle-income countries thirteen triage tools are available for children, at varying stages of validation and with variable performance. The triage tools vary greatly in format and content, as well as in the reference standards used for their validation. One tool (SCREEN) was developed for primary care, the others for use in hospital EDs. In Tanzanian primary care, many clinical signs and symptoms could be feasible for triage of children, but require training of staff. Vital sign measurements scored lowest on feasibility, given a lack of resources in primary care and the need for training.

Strengths and limitations

This study provides an up-to-date overview of all available triage tools for LMIC and includes detailed information on the feasibility of all separate items of these tools. A major strength is the high response rate, resulting in 30 participants in the Delphi survey, providing rich information on the feasibility of the triage tools. The included participants have many years of relevant experience at the different levels of primary care, highlighting the relevance of their contributions. Moreover, the survey was performed in two different geographical areas of Tanzania, increasing the generalizability of results. Some limitations must be mentioned. First, due to time constraints, the review was performed by one reviewer only (JvdM) and in one database only. Second, a Delphi study usually consists of multiple survey rounds, but this was not possible within the scope of this thesis. However, since the aim of this survey was to evaluate feasibility of a triage tool among future users, and not to reach consensus, this is not a major issue. Next, the survey gave the option to answer 'I don't know', reducing the number of replies, and thereby the maximum score, especially for the domain of 'frequency of finding an abnormal value'. This could indicate that the participant had no experience at that level of care, or because the variable is never collected, so the information cannot be known by the participant. The absence of objective data on the prevalence of abnormal values limits our conclusions on feasibility of using the included variables for triage. Last, extrapolation of the results to the national level should be done with caution, since differences in epidemiology and primary care may exist across regions.

Comparison to the literature and interpretation of results

Feasibility of triage items

In 2019, Fung et al. published a Delphi study to determine predictors of sepsis in children under five in LMIC.(31) These authors evaluated the predictive potential, measurement reliability and level of resources/training required for all separate items. An important finding is that all vital sign measurements scored high in their final evaluation, due to their high predictive potential. Their top 5 variables included AVPU, SpO2, MUAC, HIV status and respiratory rate. Of these items, SpO2 and MUAC scored very low on feasibility in our study, indicating that introducing these variables as triage items in clinical practice in primary care Tanzania would require more effort in terms of training or resources. Our finding of MUAC scoring low was striking, as this is considered a community health worker skill in Tanzania (personal communication). Another finding of Fung et al. was that items reported by parents (fast breathing, difficulty breathing and convulsions) scored lower than when the same symptoms were observed by the professional. Even though we did not find this difference for fast or difficulty breathing, it is in line with our finding that 'getting the right answer' of the parent was reported as a challenge. Overall, it seems preferable to included items that can be observed, instead of reported by parents.

Choice of triage tool

Next to the systematic review on paediatric triage tools of Hansoti et al. that formed the basis of our search,(22) two other reviews on the performance of triage tools have been published recently.(56, 57) Those studies included studies in adult populations and in high-income settings as well. Both studies reported high variability in performance of triage tools, which is in line with our findings. In general, the most thoroughly studied triage tools are the Canadian Triage and Acuity Scale (CTAS), the Emergency Severity Index (ESI) and the Manchester Triage System (MTS). Of those, only ESI was evaluated in children and in a middle-income setting of Iran, and therefore included in our study. None of the three tools are studied in low-income settings. Our review showed that in low-income settings the most thoroughly studied tools were ETAT and SATS, both of which were implemented in different African countries. Both tools are mainly used in hospital settings. SCREEN was the only tool designed for primary care settings. Because most relevant evidence for the Tanzanian primary care setting is found for ETAT, SATS and SCREEN, we will discuss those tools in more detail. The complete content of the algorithms is listed in Appendix III.

ETAT

ETAT includes 28 variables, starting with emergency signs according to the ABCD system, followed by a list of 12 priority signs, shortened by the acronym 3-TPRMOB.(58) An asset of the tool is that no measurement

devices are needed, since temperature is assessed by 'feeling hot', heart rate by 'weak and fast pulse' and respiratory rate by 'fast breathing'. Also MUAC, pain score and oxygen saturation are not included, which scored low on feasibility in our Delphi study. Still, the evaluation requires a physical assessment of the child. It also includes a skin pinch and capillary refill time, both having very low measurement reliability. The questions on trauma (trauma, burns and poisoning) all scored low on reliability and frequency of finding an abnormal value in our study. A drawback of ETAT reported by Brazilian researchers is that ETAT prioritizes the identification of patients with high urgency level. This did not reflect the majority of intermediate urgent patients that presented in Brazil, which was the reason for those researchers to develop a new tool.(32, 39) This prioritization of very urgent cases poses a problem when translating a triage tool to primary care setting, where the prevalence of high urgent illness is much lower than in hospital settings. This highlights that a triage tool should reflect the distribution of urgent illness in the population properly, in order to be beneficial for clinical practice. Since we do not have data on the actual prevalence of the separate variables in the primary care population of Tanzania, this needs further research.

SATS

SATS follows a similar format as ETAT, starting with emergency signs following the ABCD system, followed by very urgent and urgent signs, resulting in 3 levels of urgency.(42) A first assessment can be done without measurement devices, but then respiratory rate, heart rate and temperature should be measured, and in some cases glucose or haemoglobin levels. The algorithm is more comprehensive, including 49 separate variables. In addition to the drawbacks mentioned for ETAT, the number of variables and the need for measurement devices are additional challenges of this tool when translating to Tanzanian primary care.

SCREEN

SCREEN is a simple list of 6 questions that can be asked by a lay person.(38) It does not require physical examination of the child, and results in 2-level urgency: needing priority evaluation or not. The simplicity of the tool is both the pro and con: it requires minimal training and resources. However, it is thereby only a very rough measure. The content of the questions all scored high on feasibility in our Delphi study, supporting its use in Tanzanian primary care.

Challenges in evaluating performance of triage tools

A major difficulty in evaluating the performance of triage tools is the lack of a good reference standard for patient acuity. In practice, many different reference standards are being used: clinical outcomes, resource use, physician-based acuity or other triage tools, as presented in our study. A limitation of often-used clinical outcomes like hospitalization or mortality is that these are dichotomous outcomes, whereas triage tools mostly have categorical outcomes. This variety of reference standards limits comparisons across studies. Two research groups have developed a reference standard specifically for the aim of evaluating performance of a triage system. A Dutch group defined a 3-category reference standard based on a combination of vital signs, ED mortality, ICU-admission, need for life-saving interventions in the ED and hospitalization.(59) Brazilian researchers adapted this to be used for evaluation of the CLARIPED tool, also included in our study.(32)

Another challenge in the evaluation of triage tools is the use of many different performance measures.(60) Often used measures are sensitivity and specificity, which are measures of diagnostic accuracy or discrimination. Other studies report a measure of agreement or reliability of the tool, expressed in a kappa statistic. Also measures of correlation (Pearson's r) were reported in our review. Even though all these measures provide some information on the performance of a triage tool, it is still difficult to translate these measures to the consequences for clinical practice: how should the tool inform treatment decisions? And what is the effect on patient and process outcomes? For example, implementation of a triage tool that is very sensitive to identify patients at risk of mortality may be beneficial if immediate treatment of those patients can avoid mortality. However, there can be negative consequences if it leads to overuse of resources or overburdening of scarce staff. Therefore, it is important that both overtriage and undertriage and their consequences are taken into account when evaluating the performance of a triage tool. This can be done by reporting multiple performance measures, but also by reporting the impact on relevant patient and process outcomes in impact studies.(60) In our review, only for SCREEN and CPETS underwent such impact analyses, both showing a shortening of waiting times in the ED.

Conclusion and recommendations

In the light of the previous discussion, we will provide recommendations for the content of a paediatric triage tool that can be integrated in an electronic decision algorithm in Tanzanian primary care, as was the aim of our study. The conclusions and recommendations will follow the five stages of the analytical framework.

Stage 1. Development and content of the algorithm

In this thesis we provided evidence for a triage algorithm, based on the current literature and consultation of experts in the field. We did not find evidence for the need for two distinct triage tools for dispensary level and health centre level. However, using two distinct triage tools for different levels of training seems reasonable: one tool that can be performed by a minimally trained lay person (similar to SCREEN) and another tool to be performed by a medical professional, usually a nurse (similar to ETAT/SATS). Depending on the local context of the health facility, especially the availability of trained staff, a choice between the two can be made.

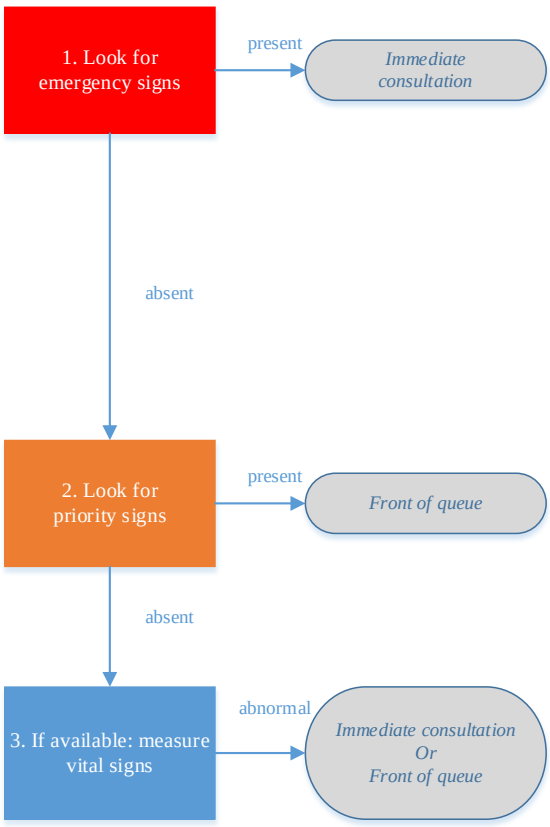
Recommendation 1: use the SCREEN triage tool for minimally trained lay person.

Based on our Delphi survey, we think all six questions of the SCREEN tool are feasible in Tanzanian primary care. Five out of six are questions to be asked to parents or guardians of the child. All these items scored high on feasibility, probably because the questions are based on terminology that is used in IMCI, that is currently used in the Tanzanian health system. One item needs to be observed: see if the child lethargic or unconscious. In the way it was asked in our Delphi survey 'Lethargy (AVPU)' it scored around average on reliability, and below average on prevalence and above average on required training. This item should therefore get special attention when training the lay people in the performance of SCREEN.

This tool is suitable for dispensaries where there is only one nurse doing the consultation, and no other medically trained staff is available. If available, we recommend the person doing the registration of patients to perform the triage. If the answer is 'yes' to any of the questions, patients should be placed in front of the row for nurse consultation. If a registration desk is not available, community health workers or guards can be trained to perform triage. The five questions besides 'lethargy' could even be suitable for parental self-triage, but we did not find evidence for such practice, so we do not recommend this.

Recommendation 2: use an adapted ETAT/SATS for nurse triage

We found most evidence for SATS and ETAT, but based on the literature and feasibility study we recommend to make some adaptations. First, since level of training and resources are scarce, the tool should be less complicated than SATS. Next, vital sign measurement devices may not always be available, so these should be optional. We recommend to use the same terminology as the SCREEN tool, especially if both tools are used at the same facility. The proposed flowchart for triage is presented in Figure 6 below. Reasons for exclusion of other ETAT/SATS variables are presented in appendix IV.



Emergency Signs	
Airway / Breathing	Is your child unable to drink or breastfeed?
	Is the child blue (centrally cyanosed)?
	Respiratory distress (observed: chest indrawing, grunting, nasal flaring)
Circulation	Cold hands + weak and fast pulse?
Coma / Convulsions	AVPU: responds only to pain or unresponsive
	Convulsing now
Dehydration	Diarrhea or vomiting + sunken eyes + lethargy (responsive to voice AVPU)

Priority signs
Tiny baby: any sick child aged under 2 months
Temperature: the child is very hot
Pallor (severe)
Pain (severe)
Restless, continuously irritable
Respiratory distress (some)
Is your child vomiting everything?
Has your child had convulsions during this illness?
Have you been to a clinic/hospital in the past 2 days?

Vital signs	
SpO2 <92%	Emergency sign
Respiratory rate (age dependant)	Emergency sign
Heart reate (age dependant)	Emergency sign
Temperature >38.5	Priority sign
MUAC <125mm	Priority sign

Figure 6. Proposed triage tool, based on ETAT/SATS

Recommendation 3: develop a reference standard for patient acuity
In order to evaluate the validity of the triage algorithm, we recommend to develop a three-level reference standard for patient acuity, adapted from previous studies.(32, 59) This reference standard should include variables that can be easily collected for each patient, reflect disease urgency but should be independent of triage. Example items to be included are: abnormal clinical signs and symptoms, need for life-saving interventions, referral to a higher level of care, hospitalization or mortality. The content should be developed in close collaboration with local researchers and practitioners, to ensure it meets the above mentioned criteria.

Recommendation 4: evaluate internal validity of the tool
Since we do not have reliable data on the prevalence of the separate triage items and of the reference standard in Tanzanian primary care, we recommend to evaluate the internal validity of both tools before informing clinical decisions. The prevalence and predictive value of the separate items can then be used to further refine the content of the triage tools. Possible research questions that can be used for this purpose are:

- Which triage items have highest predictive value?
- What is the prevalence of the different triage items?
- Is there a difference in the prevalence/feasibility of variables across age groups? Across geographical regions? Across type of facility?

Stage 2. Clinical efficacy
Recommendation 5: implement triage tool in DYNAMIC trial
When the internal validity of the tool is established, the clinical efficacy of the triage tool should be evaluated during the conduct of the DYNAMIC trial. Implementation of the tool will need strong involvement and training of local staff, especially since triage has not been performed in usual care so far. It needs a change of behaviour and workflow, and especially in case of lay person triage a shift of responsibilities. Several challenges have been reported in the literature, and should be taken into account:

1	Hesitation of staff to embrace change, fear of the unknown
2	Lack of confidence among staff

3	Lack of measurement devices for vital signs
4	Lack of designated area for triage
5	Ineffective flow of patients through facility
6	Despite lay person identifying child as critically ill, clinics required registration, weighing and vital sign measurement first, before nurse consultation, causing delay
7	Lack of trust by nurse in lay person triage
8	Belief that all children should wait their turn
9	Patients leaving without being seen

Table 8. Challenges reported in implementation of triage tools. Challenges 1-4 were reported in implementation of SITS;(36) 5-9 in implementation of SCREEN.(33)

Given these challenges, it is important to engage all stakeholders in the implementation, provide multiple training sessions and provide real-time support.(36) Regarding the last challenge: in implementation of SCREEN in South Africa it was anticipated that triage may increase waiting time for non-urgent patients, which may cause these patients to leave without being seen by a nurse. However, in practice the number of patients that left without being seen was reduced after implementation of the tool. The authors attributed this positive effect to the early engagement of the parent by a representative of the clinic.(33)

Recommendation 6: evaluate clinical efficacy of the triage tool

In order to evaluate the clinical efficacy of triage, the effect on clinical relevant outcomes should be measured. Relevant outcomes to evaluate would be: waiting times, duration of triage assessment, duration of consultation, resource use, adverse events, patients leaving without being seen, patient and user satisfaction. Definition of relevant outcomes should be decided on in collaboration with local users and patients.

In the implementation of CPETS in China family satisfaction was measured using a telephone survey, but detailed methods were not reported.(37) Validated questionnaires for patient satisfaction of healthcare services are the PSQ-18(61) and the consumer assessment health plans (CAHPS) survey,(62) but these are very general and do not provide relevant information on triage. An often used alternative is to develop an instrument internally, asking participants level of agreement on specific relevant statements on a Likert scale. For the evaluation of patient and user satisfaction, questions on knowledge of and trust in triage could be useful. In addition, pros and cons of triage could be asked. A qualitative approach, using in-depth interviews or focus group discussions may provide more rich information on the perception of triage by users and patients.

Stages 3 and 4. Clinical effectiveness and impact

Recommendation 7: evaluate clinical effectiveness and impact in routine care

When the clinical efficacy of te tool is proven, the algorithm should be implemented in routine care. The same outcomes as in efficacy should be measured to evaluate the clinical effectiveness of the tools. When the tool is implemented at large scale, other health system outcomes should be evaluated as well: costs, impact human resources. To ensure successful implementation of triage at a larger scale, it is of vital importance that it is embedded in usual training of healthcare workers and in local and national protocols. This requires close collaboration with stakeholders at all levels: policy makers, universities, health care professionals, hospital management, etcetera.

Stage 5. Responsiveness.

Recommendation 8: Collect real-time data

Throughout all previous steps of validation, data should be collected on all triage items and outcomes. This enables the researchers to refine the tool, based on the prevalence of triage items, levels of urgency and availability of resources, business of the clinics. Moreover, it provides up-to-date epidemiological data that can be inform policy-makers, researchers and clinicians in the performance of health care.

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Appendices

Appendix I. Search strategy literature review

Pubmed search strategy (coverage January 1 2015 – September 24, 2019):
("Triage"[mh] OR "triage" OR "triaged")
AND
("developing country"[tiab] OR "developing countries"[tiab] OR "developing nation"[tiab] OR "developing nations"[tiab] OR "developing population"[tiab] OR "developing populations"[tiab] OR "developing world"[tiab] OR "less developed country"[tiab] OR "less developed ountries"[tiab] OR "less developed nation"[tiab] OR "less developed nations"[tiab] OR "less developed population"[tiab] OR "less developed populations"[tiab] OR "less developed world"[tiab] OR "lesser developed country"[tiab] OR "lesser developed countries"[tiab] OR "lesser developed nation"[tiab] OR "lesser developed nations"[tiab] OR "lesser developed population"[tiab] OR "lesser developed populations"[tiab] OR "lesser developed world"[tiab] OR "under developed country"[tiab] OR "under developed countries"[tiab] OR "under developed nation"[tiab] OR "under developed nations"[tiab] OR "under developed population"[tiab] OR "under developed populations"[tiab] OR "under developed world"[tiab] OR "underdeveloped country"[tiab] OR "underdeveloped countries"[tiab] OR "underdeveloped nation"[tiab] OR "underdeveloped nations"[tiab] OR "underdeveloped population"[tiab] OR "underdeveloped
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prived nation"[tiab] OR "deprived nations"[tiab] OR "deprived population"[tiab] OR "deprived populations"[tiab] OR "deprived world"[tiab] OR "poor country"[tiab] OR "poor countries"[tiab] OR "poor nation"[tiab] OR "poor nations"[tiab] OR "poor population"[tiab] OR "poor populations"[tiab] OR "poor world"[tiab] OR "poorer country"[tiab] OR "poorer countries"[tiab] OR "poorer nation"[tiab] OR "poorer nations"[tiab] OR "poorer population"[tiab] OR "poorer populations"[tiab] OR "poorer world"[tiab] OR "developing economy"[tiab] OR "developing
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OR "underdeveloped economies"[tiab] OR "middle income economy"[tiab] OR "middle income economies"[tiab] OR "low income economy"[tiab] OR "low income economies"[tiab] OR "lower income economy"[tiab] OR "lower income economies"[tiab] OR "low gdp"[tiab] OR "low gnp"[tiab] OR "low gross domestic"[tiab] OR "low gross national"[tiab] OR "lower gdp"[tiab] OR "lower gnp"[tiab] OR "lower gross domestic"[tiab] OR "lower gross national"[tiab] OR lmic[tiab] OR lmics[tiab] OR "third world"[tiab] OR "lami country"[tiab] OR "lami countries"[tiab] OR "transitional country"[tiab] OR "transitional countries"[tiab] OR Africa[tiab] OR Asia[tiab] OR Caribbean[tiab] OR West Indies[tiab] OR South America[tiab] OR Latin America[tiab] OR Central America[tiab] OR "Atlantic Islands"[tiab] OR "Commonwealth of Independent Stat es"[tiab] OR "Pacific Islands"[tiab] OR "Indian Ocean Islands"[tiab] OR "Eastern Europe"[tiab] OR Afghanistan[tiab] OR Albania[tiab] OR Algeria[tiab] OR Angola[tiab] OR Antigua[tiab] OR Barbuda[tiab] OR Argentina[tiab] OR Armenia[tiab] OR Armenian[tiab] OR Aruba[tiab] OR Azerbaijan[tiab] OR Bahrain[tiab] OR Bangladesh[tiab] OR Barbados[tiab] OR Benin[tiab] OR Byelarus[tiab] OR Byelorussian[tiab] OR Belarus[tiab] OR Belorussian[tiab] OR Belorussia[tiab] OR Belize[tiab] OR Bhutan[tiab] OR Bolivia[tiab] OR Bosnia[tiab] OR Herzegovina[tiab] OR Hercegovina[tiab] OR Botswana[tiab] OR Brasil[tiab] OR Brazil[tiab] OR Bulgaria[tiab] OR Burkina Faso[tiab] OR Burkina Fasso[tiab] OR Upper Volta[tiab] OR Burundi[tiab] OR Urundi[tiab] OR Cambodia[tiab] OR Khmer Republic[tiab] OR Kampuchea[tiab] OR Cameroon
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Dominica[tiab] OR Dominican Republic[tiab] OR East Timor[tiab] OR East Timur[tiab] OR Timor Leste[tiab] OR Ecuador[tiab] OR Egypt[tiab] OR United Arab Republic[tiab] OR El Salvador[tiab] OR Eritrea[tiab] OR Estonia[tiab] OR Ethiopia[tiab] OR Fiji[tiab] OR Gabon[tiab] OR Gabonese Republic[tiab] OR Gambia[tiab] OR Gaza[tiab] OR Georgia Republic[tiab] OR Georgian Republic[tiab] OR Ghana[tiab] OR Gold Coast[tiab] OR Greece[tiab] OR Grenada[tiab] OR Guatemala[tiab] OR Guinea[tiab] OR Guam[tiab] OR Guiana[tiab] OR Guyana[tiab] OR Haiti[tiab] OR Honduras[tiab] OR Hungary[tiab] OR India[tiab] OR Maldives[tiab] OR Indonesia[tiab] OR Iran[tiab] OR Iraq[tiab] OR Isle of Man[tiab] OR Jamaica[tiab] OR Jordan[tiab] OR Kazakhstan[tiab] OR Kazakh[tiab] OR Kenya[tiab] OR Kiribati[tiab] OR Korea[tiab] OR Kosovo[tiab] OR Kyrgyzstan[tiab] OR Kirghizia[tiab] OR Kyrgyz Republic[tiab] OR Kirghiz[tiab] OR Kirgizstan[tiab] OR "Lao PDR"[tiab] OR Laos[tiab] OR Latvia[tiab] OR Lebanon[tiab] OR Lesotho[tiab] OR Basutoland[tiab] OR Liberia[tiab] OR Libya[tiab] OR
Lithuania[tiab] OR Macedonia[tiab] OR Madagascar[tiab] OR Malagasy Republic[tiab] OR Malaysia[tiab] OR Malaya[tiab] OR Malay[tiab] OR Sabah[tiab] OR Sarawak[tiab] OR Malawi[tiab] OR Nyasaland[tiab] OR Mali[tiab] OR Malta[tiab] OR Marshall Islands[tiab] OR Mauritania[tiab] OR Mauritius[tiab] OR Agalega Islands[tiab] OR "Melanesia"[tiab] OR Mexico[tiab] OR Micronesia[tiab] OR Middle East[tiab] OR Moldova[tiab] OR Moldovia[tiab] OR Moldovian[tiab] OR Mongolia[tiab] OR Montenegro[tiab] OR Morocco[tiab] OR Ifni[tiab] OR
Mozambique[tiab] OR Myanmar[tiab] OR Myanma[tiab] OR Burma[tiab] OR Namibia[tiab] OR Nepal[tiab] OR Netherlands Antilles[tiab] OR New Caledonia[tiab] OR Nicaragua[tiab] OR Niger[tiab] OR Nigeria[tiab] OR Northern Mariana Islands[tiab] OR Oman[tiab] OR Muscat[tiab] OR Pakistan[tiab] OR Palau[tiab] OR Palestine[tiab] OR Panama[tiab] OR Paraguay[tiab] OR Peru[tiab] OR Philippines[tiab] OR Philipines[tiab] OR Phillipines[tiab] OR Phillippines[tiab] OR
Poland[tiab] OR Portugal[tiab] OR Puerto Rico[tiab] OR Romania[tiab] OR Rumania[tiab] OR Roumania[tiab] OR Russia[tiab] OR Russian[tiab] OR Rwanda[tiab] OR Ruanda[tiab] OR Saint Kitts[tiab] OR St Kitts[tiab] OR Nevis[tiab] OR Saint Lucia[tiab] OR St Lucia[tiab] OR Saint Vincent[tiab] OR St Vincent[tiab] OR Grenadines[tiab] OR Samoa[tiab] OR Samoan Islands[tiab] OR Navigator Island[tiab] OR Navigator Islands[tiab] OR Sao Tome[tiab] OR Saudi Arabia[tiab] OR Senegal[tiab] OR Serbia[tiab] OR Montenegro[tiab] OR Seychelles[tiab] OR Sierra Leone[tiab] OR Slovenia[tiab] OR Sri Lanka[tiab] OR Ceylon[tiab] OR Solomon Islands[tiab] OR Somalia[tiab] OR Sudan[tiab] OR Suriname[tiab] OR Surinam[tiab] OR Swaziland[tiab] OR Syria[tiab] OR Syrian[tiab] OR Tajikistan[tiab] OR Tadzhikistan[tiab] OR Tadjikistan[tiab] OR
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Eritrea[mh] OR Estonia[mh] OR Ethiopia[mh] OR "Equatorial Guinea"[mh] OR Fiji[mh] OR "French Guiana"[mh] OR Gabon[mh] OR Gambia[mh] OR "Georgia (Republic)"[mh] OR Ghana[mh] OR Greece[mh] OR Grenada[mh] OR Guatemala[mh] OR Guinea[mh] OR Guinea-Bissau[mh] OR Guam[mh] OR Guyana[mh] OR Haiti[mh] OR Honduras[mh] OR Hungary[mh] OR "Independent State of Samoa"[mh] OR India[mh] OR Indonesia[mh] OR Iran[mh] OR Iraq[mh] OR Jamaica[mh] OR Jordan[mh] OR Kazakhstan[mh] OR Kenya[mh] OR Korea[mh] OR Kyrgyzstan[mh] OR Laos[mh] OR Latvia[mh] OR Lebanon[mh] OR Lesotho[mh] OR Liberia[mh] OR Libya[mh] OR Lithuania[mh] OR "Macedonia (Republic)"[mh] OR Madagascar[mh] OR Malawi[mh] OR Malaysia[mh] OR Mali[mh] OR Malta[mh] OR Mauritania[mh] OR Mauritius[mh] OR "Melanesia"[mh] OR Mexico[mh] OR Micronesia[mh] OR Middle East[Mesh:noexp] OR Moldova[mh] OR Mongolia[mh] OR Montenegro[mh] OR Morocco[mh] OR Mozambique[mh] OR Myanmar[mh] OR Namibia[mh] OR Nepal[mh] OR Netherlands Antilles[mh] OR New Caledonia[mh] OR Nicaragua[mh] OR Niger[mh] OR Nigeria[mh] OR Oman[mh] OR Pakistan[mh] OR Palau[mh] OR Panama[mh] OR Papua New Guinea[mh] OR Paraguay[mh] OR Peru[mh] OR Philippines[mh] OR Poland[mh] OR Portugal[mh] OR Puerto Rico[mh] OR "Republic of Korea"[mh] OR Romania[mh] OR Russia[mh] OR "Russia (Pre-1917)"[mh] OR Rwanda[mh] OR "Saint Kitts and Nevis"[mh] OR Saint Lucia[mh] OR "Saint Vincent and the Grenadines"[mh] OR Samoa[mh] OR Saudi Arabia[mh] OR Senegal[mh] OR Serbia[mh] OR Montenegro[mh] OR Seychelles[mh] OR Sierra Leone[mh] OR Slovenia[mh] OR Sri Lanka[mh] OR Somalia[mh] OR South Africa[mh] OR Sudan[mh] OR Suriname[mh] OR Swaziland[mh] OR Syria[mh] OR Tajikistan[mh] OR Tanzania[mh] OR Thailand[mh] OR Togo[mh] OR Tonga[mh] OR "Trinidad and Tobago"[mh] OR Tunisia[mh] OR Turkey[mh] OR Turkmenistan[mh] OR Uganda[mh] OR Ukraine[mh] OR Uruguay[mh] OR USSR[mh] OR Uzbekistan[mh] OR Vanuatu[mh] OR Venezuela[mh] OR Vietnam[mh] OR Yemen[mh] OR Yugoslavia[mh] OR Zambia[mh] OR Zimbabwe[mh])

Appendix II. Survey for Delphi study

Delphi Survey – Triage of children in Tanzanian primary health care

Expert information

1. Sex:
   - ☐ Male
   - ☐ Female
2. What are your primary affiliations?
   - ☐ Dispensary
   - ☐ Health centre
   - ☐ District hospital
   - ☐ Regional referral hospital
   - ☐ Specialized hospital
   - ☐ University
   - ☐ Other, namely:
3. What are your roles at the institution?
   - ☐ Medical attendant / nurse attendant
   - ☐ Nurse
   - ☐ Assistant clinical officer
   - ☐ Clinical officer
   - ☐ Assistant medical officer
   - ☐ Medical officer
   - ☐ Physician
   - ☐ Paediatrician
   - ☐ Other, namely:
4. What is your area of expertise?
   - ☐ Paediatrics
   - ☐ Infectious disease
   - ☐ Epidemiology
   - ☐ General medicine
   - ☐ Nursing
5. Do you have any other relevant areas of expertise?

6. How many years of experience do you have in providing clinical care to children?

Questions asked per variable

1. Can this variable be reliably measured at a dispensary in Tanzania?
   (A measurement is reliable if 2 different people would measure this variable, and they obtain the same answer)
   - ☐ Highly reliable
   - ☐ Moderately reliable
   - ☐ Unreliable

2. Can this variable be reliably measured at a health centre in Tanzania?
   - ☐ Highly reliable
   - ☐ Moderately reliable
   - ☐ Unreliable

3. How much medical training will be required to collect this variable?
   - ☐ Extensive training *5 days*
   - ☐ Moderate training *3-4 days*
   - ☐ Minimal training *1-2 days*

4. How common is this variable abnormal or this symptom present at dispensary level?
   - ☐ Frequently *in more than 50%*
   - ☐ Regularly *in less than 50%*
   - ☐ Rarely *in less than 5%*
   - ☐ I don't know

5. How common is this variable abnormal or this symptom present at health centre level?
   - ☐ Frequently *in more than 50%*
   - ☐ Regularly *in less than 50%*
   - ☐ Rarely *in less than 5%*
   - ☐ I don't know

6. Only for vital sign measurements: are the instruments available to measure this variable at a dispensary in Tanzania?
   - ☐ Always
   - ☐ Sometimes
   - ☐ Never

7. Only for vital sign measurements: are the instruments available to measure this variable at a health centre in Tanzania?
   - ☐ Always
   - ☐ Sometimes
   - ☐ Never

8. Do you see any challenges in collecting this variable at triage?

   …….

Appendix III Content of triage tools SATS, ETAT, SCREEN

SATS – South African Triage Scale	ETAT – Emergency Triage And Treatment	SCREEN
Emergency Signs	**Emergency Signs**	**Priority questions**
Airway and Breathing		Is your child unable to drink or breastfeed?
Not breathing or reported apnea	Is the child breathing?	Is your child vomiting everything?
Obstructed breathing	Is the airway obstructed?	Has your child had convulsions during this illness?
Central cyanosis or SpO2 less than 92%	is the child blue (centrally cyanosed)?	See if the child is lethargic or unconscious
Respiratory distress (severe)	Stridor?	Is your child <2 months old?
	Is the child having trouble getting breath so that it is difficult to talk, eat or breastfeed?	Have you been to a clinic/hospital in the past 2 days?
	Is he breathing very fast and getting tired?	
	Does he have severe chest indrawing or is he using axillary resp. muscles?	
Circulation		
Cold hands + two or more of the following 3	Does the child have warm hands?	
Pulse weak and fast	If not, is the capillary refill time longer than 3 seconds?	
Capillary refill time 3 sec or more	Is the pulse weak and fast?	
Lethargic		
Uncontrolled bleeding		
Coma		
AVPU: responds only to pain or unresponsive	Assign patient to one of the AVPU categories: A-Alert V-responds to Voice P-responds to Pain U-Unresponsive A child who is not alert but responds to voice is **lethargic** Coma is determined at level of P or U	
Confusion		
Convulsion		
Convulsing or immediately post ictal and not alert	Convulsing	
Dehydration		
Diarrhea or vomitting + 2 or more of the following	Is the child lethargic or unconscious?	
Lethargic/floppy infant	Does the child have sunken eyes?	
Very sunken eyes	Does the skin pinch goes back very slowly?	
Skin punch very slow - 2 sec or ore	If the child has diarrhea plus two of the above signs, the child has severe dehydration	
Other		
Facial/inhalation burn		
Hypoglycemic recorded at any time - glucose less than 3 mmol/L		
Purpuric rash		
Very Urgent Signs	**Priority signs**	
Tiny baby - younger than 2 months	Tiny baby: any sick child aged under 2 months	
Inconsolable crying/severe pain	Temperature: the child is very hot	
Presenting complaint: more sleepy than normal	Trauma or other urgent surgical condition	
Poisoning or overdose	Pallor (severe)	
Focal neurology acute	Poisoning	
Severe mechanism of injury	Pain (severe)	
Burns (circumferential, electrical, chemical, 10% or more)	Respiratory distress	
Eye injury	Restless, continuously irritable, or lethargic	

Fracture - open or threatened limb	Referral (urgent)	
Dislocation of larger joint (not finger or toe)	Malnutrition: visible severe wasting	
	Edema of both feet	
Urgent Signs	Burns	
Some respiratory distress		
Some dehydration: diarrhea or diarrhea and vomiting + 1 or more of the following		
Sunken eyes		
Restless/irritable		
Thirsty/decreased urine output		
Dry mouth		
Crying without tears		
Skin pinch slow - less than 2 seconds		
Some dehydration: unable to drink/feed or vomits everything + 1 or more sign from above		
Malnutrition (visible severe wasting)		
Malnutrition oedema (pitting edema of both feet)		
Unwell child with known diabetes		
Any other burn less than 10%		
Closed fracture		
Dislocation of finger or toe		
Triage Early Warning Score		
Mobility		
RR		
HR		
Temp		
AVPU		
Trauma		

Appendix IV Adaptations to ETAT/SATS

Adapted ETAT/SATS	Comment, reason in/exclusion
Emergency Signs	
Airway/breathing	
Is your child unable to drink or breastfeed?	Use same language as SCREEN
Is the child blue (centrally cyanosed)?	
Respiratory distress (observed: chest indrawing, grunting, nasal flaring)	
excluded:	
obstructed breathing	Based on evidence Fung review
stridor	Based on evidence Fung review
Circulation	
Does the child have cold hands?	Scored low on reliability, but if warm hands: no need for taking pulse
If so is the pulse weak and fast?	Requires training, but is important
excluded:	
capillary refill	Scored low on reliability, requires much training
Uncontrolled bleeding	Was included in variable 'significant trauma', but that was excluded based for low reliability and frequency
Coma	
AVPU: responds only to pain or unresponsive	Requires training, but is important
Excluded:	
Confusion	Not included in ETAT, is covered in AVPU
Convulsion	
Convulsing now	
Dehydration	
Diarrhea + sunken eyes + lethargy	
Excluded:	
skin pinch	Based on expert opinion, low reliability, requires much training
Other signs SATS:	Not included in ETAT
Facial/inhalation burn	Included in burns, scored low on reliability, frequency, high on training
Hypoglycemic recorded at any time - glucose less than 3 mmol/L	Not feasible in primary care
Purpuric rash	Based on evidence Fung review
Very Urgent Signs	
Tiny baby: any sick child aged under 2 months	
Temperature: the child is very hot	
Pallor (severe)	
Pain (severe)	
Restless, continuously irritable	
Respiratoty distress (some)	
Added:	Questions included in SCREEN
Is your child vomiting everything?	
Has your child had convulsions during this illness?	
Have you been to a clinic/hospital in the past 2 days?	
excluded:	
Referral (urgent)	Scored low on reliability, replaced by visit to clinic in past 2 days (screen)
Malnutrition: visible severe wasting	Based on expert opinion, low reliability and rare
Edema of both feet	Based on expert opinion, low reliability and is rare
Burns	Scored low on reliability and frequency
Vital signs	
SpO2 <92%	
Respiratory rate (age dependent)	
Heart reate (age dependent)	

Temperature >38.5	
MUAC <125mm	
excluded:	
Mobility	Scored low on reliability
Trauma	Scored low on reliability
pain score	Scored low on reliability, never used, already included in 'severe pain'