Resource Use, Availability and Cost in the Provision of Critical Care in Tanzania: A Systematic Review

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Abstract

Introduction

Critical care is essential in saving lives of critically ill patients, however, provision of critical care across lower resource settings can be costly, fragmented and heterogenous. Despite the urgent need to scale-up the provision of critical care, little is known about its availability and cost. Here, we aim to systematically review and identify reported resource use, availability and costs for the provision of critical care and the nature of critical care provision in Tanzania.

Methods

The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines¹⁷ PROSPERO registration number: CRD42020221923. We searched Medline, Embase and global health databases. We included studies that reported on provision of critical care, cost and availability of resources used in the provision of critical care published after 2010. Costs were adjusted and reported in 2019 USD and TZS using the world bank GDP deflators.

Results

A total 31 studies were found to fulfil the inclusion and exclusion criteria. Critical care identified in Tanzania was categorised into: ICU delivered critical care and non-ICU critical care. The availability of ICU delivered critical care was limited to urban settings whereas non-ICU critical care was found in rural and urban settings. 15 studies reported on the costs of services related to critical care yet no study reported an average or unit cost of critical care. Costs of medication, equipment (e.g. oxygen, PPE), services, and human resources were identified as inputs to specific critical care services in Tanzania.

Conclusion

There is limited evidence on the resource use, availability and costs of critical care in Tanzania. There is a strong need for further empirical research on critical care resources availability, utilization and costs across specialties and hospitals of different level in LMICs like Tanzania to inform planning, priority setting and budgeting for critical care services.

Background

Critical care is an essential element of healthcare whose importance has been highlighted globally during the COVID-19 pandemic with countries experiencing overwhelming numbers of critically ill patients^{1–3}. As a result, the care of critical illness has become an urgent point of focus in global health policy.

Critical care entails the care given to a patient in need of enhanced monitoring, treatment and attention, due to a life-threatening illness or injury⁴. There have been great advances in the provision of critical care for example invasive and non-invasive monitoring techniques, mechanical ventilation (MV), and renal replacement therapy, among others, resulting in reduced mortality rates in patients with critical illness, especially in high income countries⁵.

However, such critical care is provided in sophisticated intensive care units using equipment which are costly to procure and maintain⁶. This makes it difficult for low resource settings to acquire such equipment to meet the needs of their populations and has led to recommendations for the development of more affordable critical care models that can be provided in any hospital settings and to all critically ill patients^{1,7,8}. Moreover, most critically ill patients do not need critical care at ICU-level⁹ and large unmet needs of even basic lifesaving critical care have been found in LMICs^{10–12}. With various national and international stakeholders calling for critical care scale-up¹³, it is necessary to understand the resources needed in the provision of critical care and their respective costs. Unfortunately, knowledge on the current availability of resources and the costs of critical care remains sparse^{1,14,15}. There is no systematic review that examines the available resources, utilisation and costs of critical care generally¹⁶ nor in low and middle income country settings.

To inform the planning and scale up of critical care provision in a low-income country setting, this study takes a case study approach to review available knowledge on the current resource availability, utilisation and cost in the provision of critical care in Tanzania¹⁶.

Methods

The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines¹⁷ and the protocol was registered with PROSPERO; registration number: CRD42020221923¹⁶. The full methodological protocol used in this review is available elsewhere¹⁶.

Search strategy and selection process

Following PRISMA guidelines, 3 electronic databases (i.e. Medline, Embase and Global Health) were systematically searched for articles published since 2010¹⁸. A ten-year time frame was considered to ensure that findings reflect the present-day resource utilization paradigm as resources used and their costs vary as technology and clinical guidelines evolve. Bibliographies of included articles were reviewed to find relevant articles that fulfil the inclusion criteria but had not been identified. Google and Google Scholar were also used to search for published articles that may not have been indexed within the

databases. As internet search engines typically return several thousand results, the searches were restricted to the first fifty hits and links to potentially relevant material were accessed¹⁹.

The PICO framework (Table 1) describes major components used to identify key words. Other concepts and search terms are listed in the supplementary material. Key words included critical care, critical illness, resource use and setting. Some diseases were also added to the research string (for example neonatal disorders, HIV, Malaria and TB²⁰), on the premise that these are conditions that have a high risk of critical illness. See supplementary 1 for detailed key words. Rayyan QCRI software was used to identify and remove duplicates²¹ and screen articles by title and abstract through a double-review process.

Eligibility criteria

A study was considered eligible if it was published in English and reported on the provision of critical care²², services offered under critical care, resources and/or costs incurred by the health system or health providers in providing critical care in Tanzania. A detailed inclusion/ exclusion criterion can be found in supplementary 2.

Data extraction and synthesis

A bespoke data extraction form was developed and used to record extracted data. The extracted data included author, year of publication, context (location, setting- urban or rural, type of facility, level of facility), critical care services offered, critical care equipment available, costing perspective, costing year, currency used, type of provider, payer, source of cost data, costing time frame, direct medical costs, resources used.

A narrative synthesis of extracted data was conducted to report an overview of study characteristics of the eligible studies. We described the characteristics of critical care provision as identified in the literature and resources available for the provision of critical care in Tanzania. In addition, quantitative and qualitative syntheses were performed for cost and resource use data. Costs and resources used were categorized into groups based on a standard input-wise categorisation, for example, human resources, diagnostics, services, consumables and medication. Costs were first standardized by adjusting for inflation using the GDP deflators for Tanzania²³ and reported in USD and TZS of 2019 value.

Risk of bias in individual studies

The quality of the included articles was assessed using an adaptation of the Reference Case for Estimating the Costs of Global Health Services and Interventions²⁴, which provides a framework for quality assessment and data extraction. Furthermore, methodological quality of studies that reported costs were further assessed by an appraisal checklist by Adawiyah et al²⁵. Any discrepancies were addressed by a joint re-evaluation of the article among all authors.

Results

Study characteristics

Thirty-one studies fulfilled the inclusion criteria, of which 14 reported on the costs associated with critical care in Tanzania (Table 2). The disease areas covered by eligible studies included; oncology (n=1), trauma (n=4), obstetrics (n=3), neonatal/child care (n=2), HIV (n=1), renal failure (n=1), TB (n=1), malaria (n=3), stroke (n=1) and typhoid (n=1), antimicrobial resistance (n=1) surgery (n=2) respiratory illness (n=1), blood transfusion (n=1), no disease or area specific (n=8). The majority of studies were cross sectional in design (n=20) and qualitatively reported on the location of critical care and critical care services available.

Most studies were conducted in a specific region: the Coast Zone (n = 7), Lake Zone (n = 3), Northern Highland Zone (n = 3) and Southern Highland Zone (n = 3) and Central Zone (n = 1). A zone is a geographical area made up of health regions which are made up of districts. Seven studies were nationally representative (n = 7); two studies didn't specify a given region. Three studies were carried out in rural settings while the rest were urban or mixed settings. Nine studies specified that they were conducted in public (government owned) facilities and six specified non-governmental organisations including faith/missionary based hospitals.

Critical care provision in Tanzania

The structure of the health system in Tanzania comprises six levels²⁶ starting with the village health post (lowest level), dispensaries, health centres, district hospitals, regional hospitals and tertiary referral hospitals (the highest level)^{26–39}. Critical care is usually offered at the hospital level only, that is the district hospital, regional hospitals and referral hospitals^{26–31,33–40}. In addition, Nicks et al state that district hospitals offer basic forms of critical care while referral hospitals offer critical care in ICUs²⁶. Thirteen of the fifteen studies that reported on critical care provision were carried out in urban settings. Two of the fifteen studies were carried out in both rural and urban settings; no study was exclusively carried out in a rural setting. Based on the literature, we further categorise critical care into “ICU delivered critical care” (otherwise known as ICU based critical care) and “non-ICU based critical care”.

Seven studies reported on ICU delivered critical care offered in tertiary referral hospitals in Tanzania^{28,29,35,36,38,39} including regional hospitals. For example, Murthy et al state that St. Francis Hospital in Ifakara region had 10 ICU beds and Sekou Toure Regional Referral Hospital in Mwanza had 8 ICU beds³³. ICU delivered critical care services included intubation and ventilation. For example, one study found that 54.2% of all ICU patients were intubated or

ventilated³⁸. In addition, two studies reported surgical interventions that were conducted on patients cared for in ICU included wound debridement, treatment of fractures, craniotomy, underwater seal drainage, tracheostomy, eye surgery and Thoracotomy^{38,41}. The district hospitals, for which studies were available did not provide ICU delivered critical care³⁴.

Critical care outside the ICU was reported to be delivered either in operating theatres or in emergency units and general wards. For example, operating theatres at Kilimanjaro Christian Medical Centre (KCMC) offered critical care for cases like trauma and sepsis⁴². Theatres in lower-level hospitals like district hospitals often offer initial critical care before referring the patient to higher level hospitals that can offer ICU based critical care. Although district hospitals and some regional hospitals were reported not to have ICUs, these facilities were reported to offer critical care in the general wards³⁴. Some hospitals without ICUs designated areas within general wards to cater for the critically ill patients³⁴. Furthermore, Staton et al found that some critical care services including intubation were performed in the emergency units³⁹.

Availability of resources required for critical care

The majority of eligible studies reported on the known resources used for critical care (n=21). However, many studies did not report the extent to which the resources were readily available at a given hospital (n=18). Three studies reported on availability and use of critical care resources and indicate that their availability varies between hospitals and is sometimes unreliable or inconsistent (supplementary 3). Two studies find that there is a scarcity of trained staff in critical care^{34,37}. Further, the availability of critical care equipment was heterogeneous with scarcity in the areas of mask and tubing, pulse oximetry, oxygen cylinders, adult and paediatric oropharyngeal airway and PPE eye protection highlighted. In addition, a greater scarcity in paediatric than adult critical care equipment was identified^{34,37}.

Resource use and cost of resources associated with provision of critical care

Of the 31 studies, 14 reported on the resource use and critical care costs and were appraised for quality using the Adawiyah et al adapted appraisal checklist²⁵ (Supplementary 4). All 14 studies were found to have clear research questions, mentioned the specific costing perspective, included relevant inputs, clearly stated methods for quantifying resources and reported costs. Four studies did not specify the time horizon while four studies partially addressed it. The majority of the studies (n=8) carried out some form of sensitivity analysis. All studies that collected primary data stated sample size but did not mention how it was determined and whether it was sufficient.

Published costs of critical care were reported as economic costs (n = 8) or financial costs (n = 6), using a mix of bottom up (n = 9) and top down (n = 5) approaches. Sources of the costs were local data collected from hospital records, surveys and price lists. Surveys (including key informant interviews) were a common method of data collection (n = 9). Three studies used patient level data on resource use to inform costs (Kimaro⁴³; Sicuri⁴⁴; Riewpaiboon⁴⁵). Hospital or laboratory records were used in 6 of the 14 studies. Some studies used both survey and records review as the source of data (n = 6). Two studies used international literature as a source of data (n = 2). Unit costs reported included cost per program, cost per patient, cost per visit, cost per patient day, cost per episode, cost per bed day, inpatient cost, total annual cost, cost per case (see table 4).

Although many studies reported costs within differing disease specific (e.g. malaria and anaemia) or general hospital services (e.g. inpatient and outpatient care), no study identified the cost of elements that are specific for the treatment of critical illness. The highest reported average cost per patient was for a patient undergoing caesarean section (USD 471.28)⁴⁶. The lowest reported cost per patient was for hospitalisation for stroke in a rural area (USD 12.76)⁴⁷. A nationally representative study of general hospital services including critical care found that unit costs vary by provider ownership (public, NGO and private) and level of health facility⁴⁸ (regional vs primary care). Services provided at private hospitals were more expensive than the same services received at public hospitals. NGO hospitals were less expensive than public hospitals.

When looking at cost categories, 2 studies reported costs of equipment, 2 studies reported costs of consumables and 6 studies reported medication cost. Within studies, we found per item cost for equipment (4 items), consumables (3 items) and medication (13 items). The cost of a mannequin used in training was the most expensive piece of equipment reported (USD 76.03)⁴⁹. In the medication category, tranexamic acid was the most expensive per dose (USD 9.74)⁵⁰, whereas antimicrobials were the most expensive on a per case basis (USD 30.36)⁵¹.

While diagnostics are not part of critical care provision, they form part of the overall patient care and can inform future economic evaluations. Six studies reported on the cost of diagnostics, for example, FBC, serum cryptococcal meningitis test, sputum culture and imaging (see supplementary material).

Three studies reported human resource costs (see table 6). No human resource costs were identified as specifically for ICU or non-ICU critical care. Reporting of human resource cost was heterogeneous. One study provided monthly salaries for all personnel with monthly salaries ranging from USD 2721.79 for medical specialists USD 313.34 for nurses⁵². Another study reported total cost of personnel as a line item. The third study reported unit costs (i.e. cost per patient) treatment for all obstetric complications broken down by staff category. This study found that the most important cost was for an enrolled nurse or midwife (USD 43.62 per patient) and that the lowest unit personnel cost was for an anaesthesiologist (less than 0.01USD per patient)⁵³.

Discussion

Our review found limited evidence on resource use, availability and costs of critical care in Tanzania. Of the eligible evidence, we found high variability in the geographical distribution and availability of resources needed for both ICU and non-ICU critical care provision. We found that ICU critical care was provided at the tertiary level in urban areas and no published provision in rural areas, whereas, non-ICU critical care was evident in both rural and urban

areas. Within hospitals, we find that availability of key critical care resources (e.g. pulse oximeters, oxygen cylinders, mask and tubing) can be limited but the use of these resources is not documented. We, finally, find no reported estimates on the unit costs of critical care; and that the generation and reporting of cost data is not standardised thereby limiting synthesis or aggregation.

Availability of critical care in Tanzania

The majority of ICUs identified in our systematic review were located in tertiary referral hospitals and private hospitals located in urban areas (Dar es Salaam, Moshi, Mwanza, Mbeya city). This is of particular concern in Tanzania where the majority of the population (64.77) lives in rural areas⁵⁴. Although this inequity in service distribution is not unique to Tanzania as previous studies in LMICs found all hospitals with ICUs were located in cities³³, it is further exacerbated by a lack of critical care guidelines that cater to rural areas⁵⁵. Such geographical inequity in ICU critical care could be detrimental and of particular concern during a critical care crisis (e.g. COVID-19)¹.

However, critical care delivery is heterogenous and can be provided in advanced or basic forms, depending on resource availability. Critical care can involve high tech and high-cost equipment that requires highly trained staff (e.g. mechanical ventilation) and is more often found in the ICU. Investing in this level of critical care is therefore an expensive policy decision and may explain the lack of ICU critical care availability in rural areas in Tanzania. On the other hand, investing in adequately resourced critical care outside of ICUs can potentially save lives and reduce the case load that requires ICU care⁵⁶. We found that non-ICU critical care was reported to be given in wards and theatres³⁹ across rural and urban areas.

A key finding of the literature review was that neither the level of care provided, complexity, resource intensity or quality of provision was reported. We were therefore unable to characterise critical care in Tanzania other than by where it is delivered i.e. ICU vs non-ICU based critical care. This is of concern as care for the critically ill takes many forms and is not necessarily synonymous with ICU care. Critical care, at least in its more basic forms, should be readily available to all patients in need in any hospital. Characterising the minimum needs for the care of a critically ill patient will facilitate our understanding of what elements of critical care are currently available as well as recommendations for the progressive improvement of critical care in all facilities. Previous research suggests that basic critical care, which effectively identifies and treats all critically ill patients, should be available and provided in all settings within a hospital (e.g. in wards) across rural and urban settings^{57,58}. Recently, some of this paper's authors have proposed the concept of Essential Emergency and Critical Care (EECC) across LMICs. EECC is pragmatic and low-cost care of critical illness that does not need to be reliant on sophisticated technology, and have a primary focus on simple, effective actions that have large potential impact on the population⁵⁶ and the components of have been specified in a large global consensus⁸.

Given the lack of availability and access of critical care across Tanzania, such novel approaches may provide a building block to developing a fully resourced, equitable critical care system⁵⁹. However, decision makers require further evidence on the optimal design, costs, budget impact and cost-effectiveness of such critical care interventions in rural and urban systems.

Complexity of resources within critical care

At the hospital level, we found that many studies identified resources that were used in the provision of services that included a critical care component but a few studies went further to report on the availability of the resources at the facility (e.g. equipment, consumables and human resources). For example, while oxygen is one of the essential resources required in the provision of critical care, many hospitals still lack basic equipment for its storage and delivery⁶⁰. Our findings show that even when oxygen is available, the equipment and consumables required to facilitate provision of oxygen therapy can be missing^{39,61}. This leaves a considerable proportion of critically ill patients in need of medical oxygen without the necessary treatment, incurring unnecessary deaths and disability.

Many reasons exist as to why availability and supply of oxygen is limited in settings such as Tanzania. For example, supply and scaling of medical oxygen is a complex process and is often controlled through monopoly suppliers. Regulation and high investment costs create barriers for new firms to enter the market and easily scale up supply. In Tanzania, medical oxygen supply is controlled centrally by a quasi-governmental monopoly organisation⁶². On the demand side, there is limited funding for medical oxygen with procurement decentralised to individual hospitals with constraint budgets⁶⁰. Alternatives, such as oxygen concentrators and hospital plants for the local production of oxygen, are affected by the need for a constant supply of electricity, compounded by challenges with maintaining equipment. In Tanzania, approx. 50% of hospitals are without a constant oxygen supply³⁷ and there is limited local capacity to maintain and repair oxygen concentrators like Tanzania.

In addition to oxygen equipment, we found variability in availability of PPE and human resources across studies. While some personal protective equipment (PPE), especially gloves, were available in most hospitals, others, such as eye protection, remained unavailable, which is in line with previous research⁶³. In terms of human resources, evidence suggests that only 20% of hospitals have at least one health worker trained in adult critical care which includes administering complex oxygen related equipment^{34,55,57}. Technical assistance, training of health workers, and improved processes for non ICU based care, development of context-specific critical care guidelines, building capacity in equipment maintenance and biomedical engineering in facilities, and support to medical oxygen infrastructure development should be prioritised in applications to multilaterals and technical assistance agencies^{34,64,65}.

Costs of critical care

Costing of critical care is vital in eliciting potential budget constraints or impacts, assessing cost-effectiveness, providing insight into the economic burden of disease and can be useful for understanding the resources incurred by health systems, other payers, and patients. We find that no study reported or

calculated an average cost or cost per patient day for the provision of critical services. On the other hand, many studies reported individual costs of resources associated with provision of critical care and it was possible to identify the cost of specific resources needed in critical care provision (i.e. human resource cost, services, medication, and other consumables). Such limited evidence could be due to no formal or standardised definition of critical care existing thereby reducing specificity when costing critical care provisioning. Another possibility may be that patients who require critical care are heterogenous. The underlying demographics, epidemiology, risk factors, patient pathway and interventions administered are also heterogenous thereby making aggregation and estimates of average cost challenging. This is further confirmed by the data extracted in this review which showed that reporting of costs within eligible studies were inconsistent thereby making comparisons or synthesising information across studies difficult. There is an urgent need to understand the resources required and their cost implications to inform the planning of improved critical care, globally.

Limitations

There are a number of inherent limitations with this systematic review. Firstly, we tailored our search strategy to account for the lack of standardised or formal definitions for critical illness, critical care provision and ICUs⁵⁷ by including specific terms for conditions likely to lead to critical illness and identified in consultation with clinicians on the authorship team. Here, we may have introduced a personal bias by focussing on specific conditions and excluding others. Secondly, cost and resource use in an African context are traditionally poorly documented and can fluctuate due to market dynamics and resource availability. While this systematic review provides key insights into peer reviewed published information on the resource use, availability and costs of critical care in Tanzania, researchers must update a previous nationally representative facility survey conducted in 2012 extending it to include an understanding of the costs of critical care provision that includes patient level data on resource use. Finally, we opted to only include articles in English but believe the extent and effects of language bias are diminished recently because of the shift towards publication of studies in English⁶⁶.

Conclusion

Critical care is essential in the prevention of mortality among critically ill patients, yet limited evidence exists on the costs and cost-effectiveness of scaling up critical care thereby hindering informed planning for investments in key life-saving interventions. We further find that ICU based critical care provision is currently only provided in urban areas in Tanzania and there is an urgent need to assess the quality of non-ICU based critical care implemented to address the gap in critical care provision in rural and urban areas. Evidence on resources used and potential costs in critical care is limited, and, along with a specific focus on oxygen supply and delivery which is a key resource in critical care, requires further research. Improving the evidence base on the costs, utilisation, cost-effectiveness and equity impacts of different strategies for critical care services across rural and urban areas is needed to help prevent unnecessary deaths caused by critical illness in Tanzania.

Declarations

Ethical Approval and Consent to participate

This study is a review of secondary data, it is exempt from application for ethical review.

Consent for publication

All authors have consented to this publication

Availability of supporting data

Not applicable

Competing interests

Authors declare no competing interests and the funders did not in any way influence the development of the development of this study.

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Authors' contributions

Below is the detailed breakdown of their contribution.

Concept and design: JK, HS, LG, AJ, PT, OS, TB

Development of first draft: JK, HS, LG

Acquisition of data: JK, HS, LG, PT, SG

Analysis and interpretation of data: JK, HS, LG, PT, SG, OS

Drafting of the manuscript: JK, HS, LG

Critical revision of paper for important intellectual content: TB, OS, LG, KK, AJ

Statistical analysis: -

Provision of study materials:

Obtaining funding: TB, OS

Administrative and technical support:

Supervision: LG, HS

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Tables

Table 1: PICO (Population, Intervention, Comparator, Outcome) Framework used to inform the search strategy.

Element	Description
Population	Any patient in need of critical care
Intervention	Inpatient services that could form part of critical care provision
Comparison	No critical care
Outcomes	Critical care services available Cost of the different inputs to critical care provision per patient Quantity and type of resources used in provision of critical care per patient

Table 2: Study Characteristics (N=31)

Article	Disease area	Intervention	Study Type	Purpose Type	Geographical area covered	Hospital Type	Facility/hospital Level	Source of data
Studies reporting on costs								
Baynes et al 2019	Obstetrics	Providing care to women that have had an abortion	Cross sectional	Cost Analysis	Mwanza, Arusha and Zanzibar	NGO & Public	All	Records and interviews
Chris et al 2013	General	Health services	Cross sectional	Cost Analysis	National	All	All	Survey
Kabadi et al 2013	Stroke	Providing stroke care	Longitudinal	Cost Analysis	Mbeya and Dar es Salaam	NGO & Public	Tertiary referral	Survey and project data
Mengistu et al 2019	Direct obstetric complications	Emergency Obstetric and Neonatal Care	Cross sectional	Cost Analysis	Kigoma	Public	Tertiary, district hospital and primary care	Programme & hospital data
Mosha et al 2010	Malaria	Diagnostic tools and drugs	Cross sectional	Cost analysis	Kilimanjaro region and Korogwe District, Tanga region	Public	District and dispensaries	Survey
Riewpaiboon et al 2014	Typhoid	Typhoid treatment/care	Longitudinal	Cost Analysis	Pemba and Zanzibar	Public	District hospital	Record review and interviews
Sicuri et al 2011	Malaria	Malaria treatment/care	Longitudinal	Cost Analysis	Not specified	Not specified	Not specified	Survey
Chaudhury et al 2016	Neonatal care	Birth attendants training on neonatal resuscitation	Cross sectional	Cost Analysis	Mbeya	NGO & Public	All	Survey
Penno et al 2015	Antimicrobial resistance	Surveillance for Bloodstream Infections for Sepsis Management in low resource setting	Modelling	Economic evaluation	Northern Tanzania	Not specified	Not specified	Laboratory records
Githang'a et al 2020	Oncology	Oncology treatment: e.g. chemotherapy, off site radiotherapy, surgery	Cross-sectional	Economic evaluation	Mwanza	NGO	Tertiary referral	Hospital data & interviews
Guerriero et al 2010	Blood transfusion	Use of Tranexamic acid as a replacement for blood transfusion	Modelling	Economic evaluation	National	Not specified	Not specified	Literature
Kimaro et al 2017	Advanced HIV	Providing antiretroviral therapy services to HIV-infected individuals presenting with advanced HIV disease	Cohort	Economic evaluation	Dar es Salaam	Public	Primary health center	Patient survey, health care worker diaries
Phillips et al 2015	Malaria	Malaria Rapid Diagnostic test (mRDT)	Modelling	Economic evaluation	National	All	All	Local program/ records
Shayo et al 2017	Tuberculosis	Isoniazid preventive therapy	Cohort	Economic evaluation	Dar es Salaam	NGO, Public and private	Tertiary and primary care	Records and interviews

Article	Disease area	Intervention	Study Type	Purpose Type	Geographical area covered	Hospital Type	Facility/hospital Level	Source of data
Wilson et al 2020	Neonatal care	Birth attendants training on neonatal resuscitation (59 participants)	Cross sectional	Financial planning	Zanzibar	Not specified	Not specified	Survey
Studies reporting on forms and resource availability in critical care								
Baker et al 2011	Critical care	Emergency and critical care	Cross sectional	Others (structure and resources available for emergency and critical care)	National	All	Tertiary, district, and primary care	Survey
Chalya et al 2011	Trauma	Trauma care	Cross sectional	Others (describe patient characteristics and health outcomes)	Mwanza	NGO	Referral hospital	Survey
Mkoka et al 2014	Obstetrics	Emergency obstetric care	Cross sectional	Others (availability of medical supplies)	Kongwa	Public	Primary healthcare	Interviews
Mtango et al 2019	Critical care	Critical care	Cross sectional	Others (doctors' experiences of ICU referral)	Dar es salaam	Public	Tertiary referral	Interviews
Murthy et al 2015	Critical care	N/A	Review	Others (estimate the current ICU capacity)	Ifakara, Dar es Salaam and Mwanza	NGO & Public	Tertiary referral	Literature
Mwandri et al 2020	Trauma	Baseline assessment of trauma care provision	Cross sectional	Others (assessing burden and care process)	Mbeya and Dar es Salaam	NGO & Public	Tertiary referral	Hospital registry data
Mwiga & Monaghan 2020	Respiratory illness	Difficult airway trolley	Case study	Others (development of difficulty airway trolley)	Mbeya	NGO	Tertiary referral	Difficult airway trolley
Nicks et al 2012	Emergency medicine	N/A	Case study	Others (structure of health system and care processes)	National	All	All	Literature
Papali et al 2019	Critical care	N/A	Review	Others (structure and organisation of adult ICU)	N/A	All	All	Literature
Penoyar et al 2012	Surgery	Surgical care	Cross sectional	Others (capacity of first referral hospitals)	National	All	District, regional and referral	Survey
Rajaguru et al 2019	Surgery	Surgery	Cross sectional	Others (operation and financing of a referral hospital)	Mbeya	NGO	Tertiary referral	Record review
Reynolds et al 2012	General (particular injuries, pneumonia and psychosis)	Emergency care	Cross sectional	Others (Barriers to emergency care)	National	Public	Tertiary referral	Interview

Article	Disease area	Intervention	Study Type	Purpose Type	Geographical area covered	Hospital Type	Facility/hospital Level	Source of data
Sawe et al 2016	General	Emergency treatment	Cross sectional	Others (clinical presentation and resource utilization)	Dar es Salaam	Public	Tertiary referral	Hospital record
Staton et al 2017	Traumatic Brain Injury	Trauma care	Cross sectional	Others (describe quality of care for TBI)	Kilimanjaro	NGO	Referral Hospital	Survey
Sylvanus et al 2019	Renal failure	Renal failure treatment and management	Cohort	Others (renal failure case management)	Dar es Salaam	Public	Tertiary referral	Survey
Zimmerman et al 2020	Acute traumatic brain injury	Quantifying the effect on outcomes from delays in the care of trauma	Cross sectional	Others (association of hospital delays and poor outcomes)	Moshi	NGO	Tertiary referral	Hospital data

Note: Others (under purpose type) includes studies that do not report costs. Interviews in this table mean that the study used in-depth interviews to collect data.

Table 3: Types of costs reported and sources of data

Study	Economic/financial cost/both	Real world /guideline cost	Full/incremental cost	Top down/ bottom up estimations/both	Source of cost data
Githang'a et al 2020	Financial	Real world costs	Full costs	Both	Hospital data
Mengistu et al 2019	Financial	Real world costs	Full costs	Top-down estimation	Programme, hospital and health center data
Wilson et al 2020	Financial	Real world costs	Full costs	Bottom-up estimation	Staff Survey (N=59)
Kimaro et al 2017	Economic costs	Real world costs	Full costs	Bottom-up estimation	Patient survey, diaries (N=870)
Shayo et al 2017	Economic costs	Real world costs	Full costs	Bottom-up estimation	Records, government standards and market price survey
Phillips et al 2015	Economic costs	Real world costs	Full costs	Top down estimation	Local program records
Penno et al 2015	Economic costs	Real world costs	Full costs	Bottom-up estimation	Laboratory records
Kabadi et al 2013	Economic costs	Real world costs	Full costs	Bottom-up estimation	Survey (N=16) and project data
Sicuri et al 2011	Economic costs	Real world costs	Full costs	Bottom-up estimation	Patient Survey (N=150)
Guerriero et al 2010	Economic costs	Real world costs	Full costs	N/A	Literature
Baynes et al 2019	Financial costs	Real world costs	Full costs	Bottom-up estimation	Health facility Records (N=31) and key informant interviews (N=124)
Riewpaiboon et al 2014	Economic costs	Real world costs	Full costs	Bottom-up estimation	Record review and patient survey (N=17)
Sumona et al 2016	Financial costs	Real world costs	Full costs	Bottom-up estimation	Health facility Survey (N=386)
Chris et al 2013	Financial costs	Real world costs	Full costs	Top-down estimation	Facility Survey (N=155)

Table 4: Cost of services offered to patients

Study	Description	Unit cost of output	Currency year	Unit cost Price in 2019 (USD)	Unit cost Price in 2019 (TZS)
Mengistu et al 2019	Clinical care for emergency obstetric case	per case	2013	143.85	329,166.
Mengistu et al 2019	Average cost per surgical patient	per patient	2013	285.08	652,333.26
Mengistu et al 2019	Average cost per patient undergoing caesarean	Per patient	2013	471.28	1,078,396.41
Riewpaiboon et al 2014	Inpatient hospital cost	Per patient per day	2010	91.78	107.49
Sicuri et al 2011	Episode of Malaria hospitalisation and Severe anaemia	per episode	2009	57.12	130,704.61
Sicuri et al 2011	Episode of Cerebral malaria	per episode	2009	22.67	51,864.33
Sicuri et al 2011	Episode of Cerebral malaria and neurological sequela	per episode	2009	47.58	108,879.84
Kabadi et al 2013	Hospitalisation of stroke patient (Inpatient, Drugs, Registration)- Rural area	per patient	2005-2006	12.76	29,200.18
Kabadi et al 2013	Hospitalisation of stroke patient (Inpatient, Drugs, Registration)- Urban area	per patient	2005-2006	31.17	71,317.89
Kabadi et al 2013	Physiotherapy for stroke- urban area	per patient	2005-2006	44.88	102,697.20
Kabadi et al 2013	Hospitalisation of stroke patient (Inpatient, Drugs, Registration)- average	per patient	2005-2006	18.51	42,361.25
Kabadi et al 2013	Physiotherapy for stroke- average	per patient	2005-2006	14.03	32,093.43
James, Bura & Ensor 2013	Health centre: overall	Inpatient day	2011/12	18.03	41,261.22
James, Bura & Ensor 2013	Health centre: public	Inpatient day	2011/12	18.98	43,432.74
James, Bura & Ensor 2013	health centre: NGO	Inpatient day	2011/12	17.29	39,564.68
James, Bura & Ensor 2013	Hospital: all	Inpatient day	2011/12	25.95	59,387.93
James, Bura & Ensor 2013	Hospital: public	Inpatient day	2011/12	18.54	42,422.55
James, Bura & Ensor 2013	Hospital: NGO	Inpatient day	2011/12	15.76	36,062.52
James, Bura & Ensor 2013	Hospital: private	Inpatient day	2011/12	68.05	155,721.31
James, Bura & Ensor 2013	Hospital regional	Inpatient day	2011/12	17.33	39,653.32
James, Bura & Ensor 2013	Hospital - ARI-pneumonia	per case treated	2011/12	104.33	238,736.91
James, Bura & Ensor 2013	Hospital - Hypertension	per case treated	2011/12	253.98	581,166.07
James, Bura & Ensor 2013	Hospital - Myocardial infarction	per case treated	2011/12	268.57	614,533.21

Table 5: Cost of Equipment, consumables, and medication

Study	Description	Unit cost of output	Currency year	Unit cost Price in 2019 (USD)	Unit cost Price in 2019 (TZS)
Equipment					
Chaudhury et al 2016	Mannequin	per piece	2014	76.03	173,970.65
Chaudhury et al 2016	Bag-mask device	per piece	2014	16.29	37,279.43
Chaudhury et al 2016	Penguin sucke	per piece	2014	3.26	7,455.89
Mengistu et al 2019	Equipment needed for emergency obstetric care	per patient	2013	90.02	205,994.65
Consumables					
Mengistu et al 2019	Other supplies for emergency obstetric care	per patient	2013	28.68	65,635.80
Mengistu et al 2019	Blood supplies	per patient	2013	0.71	1,620.01
Guerriero et al 2010	Consumables needed in the administration of tranexamic acid (10ml syringe, 100ml bag of saline, large gauge needle)	Per dose	2007	2.00	4,576.41
Medication					
<i>Analgesics and sedatives</i>					
Riewpaiboon et al 2014	Paracetamol 120 mg/5 mL in 60-mL bottle	per bottle	2010	0.33	750.38
Riewpaiboon et al 2014	Paracetamol 500 mg tablet	Per tablet	2010	0.01	26.80
<i>Antifungal and antibacterial drugs</i>					
Riewpaiboon et al 2014	Ampicillin 500 mg vial injection	Per piece	2010	0.21	482.39
Riewpaiboon et al 2014	Ceftriaxone 250 mg vial injection	Per piece	2010	0.46	1,045.17
Riewpaiboon et al 2014	Ciprofloxacin 250 mg capsule	Per Capsule	2010	0.01	26.80
Riewpaiboon et al 2014	Ciprofloxacin 500 mg capsule	Per capsule	2010	0.05	107.20
Penno et al 2015	Antimicrobial treatment using generic drugs for sepsis management	per case	2011	15.17	34,703.66
Penno et al 2015	Evidence-based antimicrobials	Per case	2011	30.36	69,459.83
Kimaro et al 2017	Cotrimoxazole per daily dose	Per daily dose	2012	0.02	51.51
<i>Others like anti-cancers</i>					
Githang'a et al 2020	50 mg of 6-mercaptopurine (6MP)	Unclear	2013	0.39	885.94
Mengistu et al 2019	Drugs for emergency obstetric care	per patient	2013	6.90	15,795.12
Riewpaiboon et al 2014	Glucose (5%) 500 mL	Per unit	2010	0.50	1,152.37
Guerriero et al 2010	Tranexamic acid	Per dose	2007	9.74	22,279.66

Note: No cardiovascular drugs and anticonvulsant drugs were reported in included studies.

Table 6: Cost of human resources

Study	Description	Unit of output	Currency year	Unit cost Price in 2019 (USD)	Unit cost Price in 2019 (TZS)
Mengistu et al 2019	Total personnel for Emergency obstetric care	per patient	2013	103.01	235,711.74
Baynes et al 2019	Cost of Obstetrician/gynecologist on all complications	Per patient	2016	10.00	22,884.06
Baynes et al 2019	Cost of Anesthesiologist on all obstetric complications	Per patient	2016	0.00	0.00
Baynes et al 2019	Cost Anesthetist on all obstetric complications	Per patient	2016	2.23	5,112.40
Baynes et al 2019	Cost of Anesthetist Assistant on all obstetric complications	Per patient	2016	1.81	4,138.61
Baynes et al 2019	Cost of doctor/ medical officer on all obstetric complications	Per patient	2016	15.75	36,030.22
Baynes et al 2019	Cost of assistant medical officer on all obstetric complications	Per patient	2016	5.00	11,442.03
Baynes et al 2019	Cost of clinical officer on all obstetric complications	Per patient	2016	0.85	1,947.58
Baynes et al 2019	Cost of registered nurse or principal enrolled nurse on obstetric all complications	Per patient	2016	9.79	22,397.16
Baynes et al 2019	Cost of enrolled nurse or midwife on all obstetric complications	Per patient	2016	43.62	99,813.44
Baynes et al 2019	Cost of medical attendant on all obstetric complications	Per patient	2016	6.06	13,876.50
Baynes et al 2019	Cost of laboratory technician on all complications	Per patient	2016	3.19	7,303.42
Baynes et al 2019	Cost of laboratory assistant on all complications	Per patient	2016	1.70	3,895.16
Baynes et al 2019	Cost of Sonographer on all obstetric complications	Per patient	2016	2.87	6,573.08
Baynes et al 2019	Cost of pharmacist on all complications	Per patient	2016	2.55	5,842.74
Baynes et al 2019	Cost of drug dispenser on all complications	Per patient	2016	1.06	2,434.47
Baynes et al 2019	Average personnel costs at primary care level facilities for all complications	Per patient	2016	14.28	32,670.64
Baynes et al 2019	Average personnel care costs at district hospitals for all complications	Per patient	2016	8.97	20,522.62
Baynes et al 2019	Average personnel costs at Regional hospital for all complications	Per patient	2016	30.14	68,968.66
Baynes et al 2019	Average personnel costs for all complications across any level of hospital	Per patient	2016	19.16	43,844.88
Shayo et al 2017	Assistant medical officer	Monthly salary	2012	638.96	1,462,064.84
Shayo et al 2017	Nurse	Monthly salary	2012	313.34	716,994.91
Shayo et al 2017	Health Attendant	Monthly salary	2012	440.41	1,007,738.83
Shayo et al 2017	Assistant Nurse	Monthly salary	2012	338.60	774,793.40
Shayo et al 2017	Nurse Counsellors	Monthly salary	2012	819.44	1,875,051.02
Shayo et al 2017	Medical Doctors	Monthly salary	2012	1473.56	3,371,810.40
Shayo et al 2017	Medical Specialists	Monthly salary	2012	2721.79	6,228,019.13
Shayo et al 2017	Laboratory Scientific Officer	Monthly salary	2012	1106.07	2,530,924.80

Shayo et al 2017	Laboratory technician	Monthly salary	2012	819.44	1,875,051.02
Shayo et al 2017	Pharmacist	Monthly salary	2012	1106.07	2,530,924.80
Shayo et al 2017	Pharmacy technician	Monthly salary	2012	819.44	1,875,051.02

Figures

Figure 1

Flow diagram of the study selection process

Supplementary Files

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- [PRISMA2020checklist.docx](#)
- [Supplementary.docx](#)