



Original article

A cross sectional study of the availability of paediatric emergency equipment in South African emergency units

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ABSTRACT

Background: Despite children representing a significant proportion of Emergency Unit (EU) attendances globally, it is concerning that many healthcare facilities are inadequately equipped to deliver paediatric resuscitation. The rapid availability of a full range of paediatric emergency equipment is critical for delivery of effective, best-practice resuscitation. This study aimed to describe the availability of essential, functional paediatric emergency resuscitation equipment on or close to the resuscitation trolley, in 24-hour EUs in Cape Town, South Africa.

Methods: A cross sectional study was conducted over a six-month period in government funded hospital EUs, providing 24-hour emergency paediatric care within the Cape Town Metropole. A standardised data collection sheet of essential resuscitation equipment expected to be available in the resuscitation area, was used. Items were considered to be available if at least one piece of equipment was present. Functionality of available equipment was defined as: equipment that hadn't expired, whose original packaging was not outwardly damaged or compromised and all components were present and intact.

Results: Overall, a mean of 43% (30/69) of equipment was available on the resuscitation trolley across all hospitals. The overall mean availability of equipment in the resuscitation area was 49% (34/69) across all hospitals. Mean availability of functional equipment was 42% (29/69) overall, 41% (28/69) at district-level hospitals, and 45% (31/69) at regional/tertiary hospitals.

Conclusion: Essential resuscitation equipment for children is insufficiently available at district-level and higher hospitals in the Cape Town Metropole. This is a modifiable barrier to the provision of high-quality paediatric emergency care.

African relevance

- Paediatric resuscitation equipment availability impacts delivery of best-practice emergency care of children
- There is very little research evidence on this topic from African emergency settings
- This research highlights a critical resource limitation in low- middle-income regions specifically, Sub Saharan Africa
- Suboptimal availability and functionality of equipment is a modifiable barrier to high-quality paediatric emergency care
- This research identifies a key area for emergency care improvement in Africa

Introduction

Paediatric emergencies contribute significantly to the patient burden in emergency units (EU) [1–4]. This is supported by data indicating that the burden of patients under 18 years old was 25% in both Tanzania and South Africa and children represent 27% of all EU visits in the United States of America (USA) [1–3]. Despite this significant patient burden, many healthcare facilities are not adequately prepared to deliver effective paediatric emergency care [1]. The variable availability of paediatric expertise, paediatric specific equipment, appropriately trained staff and standardised treatment guidelines adversely affects the optimal emergency care of children [5].

The availability and accessibility of paediatric emergency equipment varies globally, with considerably more shortages in EUs with low paediatric volumes and in low- and middle-income (LMIC) regions

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[6–10]. A Canadian study involving 700 EUs, reported that intraosseous needles were not available in 15.9% of centres, infant bag valve mask devices in 3.5% and infant laryngoscope blades in 3.5% [6]. A similar survey in the USA indicated that only 6% of EUs had all the recommended paediatric supplies and equipment [8]. The situation in Africa is even worse: A cross sectional study undertaken in district hospitals across Rwanda reported 50% availability of infant bag valve mask devices and no intraosseous needles in any of the facilities surveyed [10].

Resources within emergency care systems differ regionally and internationally, nonetheless several universal measures have been shown to improve and promote access to high quality paediatric emergency care [5]. One such measure is defining the expected standards for the emergency care of children in EUs through the development of institutional and international guidelines, including recommendations regarding resuscitation equipment. In South Africa, one benchmark of care is an expert consensus report established by the Western Cape Provincial Clinical Governance Committees for both Child Health and Emergency Medicine [11]. The report consists of a set of recommendations focusing on the emergency care of ill and injured children within the public health service. Although the expert consensus report is an indicator of the suggested paediatric emergency equipment required, there is no available literature in South Africa to confirm that this is being implemented in healthcare facilities. The aim of the study was to describe the availability of essential, functional paediatric emergency resuscitation equipment on the resuscitation trolley, in 24-hour EUs within the Cape Town Metropolitan region.

Methods

Study design and time-period

A cross sectional study was performed over a six-month period (June 2018 to November 2018). The study was approved by the Stellenbosch University Health Research Ethics Committee (Ref: S17/11/273), University of Cape Town Human Research Ethics Committee (Ref: 820/2018) and Western Cape Provincial Health Research and Ethics Committee (Ref: WC_201804_015).

Study setting and population

Primary level health services in South Africa are provided through local clinics and 24-hour community health centres. Higher-level services are largely provided at hospitals; categorised as district, regional, or tertiary/central hospitals. The study was conducted in government funded hospitals (district-level and higher) within the Cape Town Metropolitan Health District, who provide 24-hour emergency paediatric care (Table 1). Tertiary-level hospitals have separate areas for medical- and trauma-related patients, and both areas were included in the study. A total of 11 EUs were evaluated out of a possible 13 EUs within the Cape Town Metropolitan Health District. One tertiary-level

Table 1

Study hospitals within the Cape Town Metropolitan Health District providing 24-hour paediatric emergency care.

Hospital	Location	Hospital level
Eerste River Hospital	Eerste River, Cape Town	District
False Bay Hospital	Fish Hoek, Cape Town	District
Helderberg Hospital	Somerset West, Stellenbosch	District
Karl Bremer Hospital	Bellville, Cape Town	District
Khayelitsha Hospital	Khayelitsha, Cape Town,	District
Mitchells Plain Hospital	Mitchells Plain, Cape Town	District
New Somerset Hospital	Green Point, Cape Town	Regional
Tygerberg Hospital	Bellville, Cape Town	Central/Tertiary
Victoria Hospital	Wynberg, Cape Town	District
Wesfleur Hospital	Atlantis, Cape Town	District

Table 2

Standardised data collection sheet.

	Equipment name	Size	
Airway	Endotracheal tubes (cuffed and uncuffed)	2,5	
	Endotracheal tubes (cuffed and uncuffed)	3	
	Endotracheal tubes (cuffed and uncuffed)	3,5	
	Endotracheal tubes (cuffed and uncuffed)	4	
	Endotracheal tubes (cuffed and uncuffed)	4,5	
	Endotracheal tubes (cuffed and uncuffed)	5	
	LMA	0	
	LMA	1	
	LMA	1.5	
	LMA	2	
	LMA	2.5	
	LMA	3	
	Introducer/Stylet	2 mm (paediatric)	
	Bougie	5 Ch (paediatric)	
	McGill forceps	Paediatric	
	Laryngoscope	Mac 0	
	Laryngoscope	Mac 1	
	Laryngoscope	Mac 2	
	Laryngoscope	Mac 3	
	Laryngoscope	Mac 4	
	Laryngoscope	Mi 00	
	Laryngoscope	Mi 0	
	Laryngoscope	Mi 1	
	Laryngoscope	Mi 2	
	Laryngoscope	Mi 3	
	Laryngoscope	Mi 4	
	Laryngoscope	Mi 5	
	Bag-valve mask device (BVM)	250 ml neonatal	
	Bag-valve mask device (BVM)	500 ml infant	
	Facemask for BVM	Round 00	
	Facemask for BVM	Round 0	
	Facemask for BVM	Round 1	
Facemask for BVM	Round 2		
Facemask for BVM triangular			
Oropharyngeal airway	Size 000 (pink)		
Oropharyngeal airway	Size 00 (blue)		
Oropharyngeal airway	Size 0 (black/grey)		
Oropharyngeal airway	Size 1 (white)		
Oropharyngeal airway	Size 2 (green)		
Breathing	Nasal prongs	Neonate	
	Nasal prongs	Child	
	Nasal prongs	Adult	
	Simple oxygen mask	Infant	
	Simple oxygen mask	Child	
	Venturi mask	28% infant (yellow/white)	
	Venturi mask	28% child (yellow/white)	
	Venturi mask	35–40% infant (green/pink)	
	Venturi mask	35–40% child (green/pink)	
	Venturi mask	60% infant (orange)	
	Venturi mask	60% child (orange)	
	Non rebreather mask	Infant	
	Non rebreather mask	Child	
	Nebulizer mask	Infant	
	Nebulizer mask	Child	
	Circulation	Intravenous canulae	24G (yellow)
		Intravenous canulae	22G (blue)
		Intravenous canulae	20G (pink)
Volume control device (e.g. Buretrol)		150 ml	
Volume control device (e.g. Buretrol)		50 ml	
Rate control device (e.g. dial-a-flow)			
Intraosseous (IO) needles		Mechanical device	
Intraosseous (IO) needles		Custom made IO needle	
Intraosseous (IO) needles		Bone marrow aspiration needle (15/18G)	
Intraosseous (IO) needles		Lumbar puncture needle 18G 21G needle (green)	

(continued on next page)

Table 2 (continued)

	Equipment name	Size
Disability	Weight/height estimation device	
	Defibrillator	Paediatric paddles
	Electrodes	Neonate
	Electrodes	Paediatric

hospital was excluded from the study due to failure to obtain the necessary permissions within the timeframe of the study. Primary care facilities (e.g. community health centres) were excluded as sampling of these centres exceeded the logistical capabilities of the study.

Given the small sample size of included regional- and tertiary-level facilities, the results of the single regional- and tertiary-level hospital were grouped together and compared against the results of the district-level hospitals. It would have been preferable to additionally compare the results of the regional-level hospital and the two tertiary-level hospitals had the necessary permissions been successfully obtained.

Data collection

Data was collected by the principal investigator, visiting each EU once during the study period. A standardised data collection sheet was used (Table 2). The data collection sheet included an abbreviated list of essential resuscitation equipment (grouped into four categories: airway, breathing, circulation and disability categories) expected to be available on the resuscitation trolley. Within the four categories of essential equipment a total of 69 pieces of equipment were assessed: nine types of airway equipment, five types of breathing equipment, four types of circulation equipment and three types of disability equipment. The list was adapted from The Western Cape Standards of Paediatric Emergency Care expert consensus report (resuscitation trolley equipment list) in consultation with a specialist paediatric emergency physician (Supplementary Table S1) [11]. It was not logistically feasible in this study to evaluate the presence of all proposed items and the selected items mainly represent new-born and small infant sized equipment. The rationale behind this decision was that it is very difficult to adapt adult equipment for this specific patient group.

Data collection was conducted at any time during weekday business hours. Data collection times were intentionally performed at random since it is an operational expectation that the resuscitation trolley is constantly present and stocked in the event of a resuscitation which may occur at any time, without prior notice. Data collection was rescheduled if a clinical resuscitation was in progress at the planned time.

Outcome measures

The availability of equipment was defined and measured as follows:

Resuscitation Trolley Equipment Availability

Items were considered to be available if at least one piece of equipment was present on the resuscitation trolley. In the event of multiple paediatric resuscitation trolleys within immediate proximity of each other, a single combined result was generated as it is a realistic expectation that equipment not available in one trolley would be obtained from an adjacent trolley if needed.

Functionality of Available Equipment

Functionality of equipment available on the resuscitation trolley was defined as: equipment that had not expired, whose original packaging was not outwardly damaged or compromised and all component parts were present and intact. Functionality testing was limited to those items that were present on the resuscitation trolley.

Resuscitation Area Equipment Availability

Availability of equipment in the resuscitation area (but not solely on the resuscitation trolley), was included as an additional measure during the data collection period. This was due to the observation that, in many instances, equipment not available in the resuscitation trolley was available within proximity of the resuscitation trolley. This area, in proximity of the resuscitation trolley, was formally or informally designated as the resuscitation area by the individual health facility.

Data management

Data was directly entered into an access-controlled Microsoft Excel spread sheet on an access-controlled laptop computer.

Statistical analysis

Summary statistics were used to describe the variables. Comparisons of proportions of equipment available were done using the χ^2 -test. Statistical analyses were performed using MedCalc for Windows, version 18.5 (MedCalc Software, Ostend, Belgium; <https://www.medcalc.org>; 2018). Reporting is in line with the STROBE statement for observational research.

Results

Availability on resuscitation trolley

Overall, a mean of 43% (30/69) of essential equipment pieces was available across all hospitals. The best stocked EU had 51% (35/69) pieces of essential equipment, while the worst had 33% (23/69); both were district-level hospitals. The overall availability of equipment was higher at regional/tertiary-level hospitals than at district-level hospitals (47%, 32/69 versus 41%, 28/69, $p = 0.86$) (Fig. 1). The availability of all equipment didn't differ significantly between EUs run by emergency physicians (44%, 30/69) and those run by non-emergency physicians (42%, 29/69) ($p = 0.95$).

The overall availability of equipment per category was Airway 51% (20/39), Breathing 19% (2.9/15), Circulation 41% (4.5/11) and Disability 59% (2.4/4) (Fig. 1). Equipment in the Airway and Breathing categories constituted 78% (54/69) of the essential resuscitation equipment in the data collection sheet largely due to the wide range in size of equipment. Two trends were demonstrated between airway and breathing equipment size and availability (Fig. 2). Endotracheal tubes, Laryngeal Mask Airways, Facemask for BVM and Nasal prongs were increasingly available as equipment size increased. Laryngoscope Miller blade and Oropharyngeal airway equipment were least available at the smallest and largest spectrum of sizes.

Functionality of equipment on resuscitation trolley

The mean availability of functional equipment on the resuscitation trolley across all hospitals was 42% (29/69) with a minimum of 32% (22/69) and maximum of 51% (35/69) (Fig. 3). District-level hospitals had 41% (28/69) of functional equipment available compared to 45% (31/69) at regional/tertiary-level hospitals ($p = 0.91$). A detailed breakdown of the availability and functionality of equipment is presented in supplemental material (Tables S2-S10). Functional equipment was equally available in centres run by emergency physicians and non-emergency physicians (43%, 30/69 versus 41%, 28/69, $p = 0.95$).

Availability in resuscitation area

The overall mean availability of equipment in the resuscitation area was 49% (34/69) with a minimum of 41% (28/69) and maximum of 52% (36/69) across all hospitals.

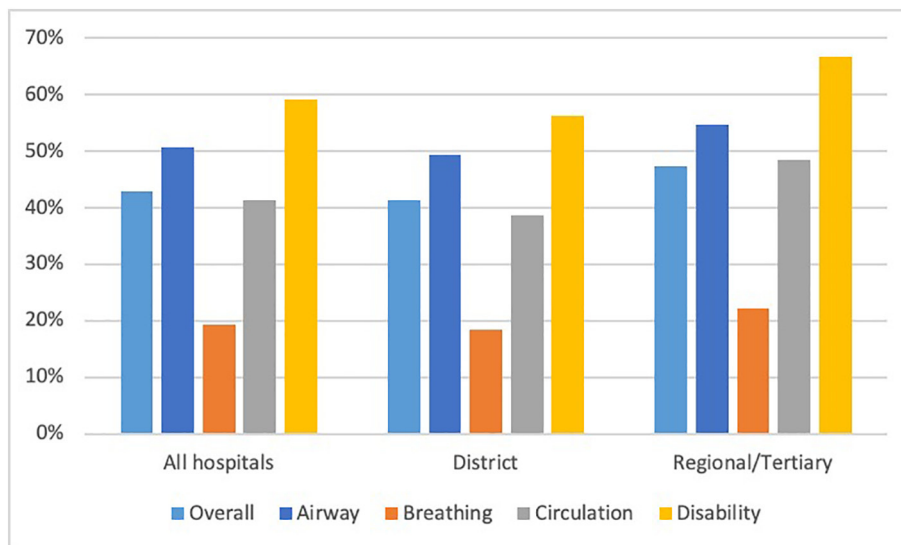


Fig. 1. Availability of essential paediatric equipment on the resuscitation trolley.

Discussion

The study indicates suboptimal availability and functionality of equipment at healthcare facilities providing district-level care and higher. We found no statistical difference in both the availability and functionality of equipment in district-level hospitals compared to regional- and tertiary-level hospitals. These findings are cause for concern as the absence of essential emergency equipment compromises the potential to achieve the most optimal outcome during a time pressured resuscitation. Furthermore, the results of this study are of clinical significance because they suggest that there exists a modifiable barrier to the provision of high-quality paediatric emergency care.

Our study indicates that, on average, less than 45% of essential equipment pieces were available in the EUs of the included Cape Town hospitals (43% on resuscitation trolleys and 49% when the nearby area was included). This finding is supported in the literature which stipulates that many EUs do not meet the necessary emergency paediatric equipment requirements, despite a high paediatric emergency care patient burden with a high acuity disease profile [1]. However, the availability and accessibility of paediatric emergency equipment is

noted to be inconsistent, with considerably more shortages in EUs with low paediatric volumes and in low- to middle-income (LMIC) regions such as Sub Saharan Africa [6–10,12]. Our results further indicate that available equipment on the resuscitation trolley was mostly functional. This is important as a seemingly well-stocked resuscitation area could contain non-functional or expired items, thus creating a false sense of assurance. The recent implementation of a National Core Standards (NCS) Policy in South Africa, may have contributed to removal of expired items [13,14]. The NCS Policy addresses the operational management of health facilities (including essential equipment), which is checked during compulsory quality assurance and NCS audits [13,14].

The discrepancy of overall availability and functionality of equipment between regional/tertiary-level and district-level hospitals was not statistically significant (45% versus 41%, $p = 0.91$). This suggests that resuscitation equipment capabilities are similar, albeit suboptimal, in EUs across the different levels of care in Cape Town. We attribute this to the fact that although regional- and tertiary-level hospitals provide a more specialised, definitive paediatric service as compared to the district-level hospitals, initial paediatric emergency care remains the same irrespective of the level of care. This is also reflected in international

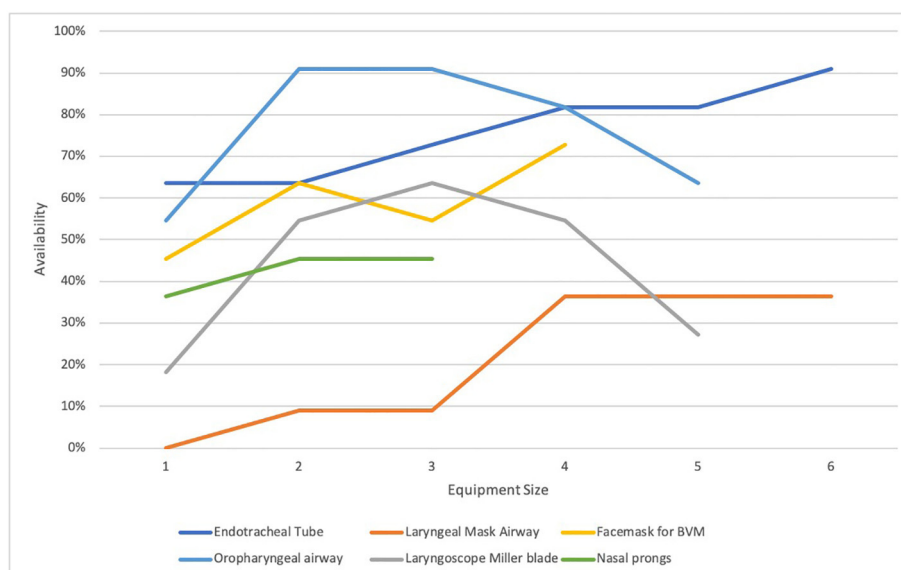


Fig. 2. Relationship between availability of airway and breathing equipment and equipment size.

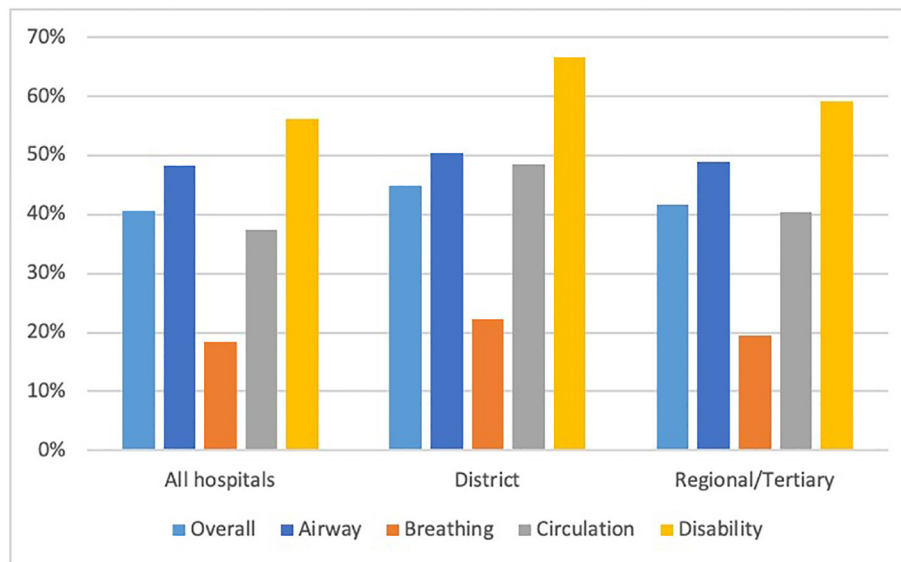


Fig. 3. Functional Essential Paediatric Equipment Available on the Resuscitation Trolley.

emergency care standards, where the standards are specifically designed to be applied to any emergency care system and do not mandate the need for highly specialised equipment, staff or facilities [15–17]. The district health system functions as the backbone of the South African health system and as such, it is important and expected that adequate essential equipment be available at district-level facilities [18]. This is further supported by international data which indicates that EUs with a dedicated in-patient paediatric service, as is the case in district-level and higher EUs in Cape Town, are likely to have adequate paediatric supplies available [12].

The strength of the study is its contribution to the limited data pertaining to the practical delivery of paediatric emergency care, particularly in LMIC regions. The description of the presence of equipment on the resuscitation trolley and the nearby resuscitation area is an important indicator of the ability to provide high quality advanced life support to children, with the potential to positively influence morbidity and mortality [19,20]. However, the study is limited in the following ways. The study was restricted to the Cape Town Metropole in the Western Cape and care must be taken in generalising the results to other settings. Secondly, a dedicated paediatric tertiary level hospital in the Cape Town Metropolitan Health District was excluded from the study due to failure to obtain the necessary permissions within the timeframe of the study. Data from the excluded site might have influenced the study, although the direction cannot be determined.

The results of this study serve as a valuable benchmark for future advocacy efforts to improve health facilities and essential paediatric emergency resuscitation equipment. The results of this study have the potential to inform low cost, actionable change with immediate improvement to clinical safety and clinical outcomes. Follow up research questions, to build on the results of this study, would be helpful to the research and clinical community given the paucity of literature focused on paediatric emergency care in EUs. In view of the poor performance by a range of health facilities in the Cape Town Metropole, we believe that it is an important next step to re-evaluate and critically assess what are the determinants for not being able to meet the required standards and to consider if the standardised emergency equipment list is a reasonable and appropriate standard for health facilities in LMIC regions, such as sub-Saharan Africa.

Conclusion

To the best of our knowledge, this is the first study to describe the availability and functionality of paediatric emergency equipment in

EUs in district-, regional- and tertiary-level facilities in South Africa. The study indicates suboptimal availability of functional equipment at healthcare facilities providing district-level care and higher, which is a potential modifiable barrier to the provision of high-quality paediatric emergency care.

Dissemination of results

Results from this study were shared with staff members at the data collection sites and the Health Research Department of the Western Cape Provincial Department of Health. Furthermore, the results of the research were presented at the 2019 EMCT annual academic research day and in abstract form at the 7th EMSSA International Conference.

Authors' contribution

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: LLK contributed 50%; BC 25%; and DJVH 25%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of competing interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.afjem.2020.06.008>.

References

- [1] Institute of Medicine. Emergency care for children: growing pains. Washington, DC: The National Academies Press; 2007. <https://doi.org/10.17226/11655> [accessed 05 January 2019].
- [2] Reynolds TA, Mfinanga JA, Sawe HR, Runyon MS, Mwafongo V. Emergency care capacity in Africa: a clinical and educational initiative in Tanzania. *J Public Health Pol* 2012;33(Suppl1):S126. <https://doi.org/10.1057/jphp.2012.41>.
- [3] Wallis LA, Twomey M. Workload and casemix in Cape Town emergency departments. *S Afr Med J* 2007;97(12):1276–80.
- [4] Atiq H, Siddiqui E, Bano S, Feroze A, Kazi G, Fayyaz J, et al. The pediatric disease spectrum in emergency departments across Pakistan: data from a pilot surveillance system. *BMC Emerg Med* 2015;15(2):S11. <https://doi.org/10.1186/1471-227X-15->

- S2-S11.
- [5] Committee on Pediatric Emergency Medicine. Access to optimal emergency care for children. *Pediatrics* 2007;119(1):161–4. <https://doi.org/10.1542/peds.2006-2900>.
 - [6] McGillivray D, Nijssen-Jordan C, Kramer MS, Yang H, Platt R. Critical pediatric equipment availability in Canadian hospital emergency departments. *Ann Emerg Med* 2001;37(4):371–6. <https://doi.org/10.1067/mem.2001.112253>.
 - [7] Gnanalingham MG, Harris G, Didcock E. The availability and accessibility of basic paediatric resuscitation equipment in primary healthcare centres: cause for concern? *Acta Paediatr* 2006;95(12):1677–9. <https://doi.org/10.1080/08035250600763034>.
 - [8] American Academy of Pediatrics, Committee on Pediatric Emergency Medicine, American College of Emergency Physicians, Pediatric Committee, Emergency Nurses Association Pediatric Committee. Joint policy statement-guidelines for care of children in the emergency department. *Pediatrics* 2009;124(4):1233–43. <https://doi.org/10.1542/peds.2009-1807>.
 - [9] Nolan T, Angos P, Cunha AJLA, Muhe L, Qazi S, Simoes EAF, et al. Quality of hospital care for seriously ill children in less-developed countries. *Lancet* 2001;357(9250):106–10. [https://doi.org/10.1016/s0140-6736\(00\)03542-x](https://doi.org/10.1016/s0140-6736(00)03542-x).
 - [10] Hategeka C, Shoveller J, Tuyisenge L, Kenyon C, Cechetto DF, Lynd LD. Pediatric emergency care capacity in a low-resource setting: an assessment of district hospitals in Rwanda. *PLoS One* 2017;12(3):e0173233 <https://doi.org/10.1371/journal.pone.0173233>.
 - [11] Cheema B, Westwood A, editors. Standards for paediatric emergency care: expert consensus report for emergency centres in the Western cape. 2015 http://www.emct.info/uploads/1/4/1/7/14175478/paeds_emergency_standards_report_2015_full.pdf (accessed on 05 January 2019).
 - [12] Middleton KR, Burt CW. Availability of pediatric services and equipment in emergency departments: United States, 2002-03. *Adv Data* 2006(367):1–16.
 - [13] Whittaker S, Shaw C, Spieker N, Linegar A. Quality standards for healthcare establishments in South Africa. 2015. https://www.researchgate.net/publication/267424557_Quality_Standards_for_Healthcare_Establishments_in_South_Africa. (accessed 18 March 2019).
 - [14] National Department of Health of South Africa. National core stands for health establishments in South Africa. Tshwane (ZA): National Department of Health of South Africa; 2011.
 - [15] International Federation for Emergency Medicine Paediatric Emergency Medicine Special Interest Group. 2012 international standards of care for children in emergency departments. West Melbourne: International Federation for Emergency Medicine <https://www.ifem.cc/wp-content/uploads/2016/07/International-Standards-for-Children-in-Emergency-Departments-V2.0-June-2014-1.pdf>; 2012, Accessed date: 5 January 2019.
 - [16] World Health Organisation. Standards for improving the quality of care for children and young adolescents in health facilities. Geneva: World Health Organization https://www.who.int/maternal_child_adolescent/documents/quality-standards-child-adolescent/en/; 2018, Accessed date: 5 January 2019.
 - [17] Duke T, Cheema B. Paediatric emergency and acute care in resource poor settings. *J Paediatr Child Health* 2016;52(2):221–6. <https://doi.org/10.1111/jpc.13105>.
 - [18] Cullinan K. Health services in South Africa: a basic introduction. <https://www.health-e.org.za/2006/01/29/health-services-in-south-africa-a-basic-introduction/>; 2006, Accessed date: 5 January 2019.
 - [19] Furstenburg P, Oosthuizen A, Wallis L. Purpose-orientated stocking of procedure trolleys saves time in busy emergency centres. *S Afr Med J* 2018;108(12):1024. <https://doi.org/10.7196/samj.2018.v108i12.13422>.
 - [20] Obermeyer Z, Abujaber S, Makar M, Stoll S, Kayden SR, Wallis L, et al. Emergency care in 59 low- and middle-income countries: a systematic review. *Bull World Health Organ* 2015;93(8):577–86. <https://doi.org/10.2471/BLT.14.148338>.