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A 12-month retrospective descriptive analysis of a single helicopter emergency medical service operator in four South African provinces

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Helicopter Emergency Medical Services (HEMS) is integrated into modern emergency medical services because of its suggested mortality benefit in certain patient populations, it is an expensive resource and appropriate use/feasibility in low- to middle income countries (LMIC) is highly debated. To maximise benefit, correct patient selection in HEMS is paramount. To achieve this, current practices first need to be described. The study aims to describe a population of patients utilising HEMS in South Africa, in terms of flight data, patient demographics, provisional diagnosis, as well as clinical characteristics and interventions.

Methods: A retrospective flight- and patient-chart review were conducted, extracting clinical and mission data of a single aeromedical operator in South Africa, over a 12-month period (July 2017 – June 2018) in Gauteng, Free State, Mpumalanga and North-West provinces.

Results: A total of 916 cases were included (203 primary cases, 713 interfacility transport (IFT) cases). Most patients transported were male (n=548, 59.8%) and suffered blunt trauma (n=379, 41.4%). Medical pathology (n=247, 27%) and neonatal transfers (n=184, 20.1%) follows. Flights occurred mainly in daylight hours (n=729, 79.6%) with median mission times of 1-hour 53 minutes (primary missions), and 3 hours 10 minutes (IFT missions). Median on-scene times were 26 minutes (primary missions) and 55 minutes (IFT missions). Almost half were transported with an endotracheal tube (n=428, 46.7%), with a large number receiving no respiratory support (n=414, 45.2%). No patients received fibrinolysis, defibrillation, cardioversion or cardiac pacing. Intravenous fluid therapy (n=867, 94.7%) was almost universal, with common administration of sedation (n=430, 46.9%) and analgesia (n=329, 35.9%).

Conclusion: Apart from the lack of universal call-out criteria and response to the high burden of trauma, HEMS seem to fulfil an important critical care transport role. It seems that cardiac pathologies are under-represented in this study and might have an important implication for crew training requirements.

African Relevance

- HEMS research stem from high-income countries but is used in both private and state sectors in South Africa.
- Literature is sparse on the usage and benefit of HEMS in LMICs and further research is needed.
- HEMS is suggested to fulfil a greater critical care transport role, especially in LMIC.
- Important questions with regards to patient selection, HEMS crew training and overall mortality benefit of HEMS in LMIC remain unanswered.

Introduction

Helicopter Emergency Medical Services (HEMS) play an important role in integrated modern emergency medical services because of a suggested mortality benefit in certain patient populations. These include those affected by severe trauma and those with time-sensitive pathologies such as acute myocardial infarction and stroke. [1–5]. This effect is more prominent in rural areas remote from definitive or specialised care [6,7]. In conditions like acute myocardial infarction and ischemic stroke, time to intervention might be crucial for optimal outcome, as it is recognised that patients suffering critical illness in rural settings carry a higher mortality that their urban counterparts [8–11]. Despite the benefit of HEMS, it comes at great financial cost with the question of cost-effectiveness a globally debated issue, even more relevant in a resource-constrained environment [12–16].

Recently, an increase in South African HEMS publications addressing controversies regarding mortality benefit, outcomes, staffing and interventions are noted, but remains observational in nature [7,17–22]. In one retrospective study, Stassen et. al. included a cohort of HEMS major trauma patients transported to a private trauma centre in Johannesburg,

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matched to similar ground emergency medical service (GEMS) patients (410 matched cohorts) [23]. They report no significant differences in mortality of HEMS over GEMS (OR 1.35; 95% CI 0.5-3.4; p= .503). One explanation for this result could be the two-tiered HEMS dispatch model in South Africa, where HEMS acts as a back-up instead of a primary response unit. This may prolong the pre-hospital time and introduce confounding [23]. Despite Laatz's locally developed HEMS dispatch criteria (South African Helicopter Activation Screen), it remains unvalidated and more importantly unknown if HEMS funders would be agreeable to the dispatch criteria [7].

In 2013 Chatsika found that most (n=140, 70%) flights were conducted for trauma, and that analgesia administration and advanced airway management were the most common performed interventions by an ALS paramedic-staffed, Gauteng based, private HEMS [20]. Muhlbauer conducted a similar study of private HEMS (n=537) based in Gauteng and KwaZulu-Natal in 2015 [19]. The majority were males (n=398; 74.1%), and trauma due to motor vehicle crashes (n=193; 36%) resulted in the most frequent utilisation of HEMS [19]. In order to maximise the impact of HEMS, Muhlbauer suggests a physician-based staffing model and favours a more rural distribution of HEMS [19]. There is certainly a paucity of data that may inform the development of appropriate HEMS utilisation in South Africa, as it should form the baseline to further develop flight criteria, staffing models and guide policy [19].

When looking at procedural competency, Stassen et al. report a similar intubation success rate by South African HEMS paramedics, when compared to similar settings elsewhere in the world [17]. Van Niekerk reports that although HEMS is not necessarily faster than ground EMS in South Africa, that time spent on scene is used to perform useful interventions and has a positive effect on patient stability [18].With the inherent significant burden of expenditure, risk, and debateable mortality benefit, it becomes paramount that patient selection should be a critical discussion in HEMS. In order to evaluate this, the current practices first need to be described.

The aim of this study therefore was to retrospectively describe a population of patients being transported by HEMS in South Africa, in terms of flight data, patient demographics, provisional diagnosis and clinical interventions.

Methods

Study Design

All cases meeting inclusion criteria and flown by the five helicopters over a 12-month period (July 2017 to June 2018) were reviewed retrospectively, including Neonates (Newborn-30 days), Infants (30 Days to 1 Year) Paediatrics (1 – 18 Years), and Adults (>18 Years). This period was selected as it had the most comprehensive dataset for all four provinces, providing a unique opportunity to analyse and compare different settings. Excluded cases were missions that no actual patient care occurred such as ferry flights, rescue operations, specialist outreach or cases missing critical flight or mission data.

This article has been reported according to the Strengthening the Reporting of Observational Studies in Epidemiology reporting standard for cross-sectional studies [24].

Study Setting

The aeromedical service provider (ASP) is a private, South African Civil Aviation Authority Part 138-certified aeromedical operator established in 2009. During the study period, the ASP operated five helicopter bases located in Johannesburg (Gauteng), Klerksdorp (North-West), Bloemfontein (Free State), Bethlehem (Free State) and Nelspruit (Mpumalanga). The ASP was contracted by the individual provinces to act as the designated helicopter medical service provider in all the provinces apart from Gauteng during the study period. Therefore, the largest part of the flights serviced includes state-funded patients (no medical insurance), with a minority insured (including privately funded, voluntary medical aids, Workmen's Compensation Act and Road Accident Fund). The various bases were staffed to the following specifications during the study period. Gauteng, North-West and Free-State (Bloemfontein) operated 24 hours, whereas Mpumalanga and Free-State (Bethlehem) operated during daylight hours only. Primary crew on each helicopter was ASP employed advanced life support (ALS) staff, with Gauteng incorporating doctors as primary crew. Secondary crew consisted of ASP ALS in Gauteng with provincial staff (either ALS or intermediate life support) across the remaining bases.

Authorisation for flights conducted on behalf of the provincial emergency medical service (EMS) consisted of a specific request from the various departments of health (via their control centre or dedicated representative) to a dedicated flight desk. After an aviation decision made by the relevant pilot-in-command, the decision was communicated back to the relevant EMS control centre whether the flight can be serviced or not. Requests sourced from elsewhere were assessed and referred to the ASP's own internal authorising personnel (either CEO, CMO or Lead Flight Paramedic) according to local accepted callout criteria (Supplement 1). All primary medical crew are employed by the ASP and therefore responsible for clinical care, completed relevant patient documentation using the ASP's patient report forms, and reported to the ASP's clinical governance structure.

Data collection

The ASP was approached personally by the corresponding author who agreed to participate in the study. Demographic, flight- and clinical data were extracted at the ASP's head office where patient records were stored as original handwritten patient report forms. All data were anonymised at extraction. Data collection was undertaken by two trained, independent data-capturers (familiar with clinical patient care) blinded to the outcomes of the study. Regular meetings were held to discuss and resolve any uncertainties.

This data was collated into an a priori developed abstraction from in a password protected Microsoft Excel work sheet (Microsoft Corporation, Washington D.C., USA). A random 10% sample generated using the spreadsheet was individually cross-checked by both the researcher and the data-capturer and found to have near perfect inter-rater reliability (Cohen's Kappa 0.99). [5]

Data variables

As no validated or agreed variables for this type of research exist, variables as per the national Finnish HEMS database were adapted for use, as it was felt by the researchers to be the most comprehensive and applicable [5]. All data variables and their definitions are defined in the supplementary file, S2.

Missing clinical variables were universally substituted with the word "unknown" which were weight (n=44), age (n=26), gender (n= 130 and time on scene (n=6).

Data Analysis

The nominal categorical values (sex, time of day, interventions and case type) are represented as frequencies and as proportions. The continuous numerical variables (flight times) were reported as medians and inter-quartile ranges in order to limit possible skewing of data due to outliers. The total sample was split into two groups, namely primary missions and interfacility (IFT) missions. An important note, although Free State Province is representative of two separate aeromedical bases as described previously, it is seen as one geographic operation.

Ethics

Ethical approval was obtained from the Health Research Ethics Committee (HREC) of the Faculty of Health Sciences of the University of Cape

Town (HREC 818/2020), along with further organisational approval from the ASP. A waiver of consent was approved as no direct patient contact occurred and all retrospectively extracted data were anonymised.

Results

A total of 936 cases were identified and captured, with 20 cases excluded due to missing data. Therefore 916 cases included in the final sample (primary missions n=203, 22.2% & IFT missions n=713, 77.8%), including 15 (1.6%) patients who died during transport. Figure 1 summarises the determination of the sample. Tables 1 and 3 outline the case details for primary and interfacility flights.

Males constituted most patients transported (n=548, 59.8%), with 138 (68%) in the primary group and 410 (57.5%) in the IFT group. In the primary group the most common indication was blunt trauma (n=172, 84.7%), whereas in the IFT group medical pathologies (n=226, 31.7%) predominated. Most flights occurred in daylight (n=729, 79.6%), irrespective of whether it was a primary (n=164, 80.8%) or IFT (n=565, 79.2%) flight.

IFT missions lasted longer than primary missions when observing time airborne (2hrs 16min vs 1hr 18min), mission time (3hrs 10min vs 1hr 53min) and on-scene time (55min vs 26min). Most flights were funded by provincial means (n=820, 89.5%), in both the primary (n=147, 72.4%) and IFT (n=673, 94.4%) cohorts.

Tables 2 and 4 outline the clinical interventions for primary and IFT cases. As a collective, almost half of the patients were transported with an endotracheal tube (n=428, 46.7%), while 348(37.9% only receiving supplemental oxygen via other means. Advanced cardiac interventions were absent as no patients received fibrinolysis, defibrillation, cardioversion or cardiac pacing. Nearly all patients (n=895, 97.7%) received intravenous fluid therapy of sorts (bolus or maintenance), with only two patients (0.3%) transferred with intraosseous or central access, and 19 patients (2%) without any vascular access at all. Other common interventions were patients receiving intravenous sedation (n=430, 46.9%) and analgesia (n=329, 35.9%).

The most common airway intervention in the primary group (Table 2) was supplemental oxygen (n=87, 42.9%) with most patients

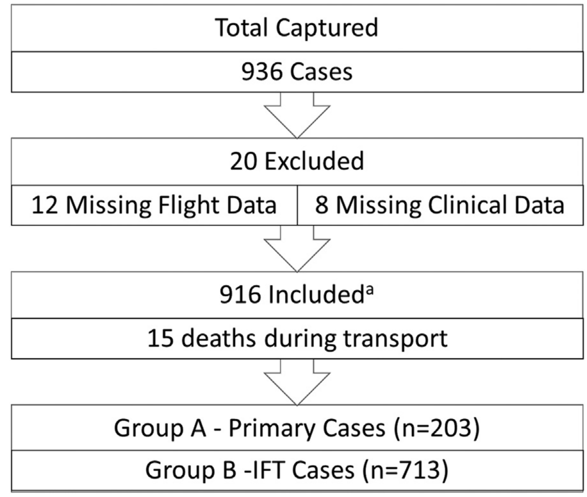

Fig. 1. A flowchart showing determination of the included records.

Table 1
Case details for primary flights.

		n= (%) 203 (100)	Gauteng 39 (19.2)	Free State 102 (50.2)	Mpumalanga 35 (17.2)	North-West 27 (13.3)
Sex	Male	138 (68)	27 (13.3)	64 (31.5)	27 (13.3)	20 (9.9)
	Female	63 (31)	11 (5.4)	37 (18.2)	8 (3.9)	7 (3.4)
	Unknown	2 (1)	1 (0.5)	1 (0.5)	-	-
Case Type		n= (%)				
	Trauma (Blunt)	172 (84.7)	34 (16.7)	84 (41.4)	30 (14.8)	24 (11.8)
	Trauma (Pen)	8 (3.9)	3 (1.5)	5 (2.5)	-	-
	Medical	21 (10.3)	2 (1.0)	11 (5.4)	5 (2.5)	3 (1.5)
	Obstetric	1 (0.5)	-	1 (0.5)	-	-
	Neonatal	1 (0.5)	-	1 (0.5)	-	-
Flight & Mission Times		Median (IQR)				
Flight Time hh:mm	*Total time airborne*	1:18 (1:00-1:57)	1:11 (0:59-1:20)	1:18 (0:56-1:51)	1:20 (1:02-1:54)	2:16 (1:44-2:32)
Mission Time hh:mm	*Call to patient delivery*	1:53 (1:24-2:33)	1:32 (1:05-2:00)	1:48 (1:24-2:29)	2:05 (1:46-2:30)	2:23 (1:48-3:29)
On-Scene Time hh:mm		0:26 (0:16-0:42)	0:14 (0:11-0:36)	0:27 (0:18-0:40)	0:30 (0:23-0:49)	0:27 (0:17-1:01)
Time of Day		n= (%)				
	Day	164 (80.8)	17 (8.4)	96 (47.3)	35 (17.2)	16 (7.9)
	Night	39 (19.2)	22 (10.8)	6 (2.9)	-	11 (5.4)
Funding						
	Provincial	147 (72.4)	8 (3.9)	91 (44.8)	33 (16.3)	15 (7.4)
	RAF	38 (18.7)	27 (13.3)	1 (0.5)	-	10 (4.9)
	Medical Aid	15 (7.4)	2 (1)	9 (4.4)	2 (1)	2 (1)
	WCA	1 (0.5)	-	1 (0.5)	-	-
	Private	2 (1)	2 (1)	-	-	-

Table 2
Number of patients with clinical interventions for primary cases.

	n= (%)	Gauteng	Free State	Mpumalanga	North-West
	202 (100)	39 (19.2)	102 (50.2)	35 (17.2)	27 (13.3)
Airway					
Supplemental O2	87 (42.9)	9 (4.4)	53 (26.1)	16 (7.9)	9 (4.4)
Advanced Airway - Endotracheal	70 (34.5)	22 (10.8)	23 (11.3)	10 (4.9)	15 (7.4)
Nil/Unknown	46 (22.6)	8 (3.9)	26 (12.8)	9 (4.4)	3 (1.5)
Breathing					
Assisted Manually	9 (4.4)	6 (2.9)	2 (1)	-	1 (0.5)
Assisted Mechanically	4 (2.0)	-	3 (1.5)	-	1 (0.5)
Controlled Manually	2 (1.0)	1 (0.5)	-	1 (0.5)	-
Controlled Mechanically	58 (28.6)	16 (7.9)	19 (9.4)	9 (4.4)	14 (6.9)
Nil / Spontaneous	130 (64.0)	16 (7.9)	78 (38.4)	25 (12.3)	11 (5.4)
Circulation					
IV Access Central/IO	Nul				
IV Access Peripheral	199 (98)	39 (19.2)	98 (48.3)	35 (17.2)	27 (13.3)
Cardioversion/Defibrillation/Pacing	Nul				
Nil/Unknown	4 (2)	-	4 (2)	-	-
Drugs					
Sedation	103 (50.7)	26 (12.8)	34 (16.7)	25 (12.3)	18 (8.9)
Analgesia	125 (61.6)	30 (14.8)	59 (29.1)	18 (8.9)	18 (8.9)
Vasoactive	32 (15.8)	3 (1.5)	6 (2.9)	3 (1.5)	20 (9.9)
Paralytic	11 (5.4)	5 (2.5)	2 (0.9)	1 (0.5)	3 (1.5)
Fibrinolytic	Nul				
Fluid	171 (84.2)	39 (19.2)	97 (47.8)	35 (11.6)	-

breathing spontaneously (n=130, 64%). In terms of drug administration, intravenous fluid (n=171, 84.2%), analgesia (n=125, 61.6%) and sedation (n=103, 50.7%) were the most common interventions in primary cases.

In the IFT group (Table 4) endotracheal tubes (n=358, 50.2%) were the most common, with controlled mechanical support as the most common breathing intervention (n=402, 56.4%). The most common drug interventions in the IFT group were intravenous fluid administration (n=696, 97.6%), sedation (n=327, 45.9%) and analgesia (n=204, 28.6%). Of note is the very low rate of paralytic administration (n=9, 1.3%) which might reflect limited practitioner scope rather than actual clinical need.

Across the provinces males still comprised the majority of patients transported in Table 1. Blunt trauma predominated across all the provinces. Flight and mission times were similar in all provinces except North-West, which had average mission times almost double that of the other regions (2hrs 23 min).

Although a third of patients were intubated (n=70, 34.5%), only a minority received a paralytic agent (n=11, 5.4%). Gauteng and North-West had intubated patients as the most common means of airway interventions (56.4% and 55.6% respectively), with Free State and Mpumalanga patients (52% and 45.7%) receiving supplemental oxygen as the most common intervention. The majority of patients did not require any respiratory assistance (n=130, 64%).

IFT cases

Across the provinces males still comprised the majority of patients transported in Table 3. Most transported patients in Gauteng were blunt trauma (n=19), Free State blunt trauma (n=104), Mpumalanga neonatal (n=78), North-West medical (n=73). Flight and mission times were similar across the regions, but average mission times in Gauteng were the highest (4hrs 7 min).

More than half of the patients were intubated (n=358, 50.2%), with only a minority received a paralytic agent (n=9, 1.3%). Gauteng, Free-State and North-West had intubated patients as the most common means of airway interventions (66.7%, 54.4%, and 61.3% respectively), with Mpumalanga patients (60.2%) receiving supplemental oxygen as the most common intervention. The majority of patients were mechanically ventilated (n=402, 56.4%).

Discussion

This study aimed to describe patients being transported by HEMS in four South African provinces. In this study, we retrospectively describe flight data, patient demographics, provisional diagnosis and clinical interventions. This is one of the largest South African HEMS cohorts to date, describing 203 primary (39 Gauteng, 102 Free State, 35 Mpumalanga, 27 North-West) and 713 IFT cases (36 Gauteng, 305 Free State, 181 Mpumalanga, 191 North West). This following a study of 1 287 patients over a 5-year period in 2013 [21]. HEMS was used for 379 blunt trauma, 54 penetrating trauma, 247 medical, 51 obstetric and 185 neonatal cases.

Trauma in LMIC represents approximately 90% of the global burden [25]. Our results here indicate that 88.7% of the primary HEMS missions were due to trauma in keeping with Chatsika's (n=199) study rate of 93% [20]. This in contrast to 2021 findings where only 23.9% of Danish HEMS dispatches were for trauma cases. This accurately reflects the high burden of trauma in LMIC and South Africa [26]. Like Muhlbauer's 2016 study where the majority of patients were males (n=398; 74.1%), male

Table 3
Case details for interfacility transfer flights.

		n= (%) 713 (100)	Gauteng 36 (5)	Free State 305 (42.8)	Mpumalanga 181 (25.4)	North-West 191 (26.8)
Sex	Male	410 (57.5)	22 (3.1)	169 (23.7)	114 (16.0)	105 (14.7)
	Female	292 (41.0)	14 (2.0)	131 (18.4)	66 (9.2)	81 (11.4)
	Unknown	11 (1.5)	-	5 (0.7)	1 (0.1)	5 (0.7)
Case Type		n= (%)				
	Trauma (Blunt)	207 (29.0)	19 (2.7)	104 (14.6)	34 (4.8)	50 (7.0)
	Trauma (Pen)	46 (6.5)	2 (0.3)	21 (2.9)	10 (1.4)	13 (1.8)
	Medical	226 (31.7)	3 (0.4)	92 (12.9)	58 (8.1)	73 (10.2)
	Obstetric	50 (7.0)	1 (0.1)	40 (5.6)	1 (0.1)	8 (1.1)
	Neonatal	184 (25.8)	11 (1.5)	48 (6.7)	78 (10.9)	47 (6.6)
Flight & Mission Times		Median (IQR)				
Flight Time hh:mm	*Total time airborne*	2:16 (1:29-2:47)	2:24 (1:36-3:20)	2:00 (1:12-2:00)	2:09 (1:16-3:11)	2:28 (2:06-2:53)
Mission Time hh:mm	*Call to delivery*	3:10 (2:27-3:53)	4:07 (2:50-5:05)	2:48 (2:11-3:32)	2:53 (2:26-3:32)	3:40 (3:09-4:23)
On-Scene Time hh:mm		0:55 (0:41-1:16)	1:01 (0:51-1:30)	0:50 (0:36-1:10)	0:52 (0:40-1:08)	1:06 (0:50-1:30)
Time of Day	Day	565 (79.2)	20 (2.8)	261 (36.6)	181 (25.4)	103 (14.4)
	Night	148 (20.8)	16 (2.2)	44 (6.2)	-	88 (12.3)
Funding						
	Provincial	673 (94.4)	14 (2)	297 (41.6)	179 (25.1)	183 (25.7)
	RAF	21 (2.9)	18 (2.5)	-	-	3 (0.4)
	Medical Aid	17 (2.4)	4 (0.6)	7 (1)	2 (0.3)	4 (0.6)
	WCA	1 (0.1)	-	1 (0.1)	-	-
	Private	1 (0.1)	-	-	-	1 (0.1)

patients (n=548, 59.8%) also comprised the majority here. This is in keeping with a WHO Bulletin published in 2015 that showed that for every female death related to trauma, 4.2 male deaths are recorded in South Africa [27].

For EMS, response times are a common performance measure [28]. In this study the primary group had a median flight time of 1hr 18 min, with a longer median flight time of 2 hour 16 minutes in the IFT group. In Norway, a median flight time of 19 minutes from base to scene was observed which resonates the Norwegian national benchmark of reaching 90% of the population within 45 minutes [29]. Van Niekerk found a mean flight time of 28.3 minutes in a 2013 South African HEMS study (n=204) [18]. However median flight and mission times in this study although commonly seen as part of the "response times" are argued here not to be a benchmark of performance, but rather a reflection of the centralisation and general paucity of HEMS bases in South Africa. It is postulated that in the absence of critical care transport ground resources, it is expected that HEMS fulfils this role. North-West is smaller than the Free-State, but however was only serviced by one helicopter and thought to be the reason why flight times were longer than in other provinces.

In evaluating on-scene times in this study, Gauteng had the shortest median on-scene time (14 min), followed by Free State and North-West (27 min) and Mpumalanga (30 min). Shorter on-scene times have previously however been associated with better outcomes in trauma patients with a mean scene time of 42 minutes in a US study (n=288) [30] and a 10-minute median on scene time in Norway (n= 9 757) [31]. Van Hoving found a mean on-scene time of 31.7 minutes in a Western Cape aeromedical study (primary missions) (n=344) [22], whilst Van Niekerk finding a similar mean on-scene time of 34.1 minutes [18]. Although not the aim of the study, Gauteng's shorter on-scene times are thought to be due to operational differences. Gauteng is South Africa's most populous province and therefore has the greatest number of advanced life support (ALS) paramedics [32]. Van Niekerk previously recognised that on-scene time is linked to the number of clinical interventions performed which might have meant that less interventions needed to be performed by HEMS crew before transport in Gauteng [18]. Gauteng also the only base consistently crewed with two ALS paramedics, is argued to have more efficient decision-making and quicker clinical interventions when performed due to the scope of practice of two ALS on board, but remains unstudied and unexplored. A small South African simulation study showed that it takes an average of 15 minutes to perform a modified, pre-hospital rapid sequence intubation by a single operator, with no data representing differences in practitioner level or comparing one vs two crew [33]. An unknown factor is how the practice of loading patients whilst the rotors are turning ("hot-load") might have impacted on-scene times as this was not studied here. Only 19.2% primary missions occurred during night-time. This brings about important questions regarding cost, need and safety. Even in Europe night-time capability is not present in many European countries, with most having only limited night-time capability [34]. Whereas in the USA, almost half of US HEMS accidents occur at night-time indicating a higher risk [35].

The interfacility group had a lower rate of trauma (n=253, 35.5%) and higher rate of medical pathology (n=226, 31.7%). Whereas in a Swiss HEMS IFT cohort, a low rate of trauma pathology (n=152, 15.5%) was found [36]. Neonatal cases made up a significant portion of the IFT case load in Mpumalanga (n=78, 43.1%) and North-West (n=47, 24.6%), much higher than 11% (n=8) found by Chatsika [20]. In Central Norway, 252 neonates were transported over a 14-year period suggesting that it is a much more infrequent occurrence (18 vs 127 neonates/year) [37]. The Canadian Paediatric Society outlines the ex-

Table 4
Number of patients with clinical interventions for interfacility transfer cases.

	n= (%)	Gauteng	Free State	Mpumalanga	North-West
	713 (100)	36 (5)	305 (42.8)	181 (25.4)	191 (26.8)
Airway					
Supplemental O2	261 (36.6)	7 (1)	96 (13.5)	109 (15.3)	49 (6.9)
Advanced Airway Supraglottic	6 (0.8)	-	3 (0.4)	1 (0.1)	2 (0.3)
Advanced Airway Endotracheal	358 (50.2)	24 (3.4)	166 (23.3)	51 (7.2)	117 (16.4)
Nil/Unknown	88 (12.3)	5 (0.7)	40 (5.6)	20 (2.8)	23 (3.2)
Breathing					
Assisted Manually	14 (2)	3 (0.4)	4 (0.6)	4 (0.6)	3 (0.4)
Assisted Mechanically	9 (1.3)	-	1 (0.1)	1 (0.1)	7 (1)
Controlled Manually	4 (0.6)	-	2 (0.3)	1 (0.1)	1 (0.1)
Controlled Mechanically	402 (56.4)	21 (2.9)	163 (22.9)	109 (15.3)	109 (15.3)
Nil/Spontaneous	284 (39.8)	12 (1.7)	135 (18.9)	66 (9.3)	71 (10)
Circulation					
IV Access Central/IO	2 (0.3)	-	-	1 (0.1)	1 (0.1)
IV Access Peripheral	696 (97.6)	36 (5)	300 (42.1)	174 (24.4)	186 (26.1)
Cardioversion/Defibrillation/Pacing	Nul				
Nil/Unknown	15 (2.1)	-	5 (0.7)	6 (0.8)	4 (0.6)
Drugs					
Sedation	327 (45.9)	20 (2.8)	146 (20.5)	72 (10.1)	89 (12.5)
Analgesia	204 (28.6)	14 (2)	102 (14.3)	46 (6.5)	42 (5.9)
Vasoactive	93 (13)	6 (0.8)	52 (7.3)	8 (1.1)	27 (3.8)
Paralytic	9 (1.3)	2 (0.3)	1 (0.1)	2 (0.3)	4 (0.6)
Fibrinolytic	Nul				
Fluid	696 (97.6)	36 (5)	299 (41.9)	174 (24.4)	187 (26.2)

pected standards in neonatal transport including specialised team members, specialised equipment and vehicles and appropriate metrics to ensure quality [38]. The inherent dynamic nature of transport exposes neonates to a variety of stressors such as vibration, excessive noise and hypothermia which might negatively impact outcomes and should not be disregarded in transport decisions [38]. Currently no official guidelines, consensus- or position statement exist in South Africa to guide neonatal transport.

Although obstetric patients compromised a relatively small proportion (n=50, 7%) of the patients transported, many obstetric indications for HEMS exist [39]. This was much lower than the n=413 (32.1%) flights conducted over a five-year period in KwaZulu Natal as described by D'Andrea [21]. In contrast, a Danish study revealed that only 0.1% (n=7) of their case load consist of obstetric patients and 0.4% (n=31) of neonatal patients [40]. HEMS usage described here probably not only reflects local transport resource availability, but also relevant hospital capacity and centralisation of specialised maternal/neonatal care. Overall, this is suggesting that there is a much larger need for HEMS for reasons other than trauma in the public health sector [20].

The inclusion of physiological parameters as part of HEMS dispatch criteria is common [41]. Due to the lack of universally validated call out criteria, it could be argued that HEMS callout criteria used in this study reflected local need rather than evidence-based and international guidelines. Although this is believed to accurately reflect the actual need in South Africa and other similar LMICs. HEMS was utilised here to transport a variety of cases, not just in the primary response role for high acuity trauma that is popularised in HICs [42,43]. It is also recognised that individual provincial need might not necessarily reflect the profile of privately funded patients. Variation in authorisation between provinces is most likely subject to bias of the authorising agency and based on provincial requirement and resource availability, rather than an objective list of pre-defined criteria, but was not addressed or studied.

Although the IFT group had a higher rate of medical patients than the primary group (31.7% vs 10.3%) the absence of cardiac interventions as seen by HEMS units in HIC is notable [8]. This may however be explained South Africa's high burden of infectious disease [26]. No access to percutaneous coronary intervention for a large proportion of patients reflects the inherent healthcare system limitations [44].

In order to aid quality and clinical overview of HEMS operations despite geography and operational differences, as well as aiding future research, the following is recommended. Western European countries like Germany, Denmark and Finland (following a consensus document originally published in 2011 and updated in 2020), have shown that large, public aeromedical registries although mainly intended as a clinical quality tool, also enable these countries to rapidly perform research with relative ease[40,45,46]. It is unknown which variables however are appropriate for LMIC and remain unexplored. However, establishing such a registry might assist with future decision-making and bolster the evidence base for HEMS in South Africa.

Although this study is limited in external validity because it's limited to a single service, it is one of the largest and most representative South African HEMS studies to date. Flight and patient records were taken *prima facie* with no external means to confirm the clinical data. From a patient-centred approach, adverse events during transport and mortality outcomes were not assessed. Being a retrospective review, the study will be inherently prone to recall bias or misclassification bias.

Conclusion

The current study describes HEMS patients across four different provinces in South Africa and is not limited to either one province, one population group or one funder e.g. private funding as previous studies. Although it is impossible to extrapolate the data to the rest of South Africa, this sample represents one of the largest cohorts in LMICs to date, therefore a better understanding is gained of how HEMS is utilised on a daily basis.

In this research, the high burden of trauma in South Africa is reflected in the primary missions. However, the predominant use of HEMS in interfacility transfers is recognised to fulfil a vital critical care transport role for non-cardiac related pathology. This might have an important implication for context-sensitive HEMS crew training, as traditionally a strong focus is placed on advanced cardiac skills in internationally recognised courses, such as American Heart Association's Advanced Cardiac Life Support.

Questions pertaining to the actual benefit of HEMS as an intervention still exist in high income countries and we are unlikely to answer this question in South Africa and other LMICs soon, unless there is a coordinated effort for gathering data and assimilating evidence. Despite this and the lack of universal call-out criteria in LMICs, it does not seem to be a barrier in South Africa, as HEMS continue to play an important role in organised EMS. This is due to the recognition that HEMS fulfil an unmet need to treat and transport critically ill patients not only from scene, but also between healthcare facilities.

The complex dynamics and inherent differences of the provinces such as infrastructure, financial and human resources, local epidemiology and geographic differences might have a significant impact on case-mix and dispatching patterns. Owing to this, the responsibility of ethical usage, cost-effectiveness and feasibility would then become highly individualised and will remain the responsibility and function of the funder (whether public or private) rather than guided by high quality science. Does this then mean that the patients transported did not have any benefit from HEMS transport? Using this data we might not be any closer to an answer, but in a low-resource setting, it might be useful to argue that any care is better than none. Important considerations and questions to factor in would be at what cost and what alternatives exist? Patterns in HEMS dispatch might be used as a barometer of important healthcare system issues that can be addressed on a bigger scale and not just an individualistic patient level.

The lack of a universal aeromedical dataset or registry remains a significant barrier to research in HEMS operations in LMICs, especially South Africa. A universal South African HEMS Registry would act as a valuable tool in stimulating further research regarding the role of HEMS in South Africa, possibly setting the example for other LMICs and might be the first practical step.

Although several study design limitations exist, descriptive studies like this one are important to provide a snapshot and overview of current practices. This study hopes to sensitise various healthcare role players and create awareness of current HEMS South African operations. Ultimately to justify or refute its application, to stimulate further research with refined and directed research questioning, and appropriately allocate this expensive resource fairly using science.

Future studies might focus on variables that need to be collected or might form part of such a registry, whereas studies comparing crew composition, on-scene times and outcomes might be of value to answer the question of optimal staffing. Important questions with regards to context-sensitive training and to what effect ground based critical care resources can fill the need also remain unanswered.

Dissemination of results

The findings of this study were communicated back via informal presentation to the aeromedical provider who participated in this study.

Author's contributions

Authors contributed as follow 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. NV contributed 75%; WS 25%; and CW contributed 5%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

NV would like to declare he consulted clinically and operationally for the aeromedical service provider during the study period. No further conflict of interest declared. WS is an editor of the African Journal for Emergency Medicine. WS did not participate in this manuscript's editorial process. The journal applies a double blinded process for all manuscript peer review. The authors declared no further conflicts of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.afjem.2023.05.007.

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