Original Article

An Analysis of Patients' Characteristics Transported by Helicopter Emergency Medical Services (HEMS) in Sabah

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Abstract

Introduction: Helicopter emergency medical services (HEMSs) in Sabah, Malaysia, are vital for overcoming healthcare accessibility challenges due to the region's diverse terrain and limited road infrastructure. These services enable the rapid transport of critically ill patients, ensuring timely access to specialized care. This study analysed patient characteristics, medical emergencies, and geographic factors influencing HEMS utilization. **Methodology:** This retrospective descriptive study reviewed 162 HEMS missions conducted in 2022. Data were obtained from the Sabah State Health Department and Hospital Queen Elizabeth, with a focus on patient demographics, medical conditions, and geographic factors. The inclusion criteria included all medical and trauma cases requiring air transport, while exclusions were applied to missions cancelled due to weather or operational constraints. **Results:** Cardiovascular emergencies were the most common reason for HEMS activation (34%), followed by oncological and gastrointestinal conditions (14% each). Hypertension (20.4%), cardiovascular diseases (13%), and diabetes (9.9%) were the most common underlying medical conditions. The median patient age was 52 years, with a male predominance (66.7%). Most missions (87%) were interhospital transfers. Geographic challenges such as mountainous terrain, poor road conditions, and extended ground ambulance travel times (median: 8 hours) significantly influenced HEMS utilization. **Conclusion:** Middle-aged males with preexisting hypertension and cardiovascular diseases were more often reported with acute medical emergencies requiring HEMS. Geographic challenges are strongly associated with HEMS activation. Streamlining coordination between smaller healthcare facilities and tertiary centres may help minimize delays and ensure faster patient stabilization.

Keywords: *helicopter emergency medical services, emergency medical services, air ambulances, interhospital transfer, geographic challenges, rural and remote healthcare*

INTRODUCTION

The history of aviation in Malaysia began with the establishment of the Taiping Aerodrome in 1929, paving the way for developments in aviation and medical evacuation (MEDEVAC) services.[1] Key milestones include the Tentera Udara Diraja Malaysia's MEDEVAC mission in 1958, the Flying Doctor Service in 1973, and the recent launch of the Emergency Medical Air Rescue Services (EMARS) by the Fire and Rescue Department (BOMBA) in 2023.[2]

In Sabah, MEDEVAC services are commissioned under the oversight of the Sabah State Health Department (JKNS) and operate within the broader prehospital care (PHC) and emergency medical services (EMS) framework. Actual air medical services, known as helicopter emergency medical services (HEMSs), are carried out in partnership with contracted

aviation/helicopter operators and other emergency agencies.

The HEMS plays a vital role in overcoming geographical barriers, where the landscape presents significant challenges to accessing specialized care[3]. It provides timely transport for critically ill patients.[4] This study on HEMS utilization in Sabah, Malaysia, addresses critical gaps in emergency medical response and aviation medicine. By examining the characteristics of patients requiring HEMS transport, this research aims to optimize resource allocation, improve emergency response decision-making, and ultimately enhance patient outcomes. The study also seeks to contribute to evidence-based protocols and healthcare policy while providing a foundation for future research and collaboration in this area.[3]

METHODOLOGY

This retrospective descriptive study focused on patients transported by HEMS in Sabah, Malaysia, during a 12-month period from January 2022 to December 2022. This timeframe was selected to reflect the post pandemic recovery phase, a period during which healthcare services resumed regular operations while maintaining adherence to strict standard operating procedures (SOPs).

The core data for this study were obtained from JKNS and Hospital Queen Elizabeth (HQE). HQE serves as the Medical Operation Coordinating Centre (MEOCC) for HEMS missions, and it is responsible for coordinating medical evacuations in Sabah. MEDEVAC missions are categorized as primary missions, involving activations via the MERS 999 system for new cases at incident sites requiring immediate emergency intervention, and secondary missions, involving interhospital transfers for patients needing specialized medical care unavailable at the referring facility. The study included all medical cases, both emergency and nonemergency, as well as trauma cases requiring MEDEVAC services. The exclusion criteria were cases where the HEMS was requested but not utilized due to external factors such as adverse weather, helicopter unavailability, or mission cancellation before departure.

Data for this study were collected via standardized forms to document demographic and clinical information on patients transported by the HEMS. Additionally, detailed reviews of medical records were conducted to extract data on patient demographics, diagnoses, and the severity of medical conditions. A descriptive approach was employed for the analysis, which utilized statistical software to identify trends in HEMS utilization in Sabah. Given the small and varied dataset, the study did not apply inferential statistical tests, instead focusing on providing practical insights to enhance HEMS service delivery and decision-making.

The sample size for this study was calculated via the Cochran's sample size formula, where *'Z'* represents the Z score for a 95% confidence level, *'p'* is the estimated proportion (0.5), and 'e' is the margin of error (0.05). On the basis of an estimated 1500 annual HEMS cases in Sabah, the initial sample size was calculated to be 385 cases. However, the actual sample size was 162 due to a lower-than-expected demand for HEMS in 2022, attributed to factors such as adverse weather, helicopter unavailability, increased onsite care at referral hospitals, and seasonal variations. This highlights the impact of operational challenges on emergency medical research and emphasizes the importance of accounting for real-world factors in study design.

This study received ethical approval from the Universiti Kebangsaan Malaysia (UKM) Research Ethics Committee under the ethics reference number JEP-2023-951. It has also been registered with the National Medical Research Register (NMRR) under Research ID RSCH ID-23-06518-L6J.

RESULTS

Table 1: Demographic characteristics of patients transported by HEMS (n=162)

Demographic factors	Median (IQR)	Number of patients (n)	Percentage (%)
Age in year	52 (29)		
Age group			
Paediatric (0-18)		45	27.8
Adult (19-64)		95	58.6
Elderly (65+)		22	13.6
Gender			
Male		108	66.7
Female		53	32.7
Not Available		1	0.6
Medical History			
Hypertension		33	20.4
Diabetes		16	9.9
Cardiovascular		21	13.0
Respiratory		5	3.1
Others (specify)			
Dyslipidaemia		12	7.4
Congenital anomaly		6	3.7
Eczema		1	0.6
Malignancy		9	5.6

Hepatobiliary disease	6	3.7
Anaemia	2	1.2
Peptic ulcer disease	2	1.2
Gout	3	1.9
Chronic Kidney Disease	8	4.9
No known medical illness	18	11.1
Not available	63	38.9

Table 1 shows that among the 162 patients transported by the HEMS, the median age was 52 years. The majority were adults aged 19--64 years (58.6%), followed by paediatric patients (0--18 years) at 27.8% and elderly patients (65+) at 13.6%. Males constituted 66.7% of the transported patients, whereas females made up 32.7%. In terms of medical history, the most common conditions were hypertension (20.4%), cardiovascular diseases (13%), and diabetes (9.9%), with 11.1% of patients having no known medical illnesses.

Table 2: Identification of primary medical emergencies and conditions leading to HEMS activation

Medical Emergencies	Frequency (n)	Percentage (%)
Type of case		
Primary mission	21	13
Secondary mission	141	87
Type of emergencies		
Traumatic injuries	7	4.3
Cardiovascular Emergencies	55	34
Respiratory Distress	13	8
Neurological Events	21	13
Oncology	22	14
Gastrointestinal emergency	22	14
Others (Specify)		
Toxicology	1	0.6
Renal emergency	2	1.2
Musculoskeletal emergency	2	1.2
Vascular emergency	7	4.3
Fever	2	1.2
Endocrine emergency	2	1.2
Body weakness	1	0.6
Headache and abdominal pain	1	0.6
Neonatal sepsis	1	0.6
Dehydration	1	0.6
Haematological emergency	1	0.6
Gynaecological emergency	1	0.6

Table 2 indicates that HEMS activations are predominantly for interhospital transfers, which account for 87% of cases, highlighting the service's primary role in transporting patients between healthcare facilities. The primary mission comprises the remaining 13%. Among the types of emergencies, cardiovascular issues are the most prevalent, accounting for 34% of activations, followed by oncological and gastrointestinal emergencies (14%), followed by neurological events (13%). Respiratory distress represents 8%, and traumatic injuries account for 4.3%, whereas other conditions, such as toxicology, renal, and musculoskeletal issues, contribute smaller percentages to the overall activations.

Table 3: Impact of geographic factors on HEMS utilization

Geographic factor	Frequency n (%)	Median (IQR)
Terrain and accessibility		
Hilly/mountainous	146 (90)	
Curvy road	52 (32)	
Narrow road	104 (64)	
Poor condition road	107 (66)	
Winding road	105 (65)	
Forested	37 (23)	
Across the sea	2 (1)	
Remote/rural	18 (11)	
Distance to referral hospital (km)		420 (170)
ETA for ground ambulances (hour)		8 (1)
Impact of weather conditions – flooding, landslides and poor visibility	162 (100)	
Availability of helipads/landing area	162 (100)	

Table 3 illustrates the geographical challenges related to HEMS in Sabah. Terrain-related factors were prominent, with hilly or mountainous areas affecting 90% of the cases, narrow roads affecting 64%, poor road conditions affecting 66%, and winding roads affecting 65%. Remote and rural locations accounted for 11%, whereas crossing the sea was necessary in 1% of the cases. The median distance to the referral hospital was 420 km (IQR: 170 km), with an estimated ground ambulance travel time of 8 hours (IQR: 1 hour). Weather-related conditions, such as flooding, landslides, and poor visibility, affected all the cases (100%), emphasizing the reliance on HEMS for timely patient transport. Helipads or landing areas were available in all the cases (100%), ensuring operational feasibility despite these challenges.

Table 4: Severity levels and levels of care required during HEMS transportation

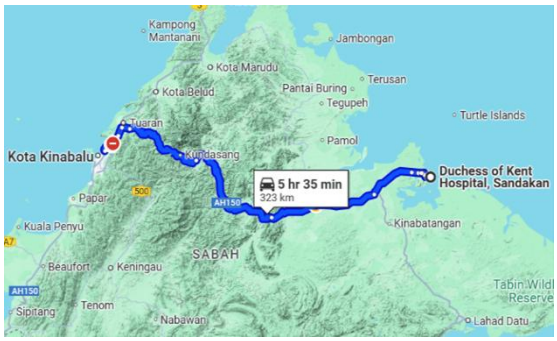
Severity level based on shock Index	Number of patients (n)	Percentage (%)
Critical (SI >1.0)	17	10.5
Serious (0.7<SI<1.0)	55	34.0
Stable (SI <0.7)	44	27.2
Not available	46	28.4
Level of care needed (Intervention done)		

Advance life support (ALS)	51	31.5
Basic Life Support (BLS)	73	45.1
Intensive care unit care (ICU)	38	23.5

The analysis revealed that during HEMS transportation, 10.5% of patients were critical, 34.0% were serious, and 27.2% were stable, with 28.4% lacking severity data. In terms of care, 31.5% required advanced life support, 45.1% needed basic life support, and 23.5% required intensive care unit (ICU) care, reflecting diverse medical needs during transport.

Geographic challenges and HEMS utilization patterns in Sabah (source: Google Maps)

The map illustrates two routes from Hospital Tawau to HQE, a shorter 447 km route taking approximately 7 hours and a longer 547 km route taking approximately 9 hours, traversing challenging terrains and mountainous regions.



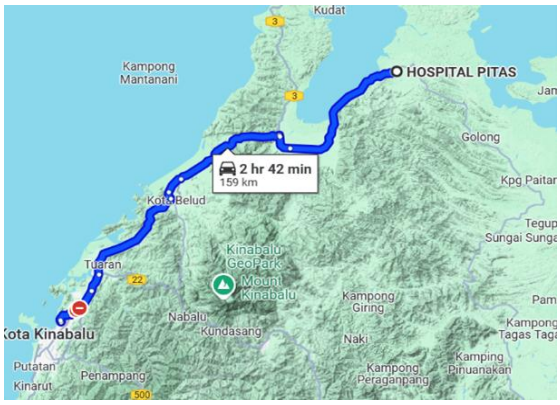
The distance between HDOK in Sandakan and HQE is approximately 323 km, with a travel time of approximately 5 hours, traversing Sabah's rugged and challenging terrains.

The journey from Hospital Lahad Datu to HQE, a shorter route of approximately 406 km, approximately 7 hours, and a longer route spanning 502 km, taking approximately 8 hours, both navigating Sabah's challenging terrains.

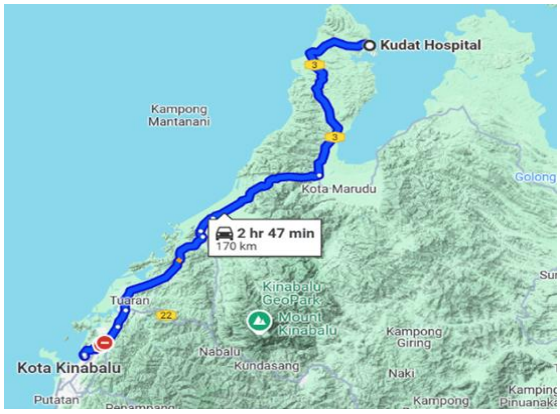
From Hospital Tawau to Hospital Likas, the shorter route approximately 457 km taking approximately 7 hours, while the longer route approximately 536 km and takes approximately 9 hours. Both routes traverse challenging terrains.

From HDOK in Sandakan and Hospital Likas is approximately 333 km, with a travel time of approximately 5 hours, traversing Sabah's rugged and challenging terrains.

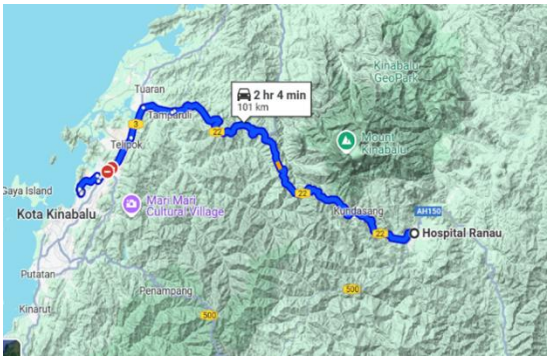
From Hospital Lahad Datu to Hospital Likas: a shorter route of approximately 395 km with a travel time of approximately 7 hours, and a longer route spanning 512 km, taking approximately 9 hours.



From Hospital Pitas to Hospital Likas is approximately 159 km, with a travel time of approximately 2 hours.

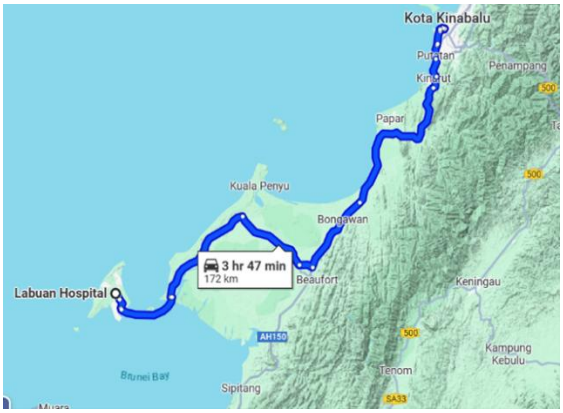


From Hospital Kudat to Hospital Queen Elizabeth is approximately 170 km, with a travel time of approximately 3 hours.



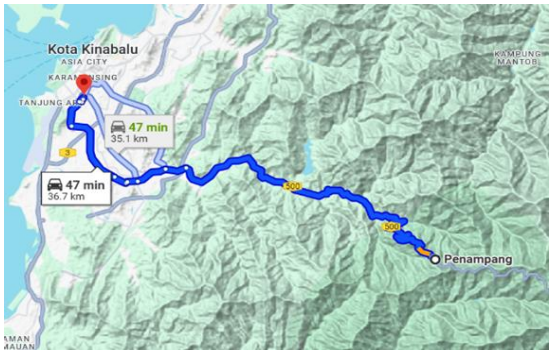
From Hospital Ranau to Hospital Likas is approximately 101 km, with a travel time of approximately 2 hours with difficult terrains.

From Hospital Beluran to Hospital Queen Elizabeth is approximately 285 km, with a travel time of approximately 5 hours.



The journey from Hospital Labuan to HQE covers approximately 172 km, with an estimated travel time of approximately 4 hours, including a sea crossing by ship.

From Hospital Keningau to Hospital Likas is approximately 120 km, with a travel time of approximately 2 hours with difficult terrains



The primary mission from Penampang to HQE covers approximately 35 km, with a travel time of approximately 1 hour. The challenging terrain makes it impossible for a ground ambulance to reach the destination.

The primary mission from Kampung Sonsongon Magandai to Hospital Kota Marudu covers approximately 180 km, with a travel time of approximately 4 hours. The challenging terrain makes it impossible for a ground ambulance to reach the destination.

The primary mission from Kampung Buayan to HQE covers approximately 36 km, with a travel time of approximately 1 hour. Due to the challenging terrain, the use of HEMS is needed.

The primary mission from Kampung Sonsongon Magandai to HQE covers approximately 300 km, with a travel time of approximately 6 hours.

DISCUSSION

This study provides a comprehensive overview of the characteristics of patients transported by HEMS in Sabah, Malaysia. The findings revealed that HEMS plays a crucial role in managing severe medical conditions, with a significant emphasis on interhospital transfers and challenges posed by geographic factors. Our analysis revealed that cardiovascular emergencies were the most prevalent among transported patients, which aligns with the findings of global studies that highlight the critical role of HEMS in handling severe cardiovascular conditions.[9,10] Of the 55 cardiovascular emergencies, 80% involved acute coronary syndrome, particularly acute myocardial infarction, which required urgent percutaneous coronary interventions. The remaining 20% of cases were attributed to heart failure, congenital heart disease, or aortic dissection. Additionally, the predominance of interhospital transfers emphasizes HEMS's essential function in facilitating patient movement between healthcare facilities, which is consistent with the literature on the

integration of air medical services into regional emergency systems.[12]

The demographic analysis of patients transported by HEMS in Sabah reveals significant insights into the patient population utilizing these services. The majority of patients were middle-aged adults, with a median age of 52 years, and a substantial proportion were male, accounting for 66.7% of the cases. This male predominance aligns with the literature, which indicates that men are more frequently involved in traumatic incidents and severe medical emergencies requiring HEMS intervention.[11] The high percentage of adults aged 19--64 years reflects the active and working age group, who are more likely to engage in activities that increase their risk of trauma or other critical health events.

Furthermore, the data revealed that hypertension, cardiovascular diseases, and diabetes were the most common preexisting medical conditions among the transported patients. This finding is consistent with global trends, where chronic conditions such as hypertension and cardiovascular diseases are prevalent among middle-aged and elderly populations, leading to an increased risk of acute medical emergencies that necessitate rapid transport to specialized care facilities.[5,6]

In terms of improving patient care, these demographic findings underscore the need for targeted health interventions that address the specific needs of the most frequently transported populations. For example, public health initiatives aimed at managing chronic diseases such as hypertension and diabetes could reduce the incidence of acute episodes requiring HEMS. Additionally, understanding the demographic profile of HEMS patients can help in resource allocation, ensuring that HEMS services are optimally equipped to handle the most common types of emergencies encountered within this population. By aligning these services with the demographic and medical profiles of the patients they serve, HEMS can continue to provide effective and life-saving interventions in critical situations.[7,8]

This study also demonstrates that geographic factors play an important role in HEMS activation and utilization, with challenging terrains such as hilly, mountainous, and poorly maintained roads driving the need for air medical services. This aligns with existing research, highlighting the role of HEMSs in overcoming barriers posed by difficult terrain and long distances to healthcare facilities.[15] These findings emphasize the necessity of strategically deploying HEMS resources to address geographic challenges and ensure that patients in isolated areas receive rapid medical care.

To improve patient care, several implications arise from our study. First, addressing geographic barriers through infrastructure improvements, such as enhancing landing zones and developing advanced navigation systems, can mitigate the impact of challenging terrains on response times.[16] Implementing region-specific guidelines for HEMS activation on the basis of geographic and medical criteria could optimize resource allocation and improve patient outcomes.[13] Second, given the high rate of interhospital transfers, optimizing HEMS deployment for these cases is crucial. The development of protocols to streamline coordination between HEMSs, ground EMSs, and healthcare facilities can increase efficiency and reduce delays in patient transfers.[14]

Moreover, the diverse medical needs and severity levels observed highlight the necessity for specialized training and equipment. Ensuring that HEMS crews are equipped to handle a range of conditions, from advanced life support to intensive care, may improve the quality of care during transport. Tailoring training programs to address specific emergencies, such as cardiovascular and neurological conditions, can further enhance patient management. Finally, improving coordination and integration within regional emergency systems is vital for optimizing overall response efforts. Strengthening communication and implementing quality assurance measures can ensure that HEMS services are aligned with best practices and evolving needs.

The findings also revealed that a significant proportion of transported patients required advanced medical interventions, underscoring the critical nature of HEMS in addressing severe cases. The diversity in severity levels highlights the importance of equipping HEMS teams to handle a broad spectrum of medical needs, from basic stabilization to advanced life support.[4]

This study however has several limitations that should be considered when interpreting the findings. First, the sample size was smaller than the calculated requirement (162 participants compared with an estimated 385), which may have reduced the statistical power and precision of the results. Secondly, the descriptive study design limits the ability to draw causal inferences between observed variables. Third, the predominance of interhospital transfers introduces potential selection bias, as the sample may overrepresent patients with more severe conditions or specific referral pathways. Additionally, the study could not differentiate whether observed patterns reflected true disease prevalence or variations in healthcare access and referral practices. The

restriction of data collection to a single geographic region and a single year further limits the generalizability of the findings to other settings or time periods. Missing data, particularly regarding clinical severity (28.4%), may have affected the completeness and robustness of the analyses. Finally, the absence of a comparison group - such as patients transported by ground ambulance - precludes direct evaluation of differences in outcomes or utilization between transport modalities.

In summary, this study thoroughly examines the characteristics of patients transported by HEMSs in Sabah, Malaysia, with a particular focus on how demographic and geographic factors influence HEMS utilization. The findings highlight that cardiovascular emergencies and interhospital transfers are the primary reasons for HEMS activation, reflecting the critical role of services in addressing severe medical conditions and overcoming challenging terrains. The study's insights into patient demographics, particularly the predominance of middle-aged males with preexisting conditions such as hypertension, underscore the need for targeted public health interventions and optimized resource allocation. By aligning HEMS services with the specific needs of the patient population and addressing geographic barriers, the effectiveness of HEMS operations can be significantly enhanced, ultimately improving patient care and outcomes in Sabah.

CONCLUSION

The demographic profile of patients shows that middle-aged males with preexisting hypertension and cardiovascular diseases were the most frequently transported, reflecting either higher emergency incidence in this group, differential access to HEMS, or referral patterns from peripheral facilities. These insights are invaluable for optimizing resource allocation, improving emergency response, and tailoring public health interventions to reduce the incidence of emergencies requiring HEMS transport.

Geographical factors including mountainous terrain and long distances to medical facilities were commonly documented in HEMS activations, though their independent effect on activation decisions requires further study. The challenges of incomplete data and reliance on retrospective records limit the ability to fully understand the impact of HEMS on patient outcomes. These findings reinforce the need for improved documentation practices and standardized protocols to ensure consistency and reliability in prehospital care.

FUTURE RECOMMENDATIONS

Future recommendations for enhancing HEMS in Sabah focus on improving coordination, training, and tailored interventions. Given that most HEMS activations were for interhospital transfers, streamlining coordination between smaller healthcare facilities and tertiary centres may help to minimize delays and ensure faster patient stabilization. Specialized training for HEMS crews should prioritize high-prevalence conditions, particularly cardiovascular emergencies, which are the most common reason for activation. Additionally, developing region-specific HEMS protocols tailored to Sabah's unique geographic and demographic challenges can optimize service efficiency, particularly in areas with limited road access or challenging terrain. Finally, addressing public health needs by enhancing early management of prevalent chronic conditions, such as hypertension and diabetes, may help reduce the demand for emergency HEMS activation and improve overall population health outcomes.

Beyond operational and clinical improvements, future efforts should prioritize data integration and outcome monitoring. Establishing a centralized HEMS registry at the state or national level would allow systematic collection of standardized data on patient characteristics, interventions, transport times, and clinical outcomes. Such a registry would facilitate benchmarking, quality improvement initiatives, and longitudinal evaluation of HEMS effectiveness, enabling evidence-based policy decisions and continuous service optimization.

Technology-enhanced decision support systems should also be explored to improve HEMS activation accuracy. Implementing digital triage tools or real-time telemedicine support between referring hospitals and HEMS medical teams may enhance patient selection, reduce unnecessary activations, and ensure that air transport is reserved for cases with the highest clinical benefit. Teleconsultation with specialists during transport could further improve prehospital management, particularly for cardiovascular and neurological emergencies.

Future strategies should include cost-effectiveness and sustainability analyses of HEMS operations in Sabah. Given the high operational costs associated with air medical services, evaluating the economic impact relative to patient outcomes is crucial. These analyses can inform funding models, guide strategic expansion, and support justification for government or public–private investment in HEMS infrastructure.

Another important recommendation is to strengthen community-level emergency preparedness in remote and rural areas. Training healthcare workers in peripheral facilities in advanced stabilization techniques, early recognition of time-sensitive conditions, and standardized referral pathways can improve patient outcomes even before HEMS arrival. Community education initiatives focusing on early symptom recognition for acute coronary syndrome and stroke may also reduce delays in seeking care.

Finally, future research should prioritize prospective, multicenter studies that assess not only transport characteristics but also short- and long-term patient outcomes, including survival rates, functional status, and hospital length of stay. Incorporating patient-centered outcomes will provide a more comprehensive evaluation of HEMS role and help refine activation criteria and clinical protocols tailored to Sabah's unique healthcare landscape.

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AUTHORS' CONTRIBUTIONS

DHMZ - conceptualisation, study design, data gathering and curation, analysis, drafting; DMS, MSCO and AKM - study design and analysis; AA and MHMH - data gathering and curation; MMMH - conceptualisation, study design, analysis and drafting.

DECLARATION OF CONFLICTING INTERESTS

We declare that there are no conflicts of interest related to the study, authorship, and/or publication of this article.

ETHICAL APPROVAL

This study had received ethical approval from Research Ethics Committee of Universiti Kebangsaan Malaysia (RECUKM code: UKM PPI/111/8/JEP-2023-951).

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