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A scoping review of the utilization of mobile stroke units in low and lower middle-income countries: current evidence, implications and future direction

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Abstract

Background Low and Lower-Middle-Income Countries (LMICs) have the highest stroke incidence, prevalence, and case fatality rates globally. Current evidence suggests Mobile Stroke Units (MSUs) outperform traditional Emergency Medicine Services (EMS) in time metrics, cost-effectiveness, and long-term outcomes. MSUs could potentially improve stroke outcomes in resource-constrained settings by addressing critical challenges related to prehospital delays, health-seeking behavior, and access to expertise.

Purpose This scoping review aims to assess the existing literature and knowledge gaps on the utilization of mobile stroke units in LMICS, their impact on stroke outcomes, and cost-effectiveness.

Materials and methods We conducted a detailed search of PubMed, Scopus, CINAHL, African Index Medicus, and Publicly Available Content Database (ProQuest) inception to April 15, 2024. Google Scholar and TRIP Pro were also searched to identify Grey literature. African Journals Online, references were also hand-searched.

Results Seven hundred and eighty-five studies were screened; only two met the eligibility criteria. Cherian et al. report the first use of a mobile stroke unit (MSU) in India, detailing its operations during the first year and the challenges encountered. According to the authors, fewer patients utilize MSUs in India compared to other parts of the world due to challenges such as a lack of awareness and affordability. Osuegbu et al. also report the absence of both fixed and mobile stroke units in Rivers State, Nigeria.

Conclusion There is currently very limited data to support the contextual suitability of MSU or implementation strategies to guide its integration into stroke care systems in LMICs. Further research is needed to examine the utilization, barriers, impact, and cost-effectiveness of Mobile Stroke Units (MSUs) in low- and middle-income countries. This could inform stakeholders and policymakers about the potential role and value of MSUs within stroke care systems in these settings.

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Keywords Mobile health units, Prehospital care, LMICs, Thrombolysis

Background

LMICs currently have the greatest age-standardized stroke incidence rates worldwide and contribute substantially to the worldwide burden of stroke [1]. Barriers such as resource constraints, poor health-seeking habits, lack of awareness, restricted access to expertise, fragmented healthcare systems, poor road infrastructure, and cultural beliefs hinder the timely and effective delivery of standard stroke care, contributing to poor outcomes [1, 2]. Strategies to overcome these obstacles are needed to bridge the treatment gaps that exist between High-Income Countries (HICs) and LMICs [3, 4].

In recent years, mobile stroke units (MSUs) have emerged as a promising innovation to expedite stroke care. The utilization of MSUs was initially instituted in Germany over a decade ago and has since garnered widespread popularity across most High and Upper-Middle-Income Countries [5, 6]. Landmark Randomized Control Trials (RCTs) have proven the benefit of MSUs in terms of time metrics, cost-effectiveness, and outcomes when compared to traditional Emergency Medicine Services (EMS) [5–8]. Mobile stroke units aid in the rapid evaluation of patients with suspected stroke for timely treatment. Because they are equipped with advanced diagnostic equipment such as a portable CT scan and point-of-care laboratory system, they allow for prompt stroke typing. They also have onboard medical experts who can rapidly assess patients in real time and initiate treatments such as intravenous thrombolysis with improved onset to needle times and better outcomes [7].

Lately, the utility of MSU has been extended to most rural areas with limited access to specialized medical facilities in HICs [9–11]. The rationale is to eliminate the pre-hospital delays, such as distance and commute time to stroke centers [12–14]. By bringing stroke expertise and diagnostic tools directly to these rural communities, MSUs aid in expedited stroke diagnosis within the crucial golden hours of stroke onset [8]. This allows rural dwellers to receive guideline-recommended reperfusion therapy such as thrombolysis and thrombectomy within the designated time window.

The evidence for the implementation of MSUs has largely originated from HICs [9]. MSU use is growing in popularity, especially with the integration of fifth-generation mobile communication technology (5G) [15]. Given the context-specific issues of low literacy level and awareness, cost constraints, limited infrastructure, and lack of robust health systems, the applicability of this innovation in underdeveloped countries remains unanswered [16]. This review aims to systematically assess the existing literature on the utilization of mobile stroke units in LMICs, their impact on stroke outcomes, and cost-effectiveness, and to further evaluate strategies employed to facilitate its adoption in these settings. By critically evaluating the current state of knowledge, we seek to identify gaps, challenges, and opportunities for optimizing the integration of MSUs in these regions.

Methods

This scoping review was conducted following the Joanna Briggs Institute's (JBI) methodology for scoping reviews [17] and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for Scoping Reviews statement [18].

Search strategy

To identify studies for inclusion in this review, a librarian (EAB) developed detailed search strategies in PubMed (U.S. National Library of Medicine, National Institutes of Health), Scopus (Elsevier), CINAHL (EBSCOhost), African Index Medicus (World Health Organization), and Publicly Available Content Database (ProQuest). The search strategies used a combination of subject headings (e.g., MeSH in PubMed) and keywords for the concepts of stroke/poststroke, mobile units, and LMICs. The PubMed search strategy was modified for the other databases, replacing MeSH terms with appropriate subject headings, when available, and maintaining similar keywords. A second librarian (TLH) peer-reviewed search strategies using a modified PRESS peer review form [19]. Google Scholar and TRIP Pro were searched to identify Grey literature. These resources were searched from inception to April 15, 2024. To identify additional articles, the authors hand-searched African Journals Online, as well as the reference lists of included articles and relevant excluded review papers. Search details are provided in Appendix 1. References were screened using Covidence [20].

Screening and study selection

References were exported into the review management software, Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia), for de-duplication and study selection. Three reviewers (PAOA, MA, SAB) independently screened titles and abstracts to determine eligibility. Conflicts during the study selection process were resolved through discussion between the reviewers. If consensus could not be reached, a third reviewer (PAOA) was consulted to make the final decision. Following the same process, all three reviewers then independently screened full-text articles with conflicts being resolved by (PAOA).

Eligibility criteria

Inclusion criteria

- Studies evaluating the utilization of mobile stroke/poststroke units.
- Low and Lower- Middle Income countries (according to the World Bank Database).
- Pediatric or adult populations.
- Study designs: primary research articles, either observational or experimental.
- Hospital-based or community-based studies.
- English or French language articles.

Exclusion criteria

- Traditional hospital-based stroke units.

Definition of Low and Lower Middle-Income Countries (LMICs) This included all countries classified as Low-Income Countries or Lower-Middle-Income Countries by the World Bank countries and lending group database. Low-income countries were defined as those with a Gross National Income (GNI) per capita of $1085 or less, while Lower-Middle-Income Countries referred to those with a GNI per capita from $1086 to $4255 [21].

Data extraction

Data was extracted from papers included in the scoping review by two independent reviewers (MA, SAB) using a customized data extraction tool form in Covidence and as per the recommended data charting method proposed by Arksey and O'Malley to extract the relevant details of the included studies [22]. Extracted Data was then forwarded for consensus by a third reviewer (PAOA). The data extracted included specific details about the participants, concept, context, study methods, and key findings relevant to the review question. A summary of the findings and their implications for the research question is provided in Table 1.

Ethics statements

Not applicable.

Results

After title and abstract screening for 785 studies, 11 studies were retrieved for further screening. Only two studies out of these met the eligibility criteria (Table 1). Figure 1. (PRISMA diagram of included studies) provides details of the number of studies identified, duplicates removed, and studies included in this review. Figure 1 also outlines the reasons for the exclusion of 774 studies from this review.

Cherian et al. report the findings of a retrospective analysis of India's first utilization of MSU after a year of operation [23]. This MSU was run by a team of

Table 1 Details of extracted studies

Covidence #	Title	Lead author	Year	Country in which the study conducted	Region	Aim of study	Study design	Study funding sources	Outcome evaluated
1004	Retrospective review and proof of concept of Asia's first mobile stroke unit experience in Kovai Medical center and hospital	Cherian et al.	2020	India	Asia	To outline the clinical care pathway involved in integrating MSU services and highlight the challenges faced in setting up an MSU in India.	Retrospective Review	No funding	Effectiveness, timeline metrics and challenges
52	Exploring the Essential Stroke Care Structures in Tertiary Healthcare Facilities in Rivers State, Nigeria.	Osuegbu et al.	2022	Nigeria	Africa	To evaluate the essential stroke care structure available in the two Tertiary Health Facilities in Rives State, Nigeria.	Cross sectional study	No funding	Purely descriptive

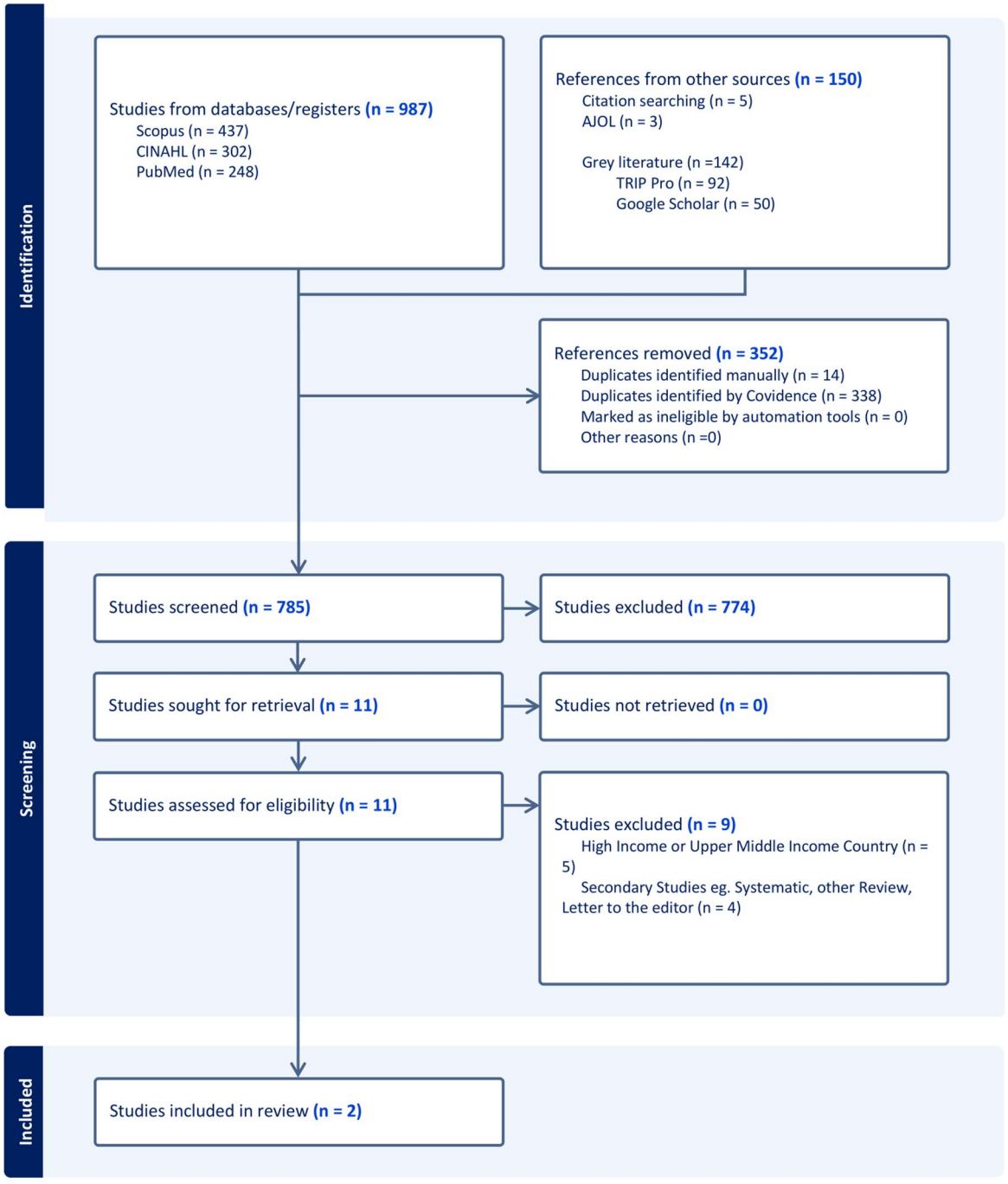

Fig. 1 PRISMA diagram of included studies. This figure illustrates the number of records identified, screened, excluded, and included in the final review

professionals consisting of drivers, trained emergency medical services staff, CT-technologist, physicians, neuroradiologists, an interventional radiologist, and nurses with in-hospital inputs from other professionals, including neurologists and emergency/critical care physicians via telemedicine. The MSU had a point-of-care laboratory system, a portable multislice helical CT scanner, an improvised Intensive Care Unit (ICU) setup, and a teleradiology facility comparable to what pertains globally. During the MSU's first full year of operation, it was used for 14 patients with acute stroke symptoms. Compared to the conventional ambulance, MSU was associated with higher rates of stroke thrombolysis, improved timeline metrics, and better outcomes. They pointed out the challenges in setting up and maximizing these services in India, emphasizing the need for increased public awareness campaigns and government assistance in the form of service subsidies to boost the uptake of these services in that country.

The second study was by Osuegbu et al., who performed a descriptive survey to assess the essential stroke care structure offered by the two tertiary health facilities in Rivers State, Nigeria [24]. They noted that stroke units, both fixed and mobile, as well as essential stroke care services such as thrombolysis, were not available in Rivers State, Nigeria [24].

Discussion

The disparities in stroke care between HICs and LMICs are expected to continue to widen [3]. Mobile Stroke units represent a viable strategy for improving acute stroke care in this setting. However, evidence supporting its contextual suitability is needed.

Status of utilization of MSUs in LMICs

The results of the current review demonstrate the paucity of research that assesses the use, impact, and cost-effectiveness of MSUs in LMICS, even though doing so offers a crucial strategy for closing the gaps in stroke care [25]. Given health-seeking behavior among people in LMICs, MSUs might be well suited for LMICs as it 'brings treatment to the patient rather than the patient to the treatment.' While Cherian et al. documented the first-time utilization of MSU in India, Osuegbu et al. confirmed the complete absence of mobile stroke units in Rivers State, Nigeria [23, 26]. Even though there is a possibility that more MSUS may exist in other LMICs, nothing has been published on their operation, impacts, or associated costs.

Impact

The utilization of MSUs was first published in Germany over a decade ago [27]. After this, several major pivotal clinical trials around the world have provided robust evidence on the impact of MSU-based care [28]. When compared to traditional hospital-based stroke units, mobile stroke units (MSUs) have been demonstrated to improve the quality of acute stroke care and increase access to prompt treatment [29]. Patients who received early care through MSUs had a better functional recovery than those who were transferred to hospital emergency departments by traditional emergency services, according to a large-scale clinical trial. These benefits have been largely attributed to the capacity of MSUs to deliver thrombolysis within the 'golden hour' for intervention.

Germany's PHANTOM-S trial, a multicenter prospective randomized clinical trial in Houston, Texas showed improved 3-month clinical outcomes, faster treatment times with tPA using an MSU, and a higher proportion of patients treated within the first hour [30]. Zhou et al. from China, also similarly found that mobile stroke units increase the rates of stroke thrombolysis and shorten the onset-to-door time [31]. Despite these promising results, not much is known about the impact of MSUs in resource-constrained settings. The findings by Cherun et al. showed that the use of MSUs in India is associated with higher stroke thrombolysis rates, improved timeline metrics, and better outcomes compared to conventional ambulances, even though these findings are rather preliminary [23].

Challenges

According to Cherun et al., local regulations in India; vehicle requirements for rural terrain making patient loading difficult; the issue of high cost (especially because this MSU was privately run); and lack of awareness among the public and even among health workers are the major barriers of MSU implementation in India [23]. This is very different for HICs, where the geographical dispersion of rural areas is the main obstacle. However, most people who live in rural areas in HICs are well-educated and know what to do in the event of a stroke [9–11].

Cost-effectiveness

The cost-effectiveness of MSUs has been demonstrated by several studies, and the overall cost-benefit analysis seems reasonable [32–35]. A Norwegian study, for example, found MSU care to be cost-effective compared to conventional care, but this is contingent on having a relatively high annual volume of acute ischemic stroke patients treated per vehicle [36]. In North America, Rink et al. also showed that mobile stroke units might be quite economical in cities. They found that two important parameters affecting lifetime cost-effectiveness were the number of stroke mimic patients and the long-term expenses of stroke survivors. The cost-effectiveness of MSUs was not evaluated by any of the studies found in this scoping review. Cherun et al. were unable to evaluate

cost-effectiveness considering the retrospective nature of their study. Even though there have been several publications on the cost-effectiveness of MSUs in high-income countries, there are context-specific concerns for LMICs that need to be investigated and strategies put in place to address them.

Implementation strategies

There is no disputing the effectiveness of MSUs in a range of settings [37]. However, different population dynamics frequently call for different implementation strategies [38, 39]. Adapting evidence-based interventions to specific settings makes it easier for stakeholders and policymakers to implement. To enhance the uptake of these services in India, Cherian et al. stress the necessity of more public awareness campaigns and government support in the form of service subsidies [23]. Even in HICs, when using MSU in rural areas with dispersed populations, the authors often highlighted how important it was to prepare innovative strategies for deployment compared to metropolitan areas [10]. MSUs frequently require customization to meet local requirements by altering the ambulance configuration, crew levels, and transport strategies. In certain HICs, the use of Air Mobile Stroke Units (Air-MSU) has been deployed to care for rural residents [11].

Conclusions

MSUs offer a potential solution to overcome the various contextual health system obstacles of stroke care in LMICs. There is however, currently limited evidence to support the suitability, impact, and cost-effectiveness of MSU in the LMIC context. Primary studies evaluating the impact of MSU on stroke outcomes, health economic benefits, and best implementation approaches in LMICs are required to inform stakeholders and policymakers about the feasibility in their context.

Abbreviations

AJOL	Africa Online Journal
CVD	Cardiovascular Diseases
EMS	Emergency Medicine Services
GNI	Gross National Income
HICs	High-Income Countries
JBI	Joanna Briggs Institute's
MSU	Mobile Stroke Unit
LMICs	Low-middle-income countries
TRIP	Turning Research Into Practice

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-025-12920-5.

Supplementary Material 1.

Authors' contributions

PAOA and EKT conceived the study design. Search strategy was developed by EB and revised by TLH, PAOA and EKT. POA, SAB and AM performed the screening, study selection and extraction of data of the included studies. All conflicts were resolved by PAOA. PAOA drafted the first version of the manuscript and was revised by EKT, FSS, KHM, EO, KFG, AM, SAB, EA. All authors revised and critically reviewed the manuscript and approved the final version before submission.

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Data availability

The author confirms that all data generated or analysed during this study are included within the paper and its Supplementary Information.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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