The cost-efficiency of mobile stroke units
Where the rubber meets the road

In the vanguard of acute stroke care, the pursuit of ultra-early diagnosis and treatment has led to the development of mobile stroke units (MSU): ambulances equipped with portable CT imaging and other advanced diagnostics capable of administering IV thrombolysis in the prehospital setting. Since initial reports of feasibility, separate research groups have demonstrated the effectiveness of MSUs to facilitate earlier treatment with IV tissue plasminogen activator (tPA).1,2

In this issue of Neurology®, Taqui et al.3 report the initial experience of a mobile stroke treatment unit (MSTU) in Cleveland, Ohio. In the evaluation of their first 100 patients, 16% received IV tPA in the field with markedly shorter median stroke onset to thrombolysis times compared to a control group of 53 stroke patients transported by conventional ambulance (97 minutes MSTU vs 122.5 minutes controls, p = 0.049). Faster treatment times were driven largely by a reduction in median alarm to CT completion (33 minutes MSTU vs 56 minutes controls, p < 0.0001). In addition, telemedicine and teleradiology were incorporated in the MSTU to augment efficiency and cost-effectiveness, although no cost data were provided.

Despite early promise of MSUs to shift the paradigm of acute stroke care, cost-effectiveness relies on the potential for long-term savings in quality-adjusted life-years (QALYs) mediated by earlier access to treatment, offsetting substantial startup and maintenance costs.4,5 Financial analyses from initial trials suggest that reduced staffing through telemedicine may improve the incremental cost-effectiveness ratio.5,6 Supporting this concept, a recent MSU study comparing on-board and remote vascular neurologists found excellent agreement for the NIH Stroke Scale, CT interpretation, and tPA treatment decision.7 Making MSUs multipurpose vehicles might also enhance cost-effectiveness. Incorporation of CT angiogram, for instance, would enable prehospital diagnosis of severe strokes with large vessel occlusion and potentially guide selective routing for endovascular therapy.8,9 With the augmentation of the portable CT scanner to include body imaging, MSUs could also support prehospital management of acute trauma and other non-neurologic emergency conditions.10

Yet, even if MSUs meet an acceptable societal threshold for cost-effectiveness, cost-efficiency may prove a taller order to achieve return on investment for individual health systems and communities. In the Cleveland experience, the MSTU was deployed 317 times to attain 16 tPA treatment cases classified as probable stroke, with just 4 treatments within the golden hour. These included 217 cancellations prior to arrival on site (68% of deployments).3 By comparison, in the Prehospital Acute Neurological Treatment and Optimization of Medical Care in Stroke (PHANTOM-S) trial in Berlin, Germany, the MSU (or STEMO) was deployed 2,027 times to achieve 200 tPA treatments, with 349 cancellations prior to arrival (17% of deployments).7 This discrepancy may speak to variations in protocol and emergency medical services (EMS) between the United States and Europe, including the frequent presence of physicians in the field on routine calls. In either case, efficient deployment of MSUs is inexorably linked to local standards of prehospital stroke care, relying on the accuracy and consistency of stroke screening by emergency call receiving operators11 and EMS first responders12 to guide triage.

Moreover, MSU deployment to date has centered mostly on health systems serving densely populated urban or suburban networks. An experimental cost-efficiency analysis from the initial MSU experience in Saarland, Germany, estimated favorable benefit-cost ratios at operating distances greater than 10 miles and optimized at 26.88 miles. Cost-efficiency improved with increasing population density, but remained efficient at densities as low as ~200 inhabitants per square mile depending on staffing requirements.6 While this suggests MSUs could be cost-efficient in rural health systems, deployment of one unit to effectively cover large geographic areas might be challenging and require a broader network of dispatch and delivery (for example, more than half of all counties in Texas have a population density of

See page 1305
fewer than 100 inhabitants per square mile). Alternatively, in the PHANTOM-S trial encompassing a densely populated urban area, efficiency was impeded in 44% of cases by simultaneous deployments or service/maintenance issues.2 Ultimately, an economy of scale will dictate the ability of one MSU to cover a designated geographic area or population density, and requirements for additional units to efficiently serve a community or health system would tip the cost balance.

In addition, the return on investment for MSUs may differ depending on the payer. Whereas in Europe most emergency and hospital services are government-funded (i.e., one-payer), systems in the United States often include different payers for pre-hospital vs hospital and long-term care. The latter may render a MSU less valuable in terms of dollars per QALY spent for a local community or EMS network, particularly in rural areas where ambulance agencies are not directly affiliated with a hospital system.

Following an initial MSU feasibility study published in 2012,13 the accompanying editorial aptly summarized “critical barriers to this revolutionary approach are logistical and financial. ‘A difference to be a difference must make a difference’; therefore, further studies are needed to establish the short- and long-term benefits in clinical outcomes.”14 Thus far, the only published analysis of MSUs in regards to functional outcomes failed to achieve significance in the primary measure of the proportion of patients with no disability at 3 months compared to conventional medical transport (modified Rankin Scale 0–1) (odds ratio 1.40, 95% confidence interval 1.00–1.97; p = 0.052). Nonetheless, secondary analyses were promising and suggested decreased mortality and an increase in the proportion of patients who were able to ambulate independently at 3 months.13

Hope remains that future trials may demonstrate the ultimate potential of mobile stroke units to improve long-term outcomes for more patients, by treating them more quickly and more effectively. In the meantime, ongoing efforts are needed to streamline MSU cost and efficiency before achieving road-readiness for widespread health system deployment.

STUDY FUNDING
No targeted funding reported.

DISCLOSURE
A.M.S.: provisional US Patent 61/867,477; research support from HRSA GO1RH27869-01-00 and the Virginia Alliance of Emergency Medical Education and Research; travel reimbursement and honoraria from the American Heart Association. Dr. Southerland also serves as Deputy Section Editor for the Neurology® Podcast. E.S.B.: research support from NIH-NINDS 5U01NS062835, Northeast Cerebrovascular Consortium, Peruse Science Group, LLC, and Janssen Research & Development, LLC. Go to Neurology.org for full disclosures.

REFERENCES