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To the Rescue: Optimally Locating Trauma Hospitals and Helicopters

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Abstract
Injury (trauma) is the leading cause of death in the United States for people younger than 45 years of age. Each day, more than 170,000 men, women, and children are injured severely enough to seek medical care. About 400 of these people will die and another 200 will sustain a long-term disability as a result of their injuries. An estimated 20-40% of trauma-related deaths could be prevented if all Americans lived in communities that were served by a well-organized system of trauma care. This Issue Brief describes a new computer model that can help State and regional policymakers decide where to place designated trauma hospitals and helicopter depots to maximize their residents' access to trauma care.

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To the Rescue: Optimally Locating Trauma Hospitals and Helicopters

Editor's Note: Injury (trauma) is the leading cause of death in the United States for people younger than 45 years of age. Each day, more than 170,000 men, women, and children are injured severely enough to seek medical care. About 400 of these people will die and another 200 will sustain a long-term disability as a result of their injuries. An estimated 20-40% of trauma-related deaths could be prevented if all Americans lived in communities that were served by a well-organized system of trauma care. This Issue Brief describes a new computer model that can help State and regional policymakers decide where to place designated trauma hospitals and helicopter depots to maximize their residents' access to trauma care.

Trauma systems save lives, but gaps in access remain

Trauma systems involve coordinated response plans to ensure that severely injured people have timely access to specialized trauma center hospitals. Typically, trauma systems involve a network of pre-hospital services (ground ambulances and helicopters), trauma center hospitals, and rehabilitation services. These systems may be organized locally, regionally, or statewide.

- From 1990-1995, the Trauma Care Systems Planning and Development Act provided federal funds for States to develop trauma systems. This helped fuel an increase in trauma systems, from five States in 1992 to 27 States in 1997. While most urban areas now have abundant hospital and ambulance resources, rural populations still have unusually long distances and travel times to trauma centers.
- Surviving a severe injury depends very heavily on the time it takes to receive trauma services. The risk of death increases three-fold after one hour without the unique surgical care of a trauma center. This is often referred to as the "golden hour." Because the initial notification and arrival of paramedics could take as long as 30 minutes, many trauma systems require 30 minutes or less to get a severely injured patient from the scene of injury to a trauma center. However, reducing transport time by as little as five minutes can improve the survival of certain categories of trauma patients.
- Trauma systems are expensive to establish and to maintain. Trauma centers have been prominent contributors to the hospital "medical arms" race of the past two decades. They have the highest patient charges per case, the highest average charge per day, and longer lengths of stay than other hospitals. Expensive technologies unique to trauma centers, such as aircraft and ambulances,

substantially contribute to this inflation. Better organized, better functioning trauma systems would generate cost savings by saving lives and preventing productivity losses, as well as by decreasing public medical expenditures and private hospital system costs.

Trauma systems planning requires more than a map

The development of trauma systems has been shaped by historical patterns, competition between local service providers and politics. Consequently, some States have unnecessary duplication of trauma care services or lack adequate coverage for rural areas.

- The question of how many trauma centers are needed for the population remains unanswered. The American College of Surgeons estimates that one trauma center per million people is sufficient to handle the typical volume of severely injured patients and to maintain the expertise of medical providers. However, this estimate provides little guidance in resolving where and how many trauma centers to establish in a particular region.
- When allocating scarce trauma resources, trauma system planners need to simultaneously consider time constraints, geographic distance, and the demand for trauma services. Often, planners simply look at a map for guidance. However, human judgment alone is unable to assess the best resource configuration from among a complex series of choices.
- Traditionally, trauma systems planners have tried to maximize coverage of land area, a strategy that has led them to locate many trauma centers and helicopters at the same sites. But this may not lead to maximal coverage of people who need trauma services. A greater number of severely injured individuals in need of trauma care can be offered access to the trauma system through helicopter depots located as satellites to one or more trauma centers.

Developing and testing a new model for allocating trauma resources

To improve resource allocation, Branas and colleagues developed and tested a new mathematical model to optimize the location of trauma centers and related resources. The Trauma Resource Allocation Model for Ambulances and Hospitals (TRAMAH) simultaneously locates trauma centers and helicopter depots and measures success by the number of severely injured people having timely access to a trauma center by either ground or air.

- In contrast to a strategy of maximizing land area covered, TRAMAH can maximize coverage based on the demonstrated need for trauma services. Because of its flexibility, it can be used to build a relatively new regional trauma system from a “clean slate” or to accommodate partially developed or well-developed systems that need only incremental improvements.
- Branas and colleagues selected Maryland as a test case for TRAMAH, because of the State’s topographic generalizability, availability of trauma-related data and centralized trauma systems leadership. Using data from hospital discharges and Maryland Vital Statistics, the investigators identified all severe injuries in Maryland from 1992-1994, and estimated the ability of the existing trauma system to serve patients within a 15-minute and 30-minute time frame.

- After estimating Maryland's present capabilities, the investigators applied TRAMAH to the system, using both a clean slate approach and an incremental analysis. To increase its feasibility, the model did not consider the construction of completely new hospital facilities; instead it repositioned existing trauma centers and helicopter depots separately and in tandem.

TRAMAH simulated equivalent coverage using fewer resources, and better coverage by relocating the same resources

The study found that Maryland's trauma system covered about 95% of the 26,774 severely injured people within 30 minutes, and covered about 70% within 15 minutes. TRAMAH was able to improve upon that by repositioning trauma centers and helicopter depots. Moreover, the model found that Maryland could achieve the same level of coverage it currently provides using fewer, repositioned, resources.

- Using the clean slate approach, TRAMAH repositioned the existing 9 trauma centers and 8 helicopter depots and covered more than 99% of the severely injured population within 30 minutes. This translates into an additional 461 severely injured people covered each year. For Maryland to keep its current level of coverage, TRAMAH estimated a need for only 7 trauma centers and 3 helicopter depots.
- Helicopter depots are often logistically and politically easier to relocate than trauma centers. Assuming that no trauma center would be moved, and using a 15-minute time standard, TRAMAH achieved the same level of coverage as that of the existing system by optimally locating only two helicopter depots. By optimally relocating all 8 existing helicopter depots, the model estimated an increase in coverage from 70% to 85% within 15 minutes, or an additional 1,348 people each year.
- By repositioning just one trauma center, and leaving all helicopter depots unchanged, TRAMAH improved 15-minute coverage by 4%, or an additional 371 people. Repositioning two trauma centers increased coverage by nearly 7%.

POLICY IMPLICATIONS

The results of this study show that quantitative location techniques, such as TRAMAH, can be used to improve trauma resource allocation and to identify potential areas for cost savings.

- State and regional planners could use TRAMAH to periodically review existing trauma care facilities, with a clearer process for designation, re-designation, and de-designation. The model could also consider the costs of selecting certain hospitals to become trauma centers in order to more accurately gauge the financial burden of creating an emergency care system.
- Planners could build in costs and patient volumes and outcomes to ensure that medical outcomes are not compromised by clinicians who are overburdened by too many severely injured patients or whose skills have been diluted in seeing too few patients.
- TRAMAH can be used to support policymaking but it does not replace the decision process. Political considerations or other unique State features may lead

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POLICY IMPLICATIONS
Continued

planners to locate trauma centers in certain hospitals or areas not deemed optimal by TRAMAH; in that case, the model can assume certain fixed sites and optimize the remaining resources.

- In a recent report on reducing the burden of injury, the Institute of Medicine concluded that trauma system development declined with the lapse of the Trauma Care Systems Planning and Development Act in 1996. The IOM recommended a reauthorization of the Act, and Congress continues to debate the issue. The development of decision tools such as TRAMAH may help convince legislators that federal funds would be well spent for this purpose.
- Trauma represents only one kind of medical emergency where time is critical to survival. The modeling techniques in TRAMAH can also be used to optimize the location of specialized centers to treat other time-critical conditions, such as stroke, where the earliest possible therapy can also improve outcomes.

This Issue Brief is based on the following articles: C.C. Branas, E.J. MacKenzie, C.S. Revelle. A trauma resource allocation model for ambulances and hospitals. Health Services Research, June 2000, vol.35, pp. 489-507; C.C. Branas & C.S. Revelle. An iterative switching heuristic to locate hospitals and helicopters. Socio-Economic Planning Sciences, December 2000, (in press); C. Branas & C. Revelle. TRAMAH to the rescue. Operations Research/Management Science Today, June 1999, vol. 26, pp. 38-40.

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