Development of a geospatial approach for the quantitative analysis of trauma center access

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Author Disclosures

Robert J.Winchell, MD – Stryker Corporation/CRICO Insurance Company, received money as consultant/expert witness.

Reviewer Disclosures

The reviewers have nothing to disclose.

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INTRODUCTION: Decisions around trauma center (TC) designation have become contentious in many areas. There is no consensus regarding the ideal number and location of TC and no accepted metrics to assess the effect of changes in system structure. We aimed to develop metrics of TC access, using publicly available data and analytic tools. We hypothesize that geospatial analysis can provide a reproducible approach to quantitatively asses potential changes in trauma system structure.

METHODS: A region in New York State was chosen for evaluation. Geospatial data and analytic tools in ArcGIS Online were used. Transport time polygons were created around TC, and the population covered was estimated by summing the census tracts within these polygons. Transport time from each census tract to the nearest TC was calculated. The baseline model includes the single designated TC. Model 1 includes one additional TC, and Model 2 includes two additional TC, chosen to maximize coverage. The population covered, population-weighted distribution of transport times, and population covered by a specific TC were calculated for each model.

RESULTS: The baseline model covered 1.12×10^6 people. The median transport time was 19.2 minutes. In Model 1, the population covered increased by 14.4%, while the population catchment, and thus the estimated trauma volume, of the existing TC decreased by 12%. Median transport time to the nearest TC increased to 20.4 minutes. Model 2 increased coverage by 18% above baseline, while the catchment, and thus the estimated trauma volume, of the existing TC decreased by 22%. Median transport time to the nearest TC decreased to 19.6 minutes.

CONCLUSIONS: Geospatial analysis can provide objective measures of population access to trauma care. The analysis can be performed using different numbers and locations of TC, allowing direct comparison of changes in coverage and impact on existing centers. This type of data is essential for guiding difficult decisions regarding trauma system design. (*J Trauma Acute Care Surg.* 2019;86: 397–405. Copyright © 2018 American Association for the Surgery of Trauma.)

LEVEL OF EVIDENCE: Care management, level IV.

KEY WORDS: Geospatial analysis; Trauma systems; Trauma center; Needs assessment; Health policy.

Care at a designated trauma center has been shown to improve outcomes after injury,[1–3] and systems of care that ensure rapid access to trauma centers have been shown to be a critical predictor of survival and recovery.[4–6] From the inception of trauma system development, it has been recognized that the lead agency for the system should have the authority to designate trauma centers based on the capabilities of the facility and the needs of the population served.[7–10] Despite this recognition, processes and standards for trauma center designation in the United States remain highly variable.[11] There are no federal standards; thus, statutory authority to designate trauma centers exists at the level of state or county agencies, if it exists at all. Moreover, there are no accepted benchmarks to establish the optimum number of trauma centers or their location in a given community.

This lack of objective guidance was rarely an issue before the early 21st century, a period when economic pressures on hospitals made trauma care an almost untenable mission. The decision to designate a new trauma center was not controversial in this era in which trauma center closings far outnumbered new trauma center designations, with more than 300 trauma centers closing their doors between 1990 and 2005.[12] Conversely, by the mid 2000s, the economic climate had shifted, and the number of new hospitals claiming trauma center status began to dwarf the number of trauma centers closing. According to self-designation data collected annually by the American Hospital Association,[13] in the year 2000, 258 (6.1%) of hospitals reported having a Level I trauma center. In 2010, the number had risen to 387 (9.4%); and in 2013, there were 416 hospitals claiming Level I trauma center status. Data from the American College of Surgeons Committee on Trauma (ACS COT) Verification, Review, and Consultation (VRC) program shows a similarly dramatic rise between 2005 and 2015; the number of verified Level I and Level II trauma centers increased from 166 to 290.[14] These new trauma centers often arise in more affluent urban and suburban areas rather than in underserved or economically depressed areas, and may compete with existing centers for patient volume as well as revenue. Despite an increase in the overall number of trauma centers, this trend may actually result in decreased access to trauma center resources for vulnerable populations.[15]

The shift from a predominance of trauma center closings to trauma center proliferation, coupled with a strong political shift away from government regulation of free markets that includes heath care, has made the process of trauma center designation a highly contentious one, and one with significant financial implications. Lacking clear standards, processes, and political support, state and county agencies are often challenged to exert their authority to control trauma center designation in the face of opposition from large health care organizations. As a result, the decision to open a new trauma center or close an existing one is most commonly left to individual health care facilities, driven by market factors and the hospital's perception of its mission.[15]

In response to this trend, the ACS COT released a position statement in 2015 outlining a set of principles that should guide decisions around trauma system development, and advocating for the establishment of a transparent and objective needs-based process to guide trauma center placement and designation.[16] The statement put forward a list of parameters that could be used to assess the need for trauma centers in a region, including Emergency Medical Services (EMS) transport times and the percentage of population within 60 minutes' transport time of a Level I or Level II trauma center as metrics of trauma system

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Presented at the 77th Annual Meeting of the American Association for the Surgery of Trauma, September 26, 2018, in San Diego, California.

DOI: 10.1097/TA.0000000000002156

access. The statement also outlined fundamental principles that should guide system development, including the preservation of a sufficient patient volume at existing centers. Although the ACS COT statement provides general guidance, to date, there is no accepted set of metrics to provide objective assessment of trauma center access or the impact of new centers on existing facilities as part of a needs-based assessment.

The purpose of this study was to describe a systematic and easily reproducible method to calculate metrics of trauma center access using publicly available data and analytic routines. Our goal is to utilize geospatial analysis to quantitatively assess the effects of potential changes in trauma system structure, such as the number and location of trauma centers in the region, to help guide policy decisions related to trauma system planning and development.

MATERIALS AND METHODS

Data Sources

Basic cartographic information, including ground transportation network data, was obtained through ArcGIS Online (ESRI; Redlands, CA). Population density information at the level of county census tract was derived from US Census Bureau data for 2014, presented as a publicly available map layer (US Census Tract Areas, updated May 22, 2017) within ArcGIS Online. For the purposes of population coverage and transportation time estimates, the population of each census tract was placed at the geographic centroid of the individual census tract. Hospital data, including location, reported trauma center designation level, and other characteristics, were obtained in spreadsheet format from the Homeland Infrastructure Foundation-Level Data website[17] and cross-checked with data from the ASC COT Verification, Review, and Consultation.[18]

Analysis

We evaluated a single region in New York state. This region was chosen based on availability of necessary geospatial data in the public domain, and because of its relative geographic isolation, being functionally served by a single designated trauma center. Our intent was to analyze the effects of adding new trauma centers to an existing system as a hypothetical case, not to model the current situation in the chosen region. Therefore, for simplicity, we did not include existing trauma centers located at the periphery of the chosen region, nor did we include population-dense census tracts located at the periphery of the region. We evaluated three different models for the index region: the current baseline, served by the single existing designated adult trauma center, Model 1 including one additional designated adult center chosen to optimize population coverage, and Model 2 including two additional designated adult centers, also chosen to optimize population coverage. This method for picking new candidate centers was used to facilitate demonstration of the modeling approach in a neutral fashion, without reference to hospital capabilities or potential interest in becoming a trauma center. For each model, several metrics were calculated: total population coverage within 60 minutes' estimated transport time, subdivided into 10-minute bands, the distribution of estimated transport times to the nearest trauma center within 60 minutes, and the estimated population catchment for each trauma center. To more accurately model the region as geographically isolated, several densely populated urban census tracts in adjacent cities located at the outer limits of the 60-minute drive time range were excluded from the analysis.

To calculate population coverage, the ArcGIS network analyst tools, available within ArcGIS Online, were used to create a set of transport-time polygons capturing the geographic area within 60 minutes' estimated transport time of the trauma centers in the model, divided in 10-minute segments. Population coverage was estimated by joining these transport-time polygons with the population density layer, summing the population for all included census tract centroids. We used the ArcGIS network analyst tools to estimate the shortest transport time from each census tract centroid to its nearest allocated trauma center, limiting the analysis to census tracts with transport times less than 60 minutes. Estimated transport times from each centroid were weighted by population, and the distribution was analyzed for each model. Population weighting was used to improve estimation over purely geographic methods.[19] Trauma center catchment population for each model was estimated by summing the population for all census tract centroids that had the shortest transport time to the index trauma center. For the model, we assume patient volume at the index trauma center to be proportional to this catchment population.

Geospatial and Statistical Analysis

All geospatial analyses were performed using ArcGIS Online, versions 5.1 [June 2017] through 6.2 [June 2018] (ESRI), and ArcGIS Desktop version 10.5 (ESRI). All descriptive statistical and graphic analyses were performed using R version 3.5.0 (R Core Team)[20] with the ggplot2 package.[21]

RESULTS

The baseline model includes a total population of 1.12×10^6 within 60 minutes of the trauma center. The population catchment of the single trauma center was the full covered population of 1.12×10^6. Addition of a second trauma center in Model 1 increased the population covered within 60 minutes of either trauma center by 14% to 1.28×10^6 while decreasing the population catchment of the existing trauma center, and thus the estimated trauma volume at that center, by 12% from baseline, to 9.86×10^5. The addition of a third trauma center in Model 2 further increased the population covered within 60 minutes of any trauma center to 1.32×10^6, an 18% increase above the baseline model, while the population catchment of the existing trauma center, and thus estimated trauma volume at that center, decreased by 22% from baseline to 8.72×10^5. A geographic representation of these models is presented in Figure 1, and summary data on the relative changes in population and trauma center volume are presented in Table 1. A more detailed examination of population coverage within 10-minute transport time bands for each model is presented in Figure 2. These data show that in addition to increasing total population coverage, the sequential addition of trauma centers in Models 1 and 2 most strongly increases population coverage in the 10- to 40-minute transport time bands while decreasing population coverage in time bands over 40 minutes.

The distribution of population-weighted transport times between each population centroid and its nearest trauma center

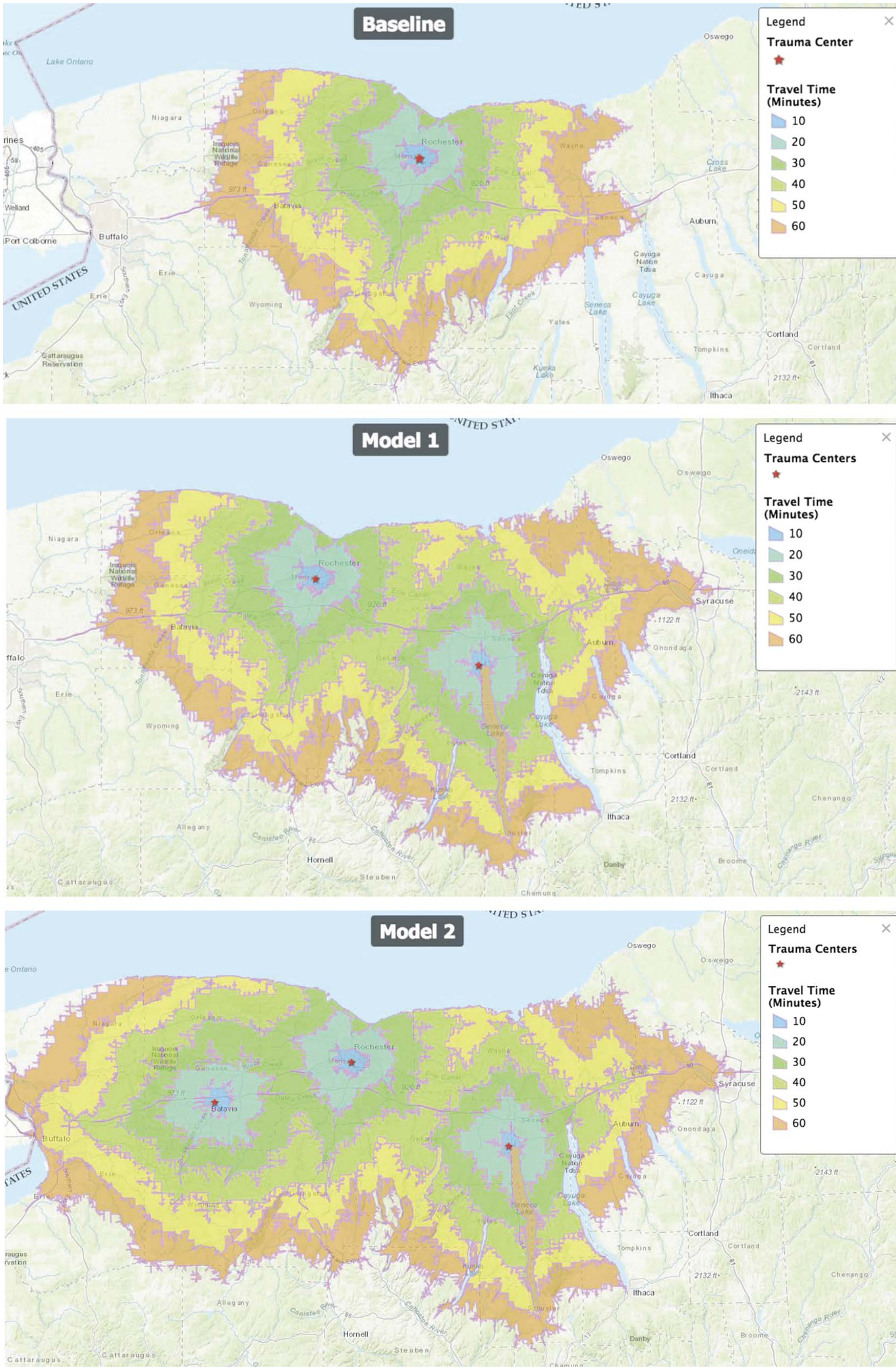

Figure 1. Geographic coverage within 60 minutes of a trauma center for each model.

TABLE 1. Population Coverage and Estimated Changes in Trauma Center Volume

	Population Coverage	Change in Population Coverage	Change in Existing Trauma Center Volume	Change in Second Trauma Center Volume
Baseline	1.12×10^6			
Model 1	1.28×10^6	+ 14%	−12%	
Model 2	1.32×10^6	+ 18%	−22%	−32%

TABLE 2. Central Tendency of Population-Weighted Transport Times (in Minutes)

	Mean	SD	Median	IQR
Baseline	25.7	14.5	20.6	14.5-15.7
Model 1	25.5	13.6	21.3	14.7-34.5
Model 2	23.7	12.6	20.6	14.5-30.1

SD, Standard deviation; IQR, interquartile range.

was also evaluated. The central tendency of the weighted average travel times, shown in Table 2, changed very little between models, whether evaluated as the mean or the median; however, the variance of the weighted transport times decreased as the additional trauma centers were added to the model. The weighted transport time histograms are shown in Figure 3. The histograms have been smoothed using a local regression (LOESS) approach to simplify display. These data also demonstrate the increase in transport times between 20 and 40 minutes and concomitant decrease in times over 40 minutes seen in Model 1 and Model 2.

DISCUSSION

The determination of need and optimal location for a trauma center is often framed as a multidimensional optimization problem. For example, the proposed center should be placed in such a way as to maximize the number of patients who can reach the trauma center within an hour to minimize transport times for patients overall and to maintain individual center volumes above a minimum level felt to be needed to maintain competency while allowing for system surge capacity in case of mass casualties. Geographic Information Systems (GIS) and geospatial techniques are ideally suited for this type of approach, allowing the simultaneous analysis of many important variables including population density, injury severity, and the existing transportation grid. The depth of such potential modeling is limited only by the availability of data and the complexities of the optimization routines, offering the attractive potential to describe the perfect system. Examples of this geospatial optimization approach include the work of Jansen et al. who developed their own optimization algorithm to evaluate trauma systems in Scotland and Colorado[22–24] and Horst et al. who used the same ArcGIS network analyst tools used in our study to evaluate trauma center placement in Pennsylvania.[25–27] These approaches yield elegant solutions, but they can fall short in practical application.

In actual practice, trauma centers and trauma systems have developed organically, not as the result of a comprehensive plan. In most cases, trauma centers have arisen in places where need, interest, and resources overlapped by happenstance, not by intent. Furthermore, trauma centers are expensive to establish, expensive to operate, and require extensive support for hospital resources and specialty personnel, making it nearly impossible, both financially and functionally, to simply create a new trauma center where it might be needed. It is equally difficult to simply remove an existing trauma center or to move it 10 miles down the road to a geospatially optimized location. This challenge is magnified by the use of population density data or injury severity data for optimization, as both of these change with time. As a

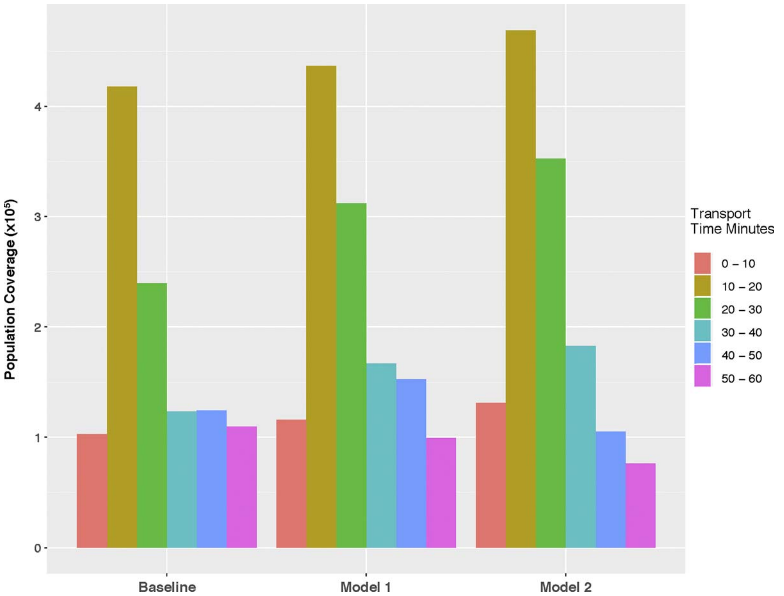

Figure 2. Population coverage with 60 minutes of a trauma center for each model.

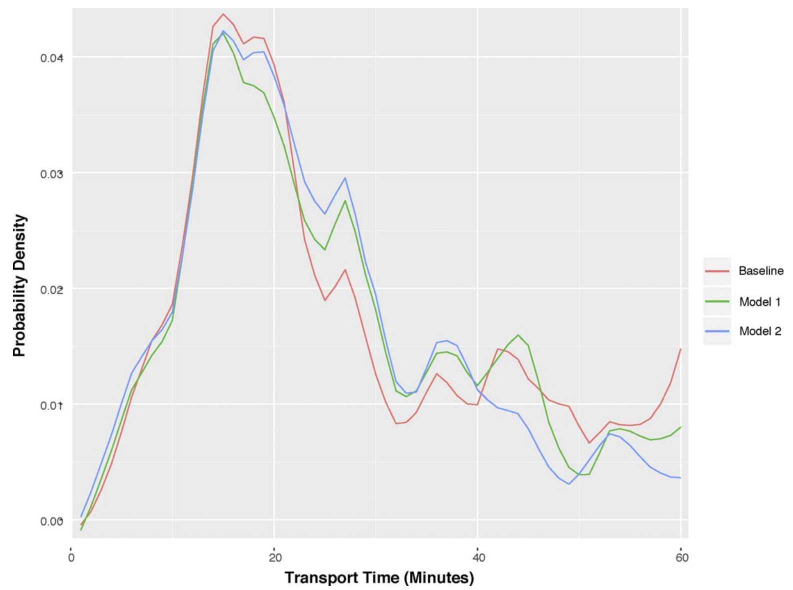

Figure 3. Smoothed histogram of transport time to nearest trauma center for each model.

result, the optimized solution calculated today will not be the same as the optimized solution calculated in 5 years, or perhaps even next year.

At an even more basic level, there is no consensus around the parameters to be optimized, or the targets of that optimization, to arrive at the ideal number and placement of trauma centers. There are inherent trade-offs affecting resource allocation and costs that do not have a single scientific answer and instead are essentially matters of public policy that will have different political solutions in different geographic regions or in different political climates. For example, there is a direct trade-off between having fewer high-volume trauma centers to maintain individual trauma center volume and having more lower-volume trauma centers to increase system surge capacity, a situation that was dramatically illustrated in the Boston area. Before 2012, there was substantial disagreement regarding the designation a new trauma center in Boston based on concerns that the region was already potentially overserved. Following the bombing at the Boston Marathon in 2013, after which the availability of surge capacity related to the number of trauma centers likely contributed to the quality of care delivered, the concerns regarding trauma center oversupply have largely disappeared.

It is with these realities in mind that we propose a different approach. If one accepts the impossibility of a single mathematically ideal solution given geographically fixed resources and in an inherently political arena, the best use of geospatial techniques is in the development of clear, transparent metrics that can provide objective input to guide what may be a highly polarized policy debate. While there is no consensus on what the correct benchmarks are, there is significant experience, as described in the references above, with respect to parameters that are both relevant and practical to assess. This experience has guided our choice of population living within 60 minutes' transport time of a trauma center, trauma center catchment population (as an estimate of trauma center volume), and estimated transport time to the nearest trauma center as our core metrics. Beyond the studies previously mentioned, there also significant experience with the use of data and analytic tools available through ArcGIS in health care– and injury-related research, which supports the choice of this platform as widely available and well accepted, as demonstrated by these examples from the recent literature[28–31] drawn from a sample of more than 65 found on PubMed covering the past 10 years.

Strengths of our methodology include the use of publicly available data and analytic routines, its lack of dependence on political boundaries, and its scalability, which allows for evaluation of small substate or large multistate regions. We have specifically chosen a straightforward analytic strategy that can be applied in areas with limited data or with limited geospatial modeling expertise. Our more granular evaluation of population coverage within drive-time polygons and detailed distribution of estimated individual transport times offers more potential insight into trauma center access for a given system configuration. Finally, changing the frame of evaluation from designing the ideal system to one that provides objective data to guide policy decisions greatly enhances the practical use of the approach.

Our study has several limitations, primarily related to our study aim to use publicly available data and an easily replicable methodology. Because we used only data that are in the public domain, we have no data on type and severity of injury in the region, actual EMS transport times, or specific hospital outcomes. Detailed geospatial analysis is often limited precisely because this type of information is not uniformly available for most areas of the country. Our data for estimated transport time are based on historic traffic data and computer-generated optimum routing and may not be reflective of real-time data. It is also likely that different routing algorithms could produce different estimates. We did not include the location of specific EMS resources in our model because of the variability in dispatch and staging strategies in individual regions. By design, our analyses dealt solely with ground transport. We chose not to include air transport because of the complexities introduced by inconsistency in criteria for its use in primary scene transport, shifting coverage by air medical providers and differences in availability due to local weather. For most trauma centers, ground transportation remains the most common mode. Furthermore, contested decisions regarding trauma center designation are more commonly based on local factors and local ground transport patterns. For demonstration purposes, we assumed that patients would be transported to the nearest trauma center, based on estimated transport time. This approach does not take into account other factors that can affect the choice of EMS destination. In addition, our approach assesses population access only and does not directly address the capabilities or level of designation of a particular facility. The determination of optimal level and capacity of centers in a given model is a different facet of needs assessment that would occur in parallel with the analysis we describe. Finally, for simplicity, we assumed our test area to be geographically isolated without interaction with other trauma centers whose temporal catchment areas might overlap. In actual practice, both temporal barriers and state, county, or regional boundaries are blurred by convenience and historic patterns of transportation.

We believe that this exploratory analysis demonstrates a widely available, meaningful, objective, and easily reproducible method to assess the current status of trauma center access and to estimate the effect of potential changes in trauma system configuration. Future work will be directed at evaluating the approach in a wide variety of geographies and system configurations, and validating the test metrics by comparison with existing data in specific regional trauma systems.

CONCLUSIONS

Geospatial analysis can provide objective measures of population access to trauma care, including the estimated population within 60 minutes of a trauma center, the population covered by a specific trauma center (as an estimate for trauma center volume), and the distribution of transport times to a trauma center. The analysis can be easily performed using publicly available data and software to model trauma system configurations that contain different numbers and locations of trauma centers, thus allowing direct comparison of potential changes in coverage and impact on existing centers. This type of data is vital to guide difficult decisions regarding trauma center designation to optimize access to care and allocation of resources.

AUTHORSHIP

R.J.W. contributed to literature search, study design, data analysis, data interpretation, writing of the manuscript, and critical revision of the manuscript. P.X. contributed to literature search, study design, data analysis, data interpretation, and writing of the manuscript. L.M. contributed to literature search, data analysis, and critical review of the manuscript. R.H. contributed to data analysis and critical review of the manuscript, and provided software support.

DISCLOSURE

The authors declare no conflicts of interest.
This study received no funding support.

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DISCUSSION

Frederick B. Rogers, M.D. (Lancaster, Pennsylvania): I would like to congratulate Dr. Winchell and his co-authors on a well-performed study, and also acknowledge Dr. Winchell's leadership through the American College of Surgeons in developing objective measures, such as the needs-based assessment of trauma systems to guide trauma center placement within a trauma system.

In the past 15 to 20 years, there has been an enormous growth in the number of trauma centers throughout the United States. While superficially this may seem like a good thing, unfortunately, this growth is not guided by intelligent design, but rather by financial considerations and large healthcare system conglomerate imperatives.

The net result is a clustering of trauma centers in more affluent urban and suburban regions, with each trauma center encroaching on each other's catchment areas, and as a result, diluting the experience of each individual trauma center. Conversely, many rural and less affluent areas are bereft of trauma center coverage for the major trauma victim.

There are now a number of studies which are beginning to address this disparity in care and look to other ways to manage the growth of new trauma centers within a defined trauma system. The geo-spacial approach for analysis of trauma center access presented here today is one such approach.

The beauty of this approach is that it uses readily available off-the-shelf software, which is frequently used by many commercial enterprises, and also publicly available, easily obtainable data that could be incorporated within any area that the data is available, without resorting to capturing sophisticated trauma demographics.

I would also add this is probably also the inherent weakness of such a preliminary analysis in that we really don't know the particulars of the trauma system they studied: the volume of trauma; the severity and the size and capabilities of the individual trauma hospitals within the trauma system.

I have two questions for the authors.

You state that Strong Memorial Hospital in Rochester is the center of your study area. You then remove census tracts from urban areas on the outer areas of the 60-minute drive to Rochester, which in this case would be both Buffalo and Syracuse.

Both these cities have existing Level 1 trauma centers, whose catchment area would presumably cover parts of the population included in your model.

Have you conducted sensitivity analysis to determine the impact of the service areas of those two trauma centers and their results? Including these trauma centers and their service areas would most likely change where the next trauma center would be located in their model.

And second, this is more of a philosophical question, while these models of theoretical trauma center placement are helpful to define the ideal location of the next trauma center within a trauma system, how do you translate that into the real world of practical application of these methods into the morass of politics and monetary demands that are currently surrounding the placement of trauma centers?

Thank you very much for the opportunity to comment on this paper.

Charles E. Lucas, M.D. (Detroit, Michigan): Robert that was an excellent presentation. The principles that you outlined need to be followed by the Committee on Trauma throughout the country.

I have one question. Most of us trauma surgeons make most of our living by taking care of non-trauma patients. When you look at your model, have you considered how the trauma people from all specialties are going to make a living related to diseases that are not related to trauma at these new trauma centers?

James W. Davis, M.D. (Fresno, California): Dr. Winchell, excellent presentation. I am concerned that with your expertise in system development and system evaluation that your analysis is flawed, because you've used logic, and it seems to be noticeably lacking in where trauma centers get put.

I'd also like to understand better what it would do for areas like mine in Central California, which is relatively underserved, and how this model could be used to identify centers that should participate, and if this could be used to perhaps provide some influence from the College to help people see the light. Thank you.

Michael B. Aboutanos, M.D. (Richmond, Virginia): Bob, thank you so much for this wonderful presentation. I also want to thank you for representing our state for our trauma system plan. We actually just finalized our plan.

The issue I have with the model – I think that it is extremely useful, but mainly in comparison to an existing model. It sounds like it's almost a fictitious aspect.

So, one question I have, your model is really based on the population increase as you have centers. That seemed to have increased as far as how many more population can be covered.

What if you keep that population constant, that does not increase, and see how the model works with additional centers being created within this same area, not being allowed to increase, and see what that does with regard to the actual plan? Because I think that's really the reality of it.

We're not adding something; we're leveling up existing facilities that are present. So how does the model apply to that? Again, I think it would be very useful, taking the reality, you know, how the model works and how it should have worked. Thank you.

Robert J. Winchell, M.D. (New York, New York): Thank you very much, and thanks, Fred, for your comments. I'll see if I can get these all figured out.

So, as to the reason that we picked that area, when I started doing this two years ago, we were approaching the GIS data a little differently. We actually were working from the ground up at a very basic level, and so we tried to pick an area that was simple, but that had all of the data that we needed. As time went on and our knowledge of the software improved, in fact, you don't have to dig to find the data, it's all out there. So we modified the process a little bit but did not change the selected geographic area.

The idea was not to pick a real-world trauma center or a real-world situation; it was to pick a test area and see how the metrics changed. And so if you put the two cities – if you put Erie and Syracuse back in at the corners of that, what you find, in fact, is that 60 minutes transport time picks up downtown Syracuse, and that's also not the real world. We could have put those population centers in the model, but it just muddles it up, and makes it that much harder to demonstrate what the differences are in a five-center model rather than a two-center model or a three-center model.

We were really just trying to pick an area to demonstrate the metrics that could be generated and how the metrics could be used to differentiate between different configurations, rather than actually trying to figure out what's going on in Rochester. I think that is the first question.

The second question was about validation, and how do we know this works. And further, still in part of Dr. Rogers' presentation, is the idea that this methodology is going to try and tell you where to put the trauma centers. I would say that, in fact, the idea behind this set of metrics is "you tell me where you want to put the trauma center, I can tell you what that's going to do to your existing center". It won't say whether it's the best or the worst configuration, just what the impact will likely be, to help guide the decisions around whether it is, in fact, an intelligent choice within a given system. As Dr. Davis noted, decisions around trauma center placement are not logical, they're political. There is no ideal solution.

Our concept in putting this together is to generate the data that will at least help guide some rationality in what is intrinsically a political decision.

We are working on trying to validate how well the transportation calculations model real transportation times. I think that can be validated. We're going to look at some before and after areas where centers have already been added and we have the data to see if the predictions are accurate. But for the most part, the use of this tool would be to hopefully figure out what might happen if you put in trauma center A without actually having to do it.

Let's see, then, so, Dr. Lucas, I'm not sure if I understood your question with respect to how we're going to be able to tell us in the trauma centers what to do in addition to trauma.

The idea of population coverage could certainly be extended to other time-sensitive illnesses. In that context, the concept of population coverage still works.

When you try to start adding more detail, and the data certainly exists to stratify the population by age groups, or groups at risk for certain types of injury, these are dynamic factors that tell me what's happening today, but will almost certainly change with time while the distribution of trauma centers is likely to be fixed.

Dr. Davis, I completely concur that there is an absence of logic. The whole idea behind this approach is to try and at least provide some reproduceable objective data so that I'll get the same answer that you will, and at least we don't have to fight about how we crunched the numbers. Whether that actually will introduce a change in the debate, I think remains to be seen as well.

And, finally, Dr. Aboutanos, if my memory now serves, we weren't really seeking to compare our outcome to a real world – the proposed models certainly do not reflect any real-world thing that was happening around the Rochester area – but more to try and demonstrate what changes in population coverage would be predicted with the addition of new centers.

The way the model works is it goes out 60 minutes based on network transport time, and that will encompass more people as those coverage areas geometrically get bigger. The population data that underlies all three models is the same. It's just you're increasing population coverage, and I think that's still valid.

The model could be easily adapted to a specific catchment district, and I could cut it off at the borders of five counties and say I'm only going to look within here, and in which case you won't add much in terms of coverage.

But having played with the model, I can tell you that if I put another trauma center right next door to Strong, those travel-time polygons don't get bigger and I won't increase the population coverage, either. It just simply will decrease the number of people that go to each hospital.

Going back to Dr. Davis's last piece, if I put a hospital in the middle of the Central Valley, the model very eloquently demonstrates that that's a brand new group of people who are covered within 60 minutes of a trauma center who weren't covered before. There is no impact on the existing centers in the region, because those polygons don't overlap, so that's not usually contentious, but again, the tools will certainly outline the need and how well those holes get plugged.

Once again, my thanks for the opportunity to present our approach.