Access to Emergency Care in the United States

Brendan G. Carr, MD, MA, MS
Charles C. Branas, PhD
Joshua P. Metlay, MD, PhD
Ashley F. Sullivan, MS, MPH
Carlos A. Camargo, Jr., MD, DrPH

From the Department of Emergency Medicine (Carr), and Department of Biostatistics and Epidemiology (Carr, Branas, Metlay), the Robert Wood Johnson Clinical Scholars Program (Carr, Metlay), the Leonard Davis Institute of Health Economics (Carr, Branas, Metlay), and the Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania, Philadelphia, PA (Carr, Branas, Metlay); the VA Medical Center, Philadelphia, PA (Metlay); and the Department of Emergency Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, MA (Sullivan, Camargo)

Study objective: Rapid access to emergency services is essential for emergency care–sensitive conditions such as acute myocardial infarction, stroke, sepsis, and major trauma. We seek to determine US population access to an emergency department (ED).

Methods: The National Emergency Department Inventories–USA was used to identify the location, annual visit volume, and teaching status of all EDs in the United States. EDs were categorized as any ED, by patient volume, and by teaching status. Driving distances, driving speeds, and out-of-hospital times were estimated with validated models and adjusted for population density. Access was determined by summing the population that could reach an ED within the specified intervals.

Results: Overall, 71% of the US population has access to an ED within 30 minutes, and 98% has access within 60 minutes. Access to teaching hospitals was more limited, with 16% having access within 30 minutes and 44% within 60 minutes. Rural states had lower access to all types of EDs.

Conclusion: Although the majority of the US population has access to an ED, there are regional disparities in ED access, especially by rurality. Future efforts should measure the relationship between access to emergency services and outcomes for emergency care–sensitive conditions. The development of a regionalized emergency care delivery system should be explored. [Ann Emerg Med. 2009;54:261-269.]

Provide feedback on this article at the journal's Web site, www.annemergmed.com.

0196-0644/$-see front matter

doi:10.1016/j.annemergmed.2008.11.016

SEE EDITORIAL, P. 270.

INTRODUCTION

Background

Time-sensitive interventions, such as coronary revascularization in acute myocardial infarction,[1,2] fibrinolytic therapy for acute ischemic stroke,[3] early goal-directed therapy in sepsis,[4] and trauma center care for severe injury,[5] highlight the importance of timely, universal access to care for emergency care–sensitive conditions. Receipt of these interventions is contingent on access to an appropriately equipped and staffed emergency department (ED) or an ED that can triage, stabilize, and rapidly transport patients to more definitive care.

Importance

Understanding which EDs have adequate resources to care for patients with emergency care–sensitive conditions is difficult. A common perception is that higher-volume teaching EDs located at referral hospitals provide more comprehensive care than their smaller community counterparts.[6] No centralized data collection system exists that characterizes ED capabilities or the resources available within their parent hospitals. This lack of knowledge about individual EDs is an important barrier for researchers and health services planners alike. Researchers cannot determine the relationship between access and resources for emergency care–sensitive conditions, and planners cannot develop systems to efficiently deliver patients to the most appropriate level of care.

Goals of This Investigation

Although details in terms of ED capabilities and resources are as yet unavailable for the nation, the basic distribution and characteristics of EDs in the United States has been recently compiled.[7] To date there have been no population-based estimates of access to these EDs. We therefore sought to generate national estimates of access to various types of EDs within 30, 45, and 60 minutes. These findings have important policy implications for future ED categorization, credentialing, and the regionalization of emergency care.[8]

Editor's Capsule Summary

What is already known on this topic

Many maladies require prompt care to optimize outcomes, care often started in an emergency department (ED).

What question this study addressed

How close are Americans to an ED?

What this study adds to our knowledge

Using an ED database and census information from 2003, the authors estimated that 71% of Americans could get to an ED within 30 minutes and 98% could do so within an hour. These overall figures are skewed by the urban and suburban population and ED densities, with rural Americans more often living at a greater travel distance from an ED.

How this might change clinical practice

This will not alter care but quantifies our intuitive understanding about the geography of ED care in the United States.

MATERIALS AND METHODS

Theoretical Model of the Problem

The traditional framework describing access to care includes 5 important domains: availability, accessibility, accommodation, affordability, and acceptability.[9] For the subset of conditions requiring prompt intervention to optimize outcome, accessibility to emergency care represents the most important domain. A basic understanding of the location of emergency care facilities relative to the population requiring prompt access to these resources is an essential first step in developing an intelligently designed emergency care delivery system.

Data Collection and Processing

ED information was obtained from the National Emergency Department Inventories, an Emergency Medicine Network[10] project that maintains an inventory of all EDs in the United States. The National Emergency Department Inventories were developed in response to the absence of a centralized mechanism by which to identify ED factors (eg, annual number of ED visits, presence of postgraduate residency training programs) potentially associated with patient outcomes. The 2003 National Emergency Department Inventories–USA database was developed by integrating data from 3 sources: the SMG Marketing Group's Hospital Marketing Profiling Solution Fourth Quarter 2001 Release, the 2001 American Hospital Association Annual Survey of Hospitals, and independent data collected by the Emergency Medicine Network staff.[7]

To calculate access to specific types of EDs, all sites were characterized in terms of annual visit volume and teaching status. In our previous work,[7] we categorized EDs as "higher" volume if they treated more than 1 patient per hour, 24 hours per day, 365 days a year. Here, we maintain this description but further classify higher-volume EDs according to hourly census and distinguish EDs that treat an average of 1 or more patients per hour ($\geq$8,760 patients/year), 2 or more patients per hour ($\geq$17,520 patients/year), and 3 or more patients per hour ($\geq$26,280 patients/year). Teaching hospitals were identified by membership in the Council of Teaching Hospitals and Health Systems.[11] To be classified as a teaching hospital by the Council of Teaching Hospitals and Health Systems, hospitals must have a documented affiliation with an accredited medical school and must sponsor or participate significantly in at least 4 approved active residency programs, not necessarily including an emergency medicine residency.

Population information was obtained with data from the US Census Bureau local and state estimates and trends in deliverable addresses from the US Postal Service (Claritus Inc, Ithaca, NY).[12,13] Our main geographic units of analysis were block groups. A block group is a geographic unit containing 600 to 3,000 people that does not cross state or county boundaries. Each block group's population was assigned a point in space (a centroid) that was nearest to most of its residents. Population estimates and population-weighted centroids for 208,649 block groups were calculated for 2003. The location (longitude-latitude coordinates) of these population-weighted centroids were then compared with the longitude-latitude coordinates representing EDs. Block group population access calculations were aggregated to compute estimates of access for the entire country, the 4 Census Bureau regions (Northeast, Midwest, South, and West), the 9 Census Bureau divisions, and all 50 states and the District of Columbia. State population totals and state estimates of rurality were based on US Census Bureau calculations. Rural was defined as territory, population, and housing units not classified as urban.

Primary Data Analysis

Access was calculated by summing the population of the block groups that could reach an ED by ground ambulance within the specified out-of-hospital period. We chose to generate access estimates for 30 minutes, 45 minutes, and 60 minutes because these intervals provide a reasonable range of transport times that might still permit timely intervention in critical diseases. Each block group was linked to the nearest ED, and redundant access to nearby EDs was not considered in these analyses. The populations or land areas of block groups that could reach an ED within the period specified were never counted more than once in the summation formula for access. Similarly, we did not account for the fact that many block groups could be assigned to the same ED. All programming code was written and tested with Compaq Visual Fortran Version 6.6 (Compaq Computer Corporation, Houston, TX), and then translated into C++ (Microsoft Corporation, Seattle, WA) and validated by comparing output from the Fortran code with output from the C++ code.

To calculate ambulance driving times, we used an average urban driving speed of 20.1 miles per hour, an average suburban driving speed of 47.5 miles per hour, and an average rural driving speed of 56.4 miles per hour.[14] Drives were classified as urban, suburban, or rural by averaging the population densities (residents per square mile) of the block group surrounding each ED and the block group of origin and then determining whether this average population density could be categorized into the highest, middle, or lowest third among all US block groups. The population densities of intervening block groups were not considered. We then added 1.4, 1.4, and 2.9 minutes to account for the average time from receipt of emergency call to departure in urban, suburban, and rural areas, respectively.[14] An additional 13.5, 13.5, and 15.1 minutes in urban, suburban, and rural areas, respectively, were added to account for the average time spent at the scene,[14] as has been done previously.[15] For our access calculations, we permitted the crossing of state lines to arrive at the closest ED.

We could not explicitly determine the location of ground ambulance depots. We therefore estimated the time from ground ambulance depot to the scene by multiplying the time from scene to ED by an empirically determined constant: 1.6, 1.5, and 1.4 for urban, suburban, and rural drives, respectively, to account for differences in travel time between the geographic regions. All driving distances were estimated with previously validated mathematical models of actual road travel.[16,17] These distance estimates have been previously demonstrated to correlate well with actual road travel distances in the United States. This analysis was considered exempt from full review by the institutional review board at the University of Pennsylvania.

RESULTS

The 2003 National Emergency Department Inventories–USA database identified 4,809 hospitals with general receiving EDs; the sum of all ED visits was 113.3 million visits, which is consistent with the 113.9 million ED visit estimate from the sample of hospitals that participate each year in the US National Hospital Ambulatory Medical Care Survey.[18] The median number of annual visits was 18,089. About one third (n=1,358) of EDs treated fewer than 8,760 patients per year. Of the 3,451 EDs that treated 8,760 or more patients per year, about one quarter (29%) were in a nonurban setting.

MAIN RESULTS

Overall, 71% of the US population has access to an ED within 30 minutes, 94% within 45 minutes, and 98% within 60 minutes. The Northeast had the greatest access within 30 minutes (76%), followed by the West (71%), the Midwest (70%), and the South (68%). Access was much less variable within 60 minutes, ranging from 99.5% in the Northeast to 97% in the West (Table 1; Figure 1).

Overall, access to EDs with higher volume (≥1 visit/hour) was similar, with 68% of the population having access within 30 minutes, 90% within 45 minutes, and 95% within 60 minutes. A greater range of access was observed across census regions for these EDs, with the Northeast having the greatest access within 30 minutes (76%), followed by the West (68%), Midwest, and South (65%). Access estimates for 60 minutes were similar, ranging from 99.1% in the Northeast to 92% in the Midwest (Table 1; Figure 2). Population access to EDs treating 1 or more, 2 or more, and 3 or more patients per hour is displayed in Table 2.

Access to teaching hospital EDs was much more limited, with only 16% of the population having access within 30 minutes, 32% within 45 minutes, and 44% within 60 minutes. Access to a teaching hospital ED demonstrated the most regional variability. The Northeast had the largest population with access within 30 minutes (31%), followed by the Midwest (17%), South (12%), and West (9%). Access to a teaching hospital within 60 minutes ranged from 36% in the South to 67% in the Northeast (Table 1; Figure 3).

Statewide access to any ED within 30 minutes ranged from 48% (Vermont) to 86% (District of Columbia), and access to any ED within 60 minutes ranged from 81% (Alaska) to 100%. Statewide access to higher-volume EDs ranged from 33% (South Dakota) to 86% (District of Columbia) for 30 minutes and 45% (South Dakota) to 100% for 60 minutes (Table 1). Access to EDs treating 1 or more, 2 or more, and 3 or more patients per hour is displayed for each state in Table 2.

Access to teaching hospitals varied considerably among states, with a range of access between 0% (Alaska, Idaho, Montana, Nevada, Wyoming) to 72% (District of Columbia) access for 30 minutes and 0% (Alaska, Idaho, Montana, Nevada, Wyoming) and 100% (District of Columbia) access within 60 minutes. In the majority of states (98%), half of the population did not have access to a teaching ED within 30 minutes, and in three quarters (73%), less than half of the population had access within 60 minutes (Table 1).

Finally, we examined the relationship between rurality and timely access to emergency services. Even in the 4 states with more than 50% of the population living in rural areas, population access within 60 minutes remained good (97% to 99% for any ED and 93% to 98% for a higher-volume ED). There was more variability associated with ED access within 30 minutes. A strong linear relationship existed between the percentage of the state population living in rural areas and access to any ED within 30 minutes (R^2=0.59). Access to higher-volume EDs within 30 minutes for the most urban states ranged from 74% to 86% and from 45% to 54% for the most rural states.

LIMITATIONS

We provide a population-level analysis of access to EDs. As such, the estimated travel times may not be directly applicable on the individual level. We believe our inventory of EDs to be comprehensive; however, it remains possible that EDs have been omitted. We think it is more likely, however, that we have included clinics that self-describe as an "ED" but that are not open round the clock or to all comers, key characteristics of an

Table 1. The percentage of population with access to any ED and any teaching ED within 30 and 60 minutes, by ED type, US region, US division, and state.

	Any ED		Teaching Hospital	
	30 minutes	**60 minutes**	**30 minutes**	**60 minutes**
US	70.8	98.4	15.7	44.3
Northeast	76.3	99.5	30.9	66.9
New England	71.7	99.5	24.7	59
Connecticut	72.2	100	38.8	82.7
Maine	51.5	97.4	9.6	20.6
Massachusetts	77.6	99.5	21.6	63
New Hampshire	63.5	99.5	2	5.3
Rhode Island	82.1	100	47.4	83.8
Vermont	48.3	98.9	17.3	34.2
Middle Atlantic	78	99.5	33.1	69.7
New Jersey	83.3	99.9	24.5	77
New York	78	99.3	45.3	74.8
Pennsylvania	74.2	99.4	20.2	56.7
Midwest	69.7	98.8	17.3	48.3
East North Central	71.5	99.2	19	52
Indiana	69.6	99.4	9.8	28.6
Illinois	79.2	99.1	18.4	53.8
Michigan	63.5	98.8	23.2	61.2
Ohio	73.4	99.9	24.1	64.2
Wisconsin	66.4	98.4	12	31.4
West North Central	65.5	97.8	13.3	39.5
Iowa	60.4	98.4	3.8	7.4
Kansas	71.8	97.5	5.6	21.7
Minnesota	64.4	97.5	11.8	43
Missouri	65.3	95	17.2	48.6
Nebraska	73	98.4	17.8	34.6
North Dakota	66.5	89.7	10.6	18.6
South Dakota	59.5	89	14.5	22.5
South	68.1	99	11.6	36.2
South Atlantic	68.4	99.1	14.1	41.5
Delaware	72.2	100	47.2	62.2
District of Columbia	86.4	100	72.4	100
Florida	77.4	99	11.2	35.3
Georgia	68.3	99.5	11.7	40.1
Maryland	64.5	99.8	22.3	68.5
North Carolina	59.9	99.7	10	28.3
South Carolina	58.3	98.6	12.1	39.5
Virginia	66.4	98	15.7	50.5
West Virginia	58.7	99	11.7	27
East South Central	62.7	99.5	7.9	25.6
Alabama	59.9	99.4	10.1	26.1
Kentucky	61.4	99.7	9	34.7
Mississippi	58.7	98.8	6	16.2
Tennessee	67.6	99.9	6.3	23.5
West South Central	70.7	98.4	9.4	32.9
Arkansas	62	97.3	7.9	18.3
Louisiana	75.6	99.3	16.8	29.7
Oklahoma	68.4	98.7	14.4	43.7
Texas	71.1	98.3	7.2	33.6
West	71.2	97	8.9	37.2
Mountain	66.3	94.9	7.6	32.1
Arizona	69.2	94.2	12.4	51.2
Colorado	63.6	95.3	3	19.8
Idaho	69.5	95.6	0	0
New Mexico	60.3	86.7	8.4	32.7
Montana	64.6	89.1	0	0
Utah	74	97.3	9.2	42.9

Table 1. (Continued) The percentage of population with access to any ED and any teaching ED within 30 and 60 minutes, by ED type, US region, US division, and state.

	Any ED		Teaching Hospital	
	30 minutes	**60 minutes**	**30 minutes**	**60 minutes**
Nevada	62.9	95.2	0	0
Wyoming	70.1	87.5	0	0
Pacific	73.6	98	9.5	39.7
Alaska	53.7	80.7	0	0
California	75.4	98.5	9.8	41.9
Hawaii	63.9	98.1	13.7	31.4
Oregon	71.5	96.2	13.1	37.7
Washington	68.7	98	6.1	33.6

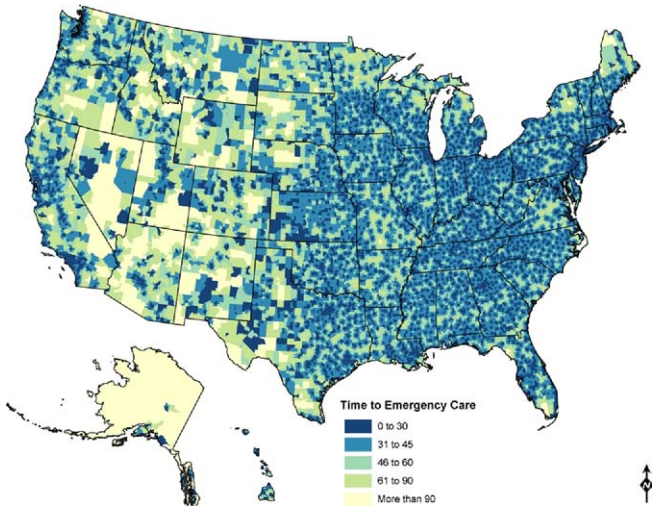

Figure 1. Access to any ED (driving only).*
*All estimates allow vehicles to cross state lines.

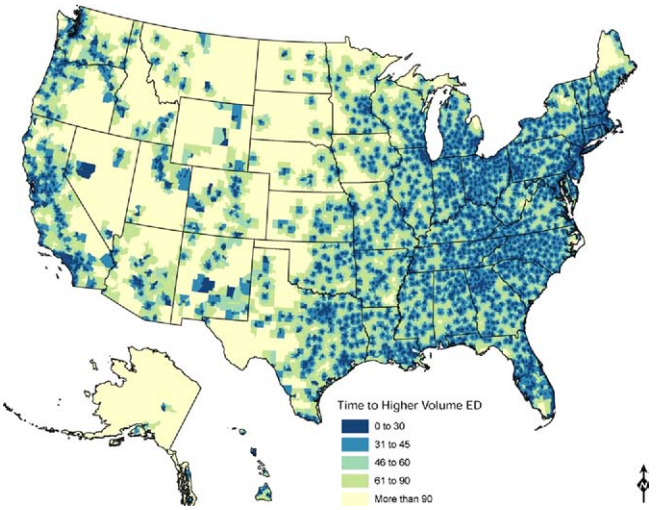

Figure 2. Access to a higher-volume* ED (driving only).
*Higher-volume EDs are defined as treating at least 1 patient/hour, 24 hours/day, 7 days/week (ie, at least 8,760 visits/year).

ED. This possibility would lead us to overestimate ED access. It is also possible that EDs with volumes near the volume thresholds that we defined may have enough annual variability to lead to some misclassification bias. In addition, ED closure, hospital closure, and change in Council of Teaching Hospitals and Health Systems affiliation since 2003 may have resulted in overestimations or underestimations of population access.

Our study has potential limitations related to our access estimates. We calculated access according to where people live, not where they might be at onset of symptoms requiring emergency services. Our estimates may underestimate population access because many Americans live in remote areas but may often spend time in more densely populated regions with better ED access. The drive times in our study were derived from a meta-analysis of out-of-hospital times for trauma, and ambulances with medical emergencies may not travel at the same speed as ambulances with trauma patients. Medical patients may also be more likely to arrive by private vehicle than the injured population. There may also be limitations associated with our assumptions about ambulance care in the United States. We assume adequate out-of-hospital coverage throughout the United States despite that there is tremendous variability in the efficiency of out-of-hospital systems, with many rural areas depending on volunteer services. Geographic barriers such as rivers and mountains were not taken into consideration in the analysis. We believe that although this may be a concern in small-unit analysis (ie, a county or city), this would not affect the state and national estimates that we present here. We did not include nongeographic factors in our driving analyses, including limited 911 service, inclement weather, traffic congestion, or rates of ED closure or diversion. We hope that by using actual ambulance drive times specific to population density, we have partly controlled for these unmeasured confounders. We did not consider the use of helicopters to transport patients to the hospital, as has been done in the trauma population because most medical diseases are not regionalized with out-of-hospital triage criteria. Finally, we did not take into consideration redundancy of ED access, and we did not attempt to control for ED crowding or diversion. In some highly crowded regions, redundancy is likely essential, whereas in other areas, redundancy may represent unnecessary inefficiencies or a

Table 2. The percentage of population with access to the ED within 30 and 60 minutes, by ED volume (visits/hour), US region, US division, and state.

	≥1 Visit/Hour		≥2 Visits/Hour		≥3 Visits/Hour	
	30 minutes	**60 minutes**	**30 minutes**	**60 minutes**	**30 minutes**	**60 minutes**
US	67.8	95.3	44.9	79.9	37.8	72.8
Northeast	75.6	99.1	54.4	89.4	45.6	82.6
New England	71	98.9	49.2	88.8	44.3	82.2
Connecticut	72.2	99.6	43.8	92.6	37.9	86.6
Maine	47.9	93.6	31.8	72.4	20.8	51.1
Massachusetts	77.6	99.5	59.4	93.6	55.6	91.3
New Hampshire	61.6	98.8	30.2	77.3	24.7	61.7
Rhode Island	82.1	100	61.3	97.3	60.9	97.3
Vermont	44.9	97.8	27.4	60.9	22.8	44
Middle Atlantic	77.2	99.1	56.2	89.7	46.1	82.8
New Jersey	82.5	99.9	63.7	99	50.2	97.5
New York	77.3	98.8	58	89.9	47.5	82.4
Pennsylvania	73.3	99	48.1	82.7	41	73.1
Midwest	64.6	92.3	43.1	77.5	36.5	69.7
East North Central	68.3	96.4	46.4	82.2	39.8	74.5
Indiana	66.3	96.4	45.7	80	32.6	66.7
Illinois	75.6	96.6	49.8	85.2	45	81.1
Michigan	61.3	95.7	45.4	83.1	41.2	76.1
Ohio	72.3	99.8	50.2	89.4	45.2	83.5
Wisconsin	58.3	90.4	32.9	61.5	22.5	46
West North Central	55.7	82.6	35.5	66.2	28.5	58.6
Iowa	44.7	71.1	27.8	49.3	18.5	35.3
Kansas	59.3	79.7	42.5	62.1	34.4	56
Minnesota	55.4	85.1	38.1	68.6	33.2	64.5
Missouri	61.8	89	46.6	70.3	39.1	64.5
Nebraska	54.5	72.2	38.7	55.8	22.9	44.1
North Dakota	48.7	56.5	37.3	50.5	18.3	27.9
South Dakota	32.6	44.7	26.6	36.6	8.4	13.1
South	65.1	96.3	41.6	77.2	35.4	69.9
South Atlantic	67.2	98.5	43.2	82.6	38.7	78.1
Delaware	72.2	100	62.9	96.8	59.7	79.5
District of Columbia	86.4	100	69.4	100	69.4	100
Florida	76.7	98.7	56.8	92.4	49.8	88.9
Georgia	64.8	97.6	40.7	78.3	35.4	77
Maryland	64.3	99.5	33.9	84.2	32.4	81.2
North Carolina	58.8	99.5	28.5	73.5	24.9	63.6
South Carolina	58	98.4	33.7	67.1	28.8	60.5
Virginia	66	97.6	43.9	84.7	42.2	82.2
West Virginia	53.5	96.9	26.8	63.5	23	54.9
East South Central	58.3	96.6	33.8	66.3	26.5	55.9
Alabama	56.6	96.3	30.9	65.3	25.2	60.4
Kentucky	57	97.5	35.7	69.9	28.2	55.2
Mississippi	52	92.5	25	50.1	17.9	39.4
Tennessee	63.5	98.2	39.1	72.6	30.5	61.2
West South Central	65.2	92.7	43.1	74	34.5	63.9
Arkansas	54.8	86.8	30.7	55.7	21.3	45.9
Louisiana	69.9	95.9	34.1	67.3	24.5	41.4
Oklahoma	57.8	86.5	35.7	60.2	31	53.1
Texas	66.8	93.8	47.7	79.9	38.7	72.5
West	68.2	93.9	42.6	79.4	36.3	73.7
Mountain	60.9	88	34.2	68.9	30.1	65.1
Arizona	67.7	92.2	34.8	77.7	31.3	75.6
Colorado	59.2	90.3	27.9	67.9	26.1	64.3
Idaho	58.6	80	26.2	42.8	26.2	42.4
New Mexico	55.5	81.8	26.8	48.7	26.8	48.7
Montana	44.6	61.3	34.6	47.4	7.3	8.2
Utah	69.5	91.9	45.7	80	34.6	67

Table 2. (Continued) The percentage of population with access to the ED within 30 and 60 minutes, by ED volume (visits/hour), US region, US division, and state.

	≥1 Visit/Hour		≥2 Visits/Hour		≥3 Visits/Hour	
	30 minutes	60 minutes	30 minutes	60 minutes	30 minutes	60 minutes
Nevada	60.3	92.7	42.2	84.8	35.5	82.2
Wyoming	45.2	54.5	4.3	7	0	0
Pacific	71.9	96.8	46.9	84.6	39.4	78
Alaska	47.5	73.2	31.3	49.6	28.7	40.7
California	74	97.9	48.6	88.4	40.8	81.2
Hawaii	61	96.2	41.2	67.5	15.2	58.3
Oregon	69.3	94.6	41.8	59.9	36.3	52.9
Washington	65.7	94.1	42.7	84	39.2	81.6

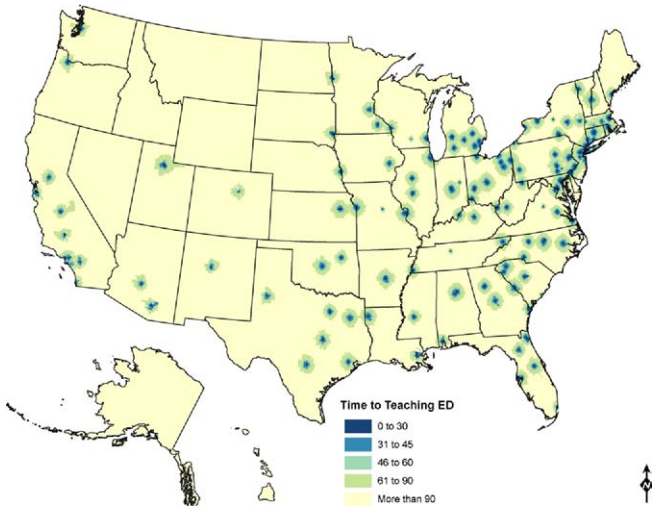

Figure 3. Access to a teaching hospital* (driving only). *As defined by the Council of Teaching Hospitals and Health Systems.

misdistribution of resources. Despite these potential shortcomings, to our knowledge our analysis provides the first and only benchmark for population access to EDs.

DISCUSSION

We provide national, regional, and statewide access estimates to EDs by volume and by teaching status. We demonstrate that the majority of the US population has access to an ED within 60 minutes and demonstrate variability by region and state for higher-volume EDs and teaching EDs. Living in a rural area is a key driver of these results because we observed a strong linear relationship between the population of a state living rurally and overall resident access to emergency care.

The central hypothesis of emergency care is that rapid diagnosis and early intervention in acute illness or acutely decompensated chronic illness improves patient outcomes.[19] The time-sensitive nature of many conditions, including myocardial infarction, stroke, sepsis, and major trauma, have been well described.[1-5] Professional organizations have developed guidelines intended to standardize the care of these conditions, including the appropriate use of specialized levels of care, such as cardiac catheterization and interventional radiology.[20-23] Despite this, fundamental details about the emergency care system, including population access to EDs and the resources available on ED arrival, are largely unknown. A notable exception to this knowledge gap is the trauma system.[24,25]

The US trauma system has been recognized by the Institute of Medicine as a model for the rapid delivery of emergency care.[8] Trauma centers are embedded within EDs but are independently accredited to meet the core explicit requirements necessary for immediate diagnostics and treatment of severe injury. Trauma systems have used principles of operations research[26] to ensure that severely injured patients are rapidly delivered to an appropriate facility either by allowing emergency medical services providers to bypass the closest hospital or by stabilizing patients outside of the trauma center, followed by rapid interhospital transfer. These systems improve outcomes[5] and allow for intelligently planned expansion to ensure optimal patient access to trauma care. The development of systems to ensure adequate access to appropriately resourced facilities for other, nontrauma emergency care–sensitive conditions has been limited.

In addition to the regional variability in ED access, we demonstrate a relationship between ED access and rurality. These findings are not surprising because we expect dense urban areas to have more hospitals and shorter transport times. However, there are unique challenges associated with attracting emergency physicians[27] and practicing emergency medicine in rural areas[28] that are related to the importance of these findings. The disparity in emergency care access that we describe may be associated with poor outcomes for time-critical diseases. Our data support efforts to advance testable pilot solutions to increase population access to emergency services for rural Americans. These solutions include subsidizing rural hospitals,[29] providing physician incentives to provide services at these hospitals,[30-32] identifying specialty centers,[33-36] and improving out-of-hospital and interhospital referral networks[8,23,37,38]; it is likely that multiple approaches will be needed to improve inequities in access. An improved understanding of the role of physical location of an ED, the resources of the ED, and the mechanism by which patients can be efficiently delivered to the

appropriate setting is essential in the ongoing planning and development of the US health care system.

In conclusion, we provide estimates of access to emergency care in the United States. The majority of Americans can arrive in a timely manner to an ED, but there are geographic inequities in timely access to emergency services and gaps in our knowledge of where appropriate interventions for emergency care–sensitive conditions are available. Future efforts should be directed toward better understanding the capabilities of EDs to provide comprehensive emergency services. An ED categorization scheme that addresses these issues, coupled with our access data, would provide a framework for the development of regionalized care delivery systems for emergency care–sensitive conditions.

The authors are grateful for the statistical and programming support of Justin Williams, PhD, Jianguo Li, MS, Karl Dailey, BS, Vicky Tam, MA, and Marlen Kokaz, MS.

Supervising editor: Donald M. Yealy, MD

Author contributions: BGC, CCB, JPM, and CAC conceived of and designed the study. BGC, AFS, and CAC obtained the data. BGC drafted the article. All the authors interpreted the data, revised the article, and contributed substantively to the work. BGC takes responsibility for the paper as a whole.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article that might create any potential conflict of interest. See the Manuscript Submission Agreement in this issue for examples of specific conflicts covered by this statement. The study was supported by the Robert Wood Johnson Foundation and the National Library of Medicine (R21LM008700).

Publication dates: Received for publication July 30, 2008. Revisions received October 23, 2008, and November 11, 2008. Accepted for publication November 24, 2008. Available online February 3, 2009.

Reprints not available from the authors.

Address for correspondence: Brendan G. Carr, MD, MA, 932 Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104-6021; 215-573-3976, fax 215-573-2265; E-mail Carrb@upenn.edu.

REFERENCES

1. Cannon CP, Gibson CM, Lambrew CT, et al. Relationship of symptom-onset-to-balloon time and door-to-balloon time with mortality in patients undergoing angioplasty for acute myocardial infarction. *JAMA.* 2000;283:2941-2947.
2. Brodie BR, Stone GW, Morice MC, et al. Importance of time to reperfusion on outcomes with primary coronary angioplasty for acute myocardial infarction (results from the Stent Primary Angioplasty in Myocardial Infarction Trial). *Am J Cardiol.* 2001;88:1085-1090.
3. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. *N Engl J Med.* 1995;333:1581-13158777.
4. Rivers E, Nguyen B, Havstad S, et al. Early goal-directed therapy in the treatment of severe sepsis and septic shock. *N Engl J Med.* 2001;345:1368-1377.
5. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med.* 2006;354:366-378.
6. Anderson GF, Greenberg G, Lisk CK. Academic health centers: exploring a financial paradox. *Health Aff (Millwood).* 1999;18:156-167.
7. Sullivan AF, Richman IB, Ahn CJ, et al. A profile of US emergency departments in 2001. *Ann Emerg Med.* 2006;48:694-701.
8. Institute of Medicine. *Hospital Based Emergency Care: At the Breaking Point*. Washington, DC: National Academies Press; 2006.
9. Penchansky R, Thomas JW. The concept of access: definition and relationship to consumer satisfaction. *Med Care.* 1981;19:127-140.
10. Emergency Medicine Network. National Emergency Department Inventory-USA. Available at: http://www.emnet-usa.org/. Accessed December 22, 2008.
11. Council of Teaching Hospitals and Health Systems. Member Teaching Hospitals and Health Systems. Available at: http://services.aamc.org/memberlistings/index.cfm?fuseaction=home.search&search_type=TH&state_criteria=ALL. Accessed December 22, 2008.
12. US Census Bureau. Census 2000 Datasets. Available at: http://www2.census.gov/census_2000/datasets/. Accessed December 22, 2008.
13. US Census Bureau. Centers of population computation for 1950, 1960, 1970, 1980, 1990 and 2000. US Census Bureau, April 2001. Available at: http://www.census.gov/geo/www/cenpop/calculate2k.pdf. Accessed December 22, 2008.
14. Carr BG, Caplan JM, Pryor JP, et al. A meta-analysis of prehospital care times for trauma. *Prehosp Emerg Care.* 2006;10:198-206.
15. Branas CC, MacKenzie EJ, Williams JC, et al. Access to trauma centers in the United States. *JAMA.* 2005;293:2626-2633.
16. Love R, Morris J. Mathematical models of road travel distances. *Manage Sci.* 1979;252:130-139.
17. Love R, Morris J, Wesolosky GO. *Facilities Location: Models and Methods*. New York, NY: North-Holland Publishers; 1988.
18. McCaig LF, Burt CW. National Hospital Ambulatory Medical Care Survey: 2003 emergency department summary. *Adv Data.* 2005;(358):1-38.
19. Neumar RW. The Zerhouni challenge: defining the fundamental hypothesis of emergency care research. *Ann Emerg Med.* 2007;49:696-697.
20. Dellinger RP, Carlet JM, Masur H, et al. Surviving Sepsis Campaign guidelines for management of severe sepsis and septic shock. *Crit Care Med.* 2004;32:858-873.
21. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction—executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1999 Guidelines for the Management of Patients With Acute Myocardial Infarction). *J Am Coll Cardiol.* 2004;44:671-719.
22. Adams HP Jr, Brott TG, Furlan AJ, et al. Guidelines for thrombolytic therapy for acute stroke: a supplement to the guidelines for the management of patients with acute ischemic stroke. A statement for healthcare professionals from a Special Writing Group of the Stroke Council, American Heart Association. Circulation. 1996;94:1167-1174.
23. American College of Surgeons Committee on Trauma. *Resources for Optimal Care of the Injured Patient: 2006.* Chicago, IL: American College of Surgeons; 2006.

24. MacKenzie EJ, Hoyt DB, Sacra JC, et al. National inventory of hospital trauma centers. *JAMA.* 2003;289:1515-1522.
25. American Trauma Society. Trauma information exchange program. Available at: http://www.amtrauma.org/tiep/index.html. Accessed December 22, 2008.
26. Branas CC, MacKenzie EJ, ReVelle CS. A trauma resource allocation model for ambulances and hospitals. *Health Serv Res.* 2000;35:489-507.
27. Steele MT, Schwab RA, McNamara RM, et al. Emergency medicine resident choice of practice location. *Ann Emerg Med.* 1998;31:351-357.
28. Williams JM, Ehrlich PF, Prescott JE. Emergency medical care in rural America. *Ann Emerg Med.* 2001;38:323-327.
29. Center for Medicare and Medicaid Services. Critical access hospitals. Available at: http://www.cms.hhs.gov/CertificationandComplianc/04_CAHs.asp. Accessed December 22, 2008.
30. Budget Reconciliation Act, P.L. 101-239, sec. 6102(c)(1). 2106 ed.; 1989:2184
31. Health Resources and Services Administration. National Health Service Corps. Available at: http://nhsc.bhpr.hrsa.gov/. Accessed December 22, 2008.
32. P.L. 100-203, sec. 4043, 101. *42 U.S. Code 1395(m).* Vol Stat. 1330.1330-1385.
33. American College of Surgeons. Consultation/verification program. http://www.facs.org/trauma/vcprogram.html. Accessed December 22, 2008.
34. The Joint Commission. Disease-specific care certified organization search. Available at: http://www.jointcommission.org/CertificationPrograms/Disease-SpecificCare/DSCOrgs/default.htm. Accessed December 22, 2008.
35. American Stroke Association. Primary stroke center certification program. Available at: http://www.strokeassociation.org/presenter.jhtml?identifier=3016808. Accessed December 22, 2008.
36. American Burn Association. Burn center verification. Available at: http://www.ameriburn.org/BurnUnitReferral.pdf. Accessed December 22, 2008.
37. Intensive Care Society. *Guidelines for Transport of the Critically Ill Adult.* London, England: ICS; 2002.
38. Institute of Medicine. *Emergency Medical Services: At the Crossroads.* Washington, DC: National Academies Press; 2006.