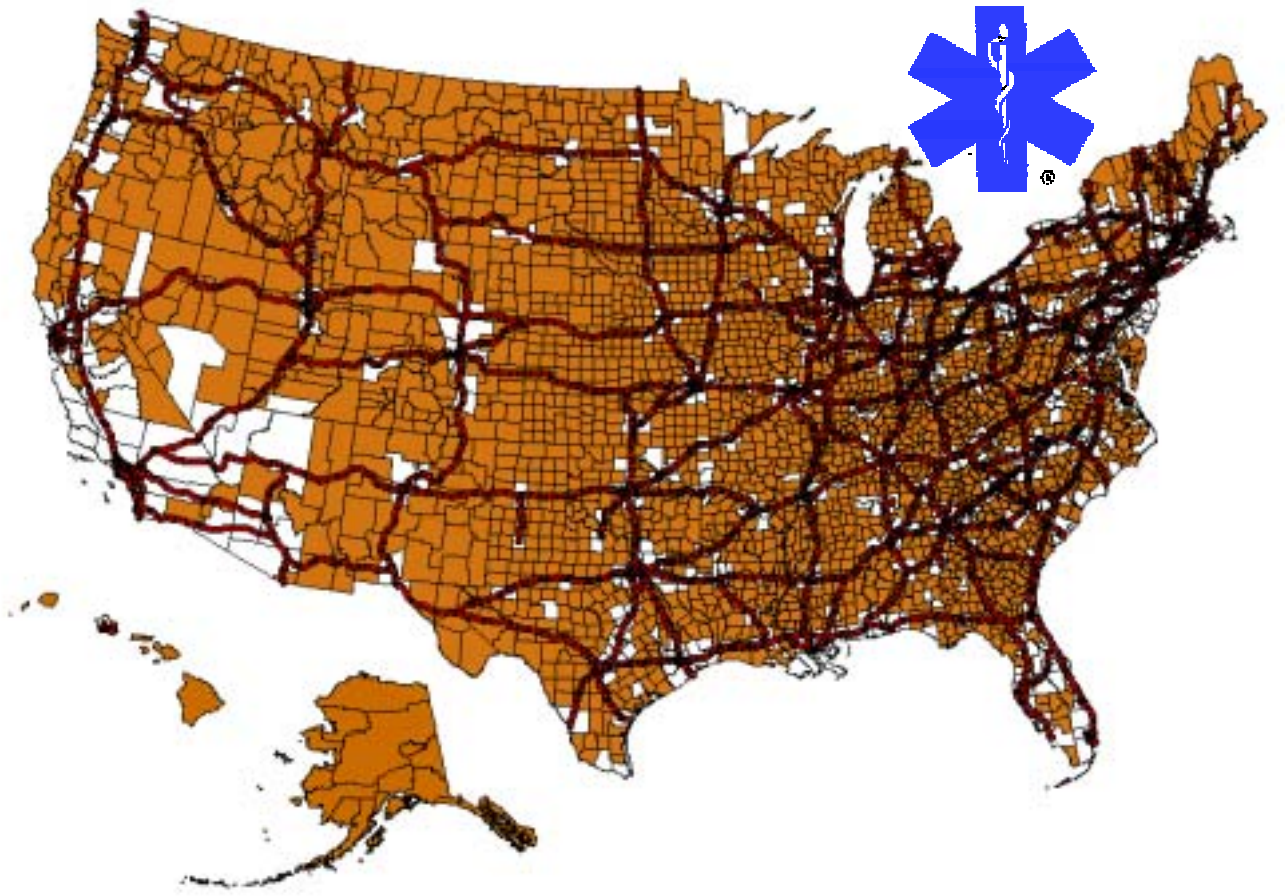
Investigating Rural Emergency Medical Service (EMS) Infrastructure

A Developmental Methodology for Measuring the Availability of EMS Resources



South Carolina Rural Health Research Center

At the Heart of Public Health Policy

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Investigating Rural Emergency Medical Service (EMS) Infrastructure:

A Developmental Methodology for Measuring the Availability of EMS Resources

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Executive Summary

Background

Emergency Medical Service (EMS) has been defined as a total and complete system capable of responding to the medical and surgical emergencies of a community with prompt and adequate emergency care. Beyond a broad definition, agreed-upon measures of EMS infrastructure are not available. Rural and frontier communities are known to experience shortages of physicians, nurses, dentists and other health professionals and may lack sufficient and adequate EMS resources.

Purpose of EMS Study

We explore a *potential* indicator of EMS availability, Expected Annual Emergency Miles per Ambulance (EXAMB). The ambulance is used as the core unit of availability due to its importance for safe transport and the initiation of medical services. The EXAMB measure calculates expected annual emergency miles per ambulance beginning with the number of ambulances, the land area of a county as a proxy for distance, and county population. These "raw" statistics are then "adjusted" using the ratio of the county value to the state value for five county characteristics: physician availability, mortality rates from disease and motor vehicle crashes, poverty rate, and age distribution.

The potential application of the EXAMB measure is illustrated using five states, (Mississippi, Oregon, South Carolina, Washington, and Wyoming) that were able to provide information on ambulance availability at the county level.

Findings

- In three of five states, EXAMB values varied in parallel with other measures of resource availability:
    - In Mississipppi, South Carolina and Washington, EXAMB values increased as rurality increased, (measured by rural/urban continuum code).
    - In the same states, EXAMB values increased as population density decreased.
    - In Mississippi and South Carolina, EXAMB values were higher in whole-county HPSAs.

- In Oregon and Wyoming, no relationship was found between the EXAMB indicator and measures of rurality or health services availability.

- In all states, the EXAMB was positively related to the proportion of the county population in poverty.

Policy Recommendations

Nationally uniform definitions and reporting of EMS resources, and the relationship of these resources to populations, are an essential prerequisite to defining "adequate" infrastructure. A consensus based set of definitions and standardized assessment of EMS infrastructure is needed before policy development can go forward. The data analysis provided in this report suggests that standardized assessment tools can be developed. The following recommendations are offered:

- The Secretary of the US Department of Health and Human Services, in collaboration with the Secretary of the US Department of Transportation, should convene a consensus conference to develop a uniform data set for defining and recording EMS infrastructure, such as practitioners, communications/dispatch services, and transport vehicles.

- The Secretary of the US Department of Health and Human Services, in collaboration with the Secretary of the US Department of Transportation, should provide technical assistance to states in the development of data systems that support monitoring and tracking of EMS personnel and facilities.

Research Recommendations

Development of a quantifiable and policy-relevant measure of EMS availability will require a significant research effort. It is therefore recommended that:

- The Secretary of the US Department of Health and Human Services should provide funding for research into the relationship between EMS infrastructure and population health outcomes, particularly across rural populations.

- The Secretary of the US Department of Health and Human Services should support research into the development of effective comparative measures of EMS infrastructure.

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Chapter One: Rural and Frontier Emergency Medical Services

Importance of EMS

The events of September 11, 2001, coupled with the anthrax bioterrorism incident later that same year, brought new prominence to the role of emergency responders. However, the importance of emergency medical services (EMS) systems as part of the continuum of care required for community health has long been recognized by health professionals. It is estimated that nearly everyone in the U.S. will need EMS assistance at least twice in their lifetime.[1] Rapid access to prehospital care for services such as defibrillation and trauma support, followed by subsequent rapid transport by EMS, can improve patient outcomes.[2-16]

Rural and frontier communities are known to experience shortages of physicians, nurses, dentists and other health professionals,[17] and may lack sufficient and adequate EMS resources. In many cases EMS is the only means for accessing more definitive (e.g., clinic or hospital-based) care in rural and frontier areas.[1] Standardized, evidence-based methods for assessing rural and frontier EMS resources on a national, regional and/or state level are currently unavailable.

The Nature of EMS

Until the late 1960s, very few municipalities provided emergency medical services. Ambulance crews offered little or no care, because their primary function was seen as rapid transport to the hospital [18]. *Accidental Death and Disability: The Neglected Disease of Modern Society* [19], published in 1966, illustrated the magnitude of civilian trauma [20] and stressed that many trauma deaths could have been prevented with prompt emergency care.[20] Federal agencies, principally the National Highway Traffic Safety Administration, outlined general guidance for the development of EMS systems and funded demonstration projects for this form of care during the late 1960s and early 1970s. Development and sustainability of EMS systems, however, has remained a local responsibility.

Emergency Medical Services (EMS) has been defined as a total and complete system capable of responding to the medical and surgical emergencies of a community with prompt and adequate emergency care.[18] According to original EMS related legislation and regulation, an EMS system should include: 1) a state level administration agency; 2) a state and local level advisory committee; 3) local councils; 4) a comprehensive operational plan; 5) appropriate laws and ordinances; 6) categorization of hospital emergency capabilities; 7) a statewide communications system; 8) a system of reporting and evaluation; 9) and a written and tested disaster plan at all levels of government.[18]

Today, EMS systems vary from state to state and from locale to locale in their composition. In all EMS systems, trained emergency personnel deliver prehospital care through collaboration with 911 dispatchers, first responders (e.g. fire fighters and police), hospitals and physicians. Certified Emergency Medical Technicians (EMTs) and Paramedics staff a wide range of vehicles from Quick Response Vehicles (QRVs) to Basic Life Support

(BLS) and Advanced Life Support (ALS) ambulances. These vehicles, manned with any combination of first responders, EMTs and Paramedics, are critical in the provision of prehospital emergency health care. Lack of adequate manpower, ambulances, equipment or collaboration with dispatch or medical oversight has the potential to negatively affect patient outcomes.

Determining If EMS Resources Are Adequate

A number of organizations and associations have developed codes, standards and benchmarks for EMS system design and evaluation (e.g., Commission on Accreditation of Ambulance Services [CAAS], The National Fire Protection Agency [NFPA], American Society for Testing and Materials [ASTM]). These recommendations provide guidance for addressing infrastructure issues such as workforce maintenance, system finance and medical oversight.

During the early development of EMS in the 1970s, several academic researchers published methods for evaluating EMS infrastructure and performance. Gibson, in a 1973 publication,[21] recommended that the availability of emergency ambulance vehicles for a given service area using standardized populations (e.g., per 100,000 persons) be calculated using total ambulances vehicles.[21] Recommendations did not, however, include minimum standards. Gibson also supplied process evaluation criteria, dispositional evaluation criteria and criteria for evaluating unmet need for EMS.

In addition to Gibson's proposed methodologies for evaluating EMS infrastructure, EMS planners have relied on "rules of thumb" developed in the early 1970s[22] to allocate EMS resources. The rule of thumb methodologies refer to two demand calculations developed by a group of researchers at the Massachusetts Institute of Technology (MIT).[22] Demand for EMS can be calculated using these methodologies as follows: 35 calls for emergency transport will be generated per one-thousand population per annum; or, one transport per 10,000 population per day.[22]

These rules of thumb and Gibson methodologies may be outdated, having been developed thirty years ago, based on experiences in an urban region in the Northeast.[22] Further, global rules that estimate demand based on population fail to account for differences in demographic and/or geographic factors across communities (e.g., poverty and rural access barriers).

More rigorous assessment techniques for EMS services have been proposed in peer-reviewed publications.[23-27] Sytkowski and associates proposed a statistical approach for the evaluation of rural emergency medical service development that would incorporate EMS system input variables (e.g., number of ambulances), system utilization variables, system process variables (e.g., response times), community factors (e.g., age / race mix) and patient outcomes.[24] However, they never actually applied their model to actual assessment of EMS resource availability.

Although more rigorous than the rule of thumb methodologies, techniques developed by Gibson and Sytkowski and associates' require very detailed EMS system and performance data. Further, an understanding of statistical modeling is essential. These requirements decrease the likelihood that the method could be broadly used at the national, regional and/or

state levels. A simpler method for assessing the availability of EMS services, easily calculated and easy to present to policy makers would have broader use.

Study Goals and Purpose

The purpose of the present study is to begin the development of resource assessment tools for EMS planners. Specifically, the study attempts to:

1. Catalog EMS entities at the local level (county) state-by-state, and

2. Propose a *developmental* indicator of EMS availability for review by EMS administrators, health planners, and academic researchers. This developmental indicator could form a framework for the development of more sophisticated assessment tools, such as those associated with measuring medically underserved areas.

Chapter Two: Theoretical Framework for Measuring the Availability of EMS Resources

Criteria for a Useful Measure

To begin the development of an indicator of EMS availability, we studied parallel indicators in other areas of health care. A review of rural provider availability issues published in 1991 suggested that the most influential measure of health care service gaps in rural and frontier areas was the physician-to-population ratio.[28] The ratio is the key component of the Health Professions Shortage Area (HPSA) measure. One academic researcher refers to the ratio as intuitive, requiring only modest expertise to compute.[28] Data required for calculating physician-to-population ratios are readily available (e.g., the number of licensed/practicing physicians and the population in the area/county), and perhaps more importantly, physician-to-population ratios are easy to present to policymakers and are grounded on access equity.[28] In the current study, we sought to develop an EMS measure with similar simplicity and relevance.

When planning, it was necessary to keep in mind the ways in which EMS care differs from all other forms of health care. A physician or other health care provider works in an office, and patients come to that office. Even mobile clinics, which may park in remote sites, follow the model of a fixed point of service to which patients travel to receive care. For EMS, the point of service is a specially equipped vehicle, generally an ambulance, which reverses the paradigm: it travels to the patient's location. Traditionally, one or more medically trained persons will staff the ambulance. The availability of the ambulance itself is key to the provision of service. We propose that ambulance availability can serve as a measure of EMS resource adequacy, in a manner paralleling the use of physicians per capita as an indicator of office- and hospital-based care availability.

To begin the development of an indicator of EMS availability, we paralleled the factors used to designate Health Professional Shortage Areas (HPSAs) and Medically Underserved Areas (MUAs). Currently, HPSAs and MUAs are designated using the physician-to-population ratio (HPSA and MUA), percent of population living below poverty (MUA), percent of population aged 65 and above (MUA), and five-year infant mortality rate (MUA) (See The Bureau of Health Professions: http://bhpr.hrsa.gov/). We sought a mathematical measure, comparable to the HPSA and MUA that could be easily calculated and easily explained to legislators and citizens. At the same time, we wished to take into consideration demographic and environmental factors shown in scientific research to be associated with utilization of EMS, which include poverty, age distribution, and health care provider availability. To parallel existing measures, as well as to capitalize on available data, we looked at developing an indicator at the county level.

The historical development of the HPSA and MUA designations suggests development of an analogous EMS indicator will take time and evolve through multiple "versions." The original indicator of health care availability across communities was the "Critical Health Manpower Shortage Area" (CHMSA), which dates back to the early 1970s. The CHMSA was solely based on the physician-to-population ratio. From the CHMSA

emerged the Health Professions Shortage Area (HPSA) indicator, which is still based on the physician-to-population ratio. When applied to other medical professions, (i.e., the dental profession), the ratio may not identify need as well as other types of measures.[29] Variables such as land area appear to serve as better measures of need when assessing need for some health care resources.[29]

The Medical Underservice Area (MUA) measure, as noted, includes demographic factors in addition to the presence of medical personnel. These factors are combined and provide a score, which is compared to an index score where zero indicates areas that are completely underserved and scores of 100 indicate areas that are best served. Variables used in the creation of MUAs serve as proxies for access and health care need and are the best available replacement for identifying need and access to care.

To apply appropriate demographic factors to measuring EMS resource availability, we reviewed the literature on EMS use. From the literature, a developmental methodology for identifying availability of EMS care was developed. We chose proxy variables which met several criteria: 1) a best available measure of availability of EMS; 2) highly correlated with utilization of EMS; 3) highly correlated with other measures of access to care; 4) the best available proxy, and 5) available on a national or state level.

In the next section of this report, we describe the elements chosen for the developmental indicator of EMS resource availability. In the following chapter, we illustrate the potential application of the measure, using information from selected states that were able to provide all of the information needed for calculation of the index. Because the measure is developmental, there are numerous limitations to its use and interpretation, which will be outlined in Chapter Four.

Factors Included in the Developmental Indicator of EMS Availability

The developmental indicator of EMS availability examines resources at the county level. In the paragraphs below, we list the key elements incorporated into a mathematical index, **EX**pected Annual Emergency Miles per **AMB**ulance (EXAMB) that can be used to compare EMS availability across counties. Details of the method used in constructing the EXAMB are provided below and in Appendix C; general principles are explained here.

Core EMS Resource: the Ambulance

To compute the developmental indicator, we begin with the ambulance. Because an ambulance must be available to facilitate a majority of EMS services, it is a fundamental component ("provider") in EMS care. In a total availability situation, an ambulance with required EMS personnel will be available for service, covering a county or service area every time a call is received. When total availability is not present, that is, when all ambulances are already engaged in response or transport actions, it is possible an ambulance will have to be obtained from another service or jurisdiction through a mutual aid agreement.

A simple count of ambulances has recognized limitations as a measure of availability. Many ambulances may be licensed but sit unused for various reasons (e.g., maintenance). Counts may include ambulances owned by private or other entities serving non-emergent purposes (e.g., facility-to-facility transports). Further, factors other than demand, such as

personnel shortages or physical wear and tear on ambulance units, can lead to ambulances being effectively unavailable. The developmental analysis offered here focuses on characterizing and comparing services under the assumption that they are staffed and maintained at effective working levels.

Core Resource Availability Assessment Unit: Expected Annual Emergency Miles Per Ambulance (EXAMB)

To estimate demand placed on each ambulance, we use the measure "Expected Annual Emergency Miles Per Ambulance," (EXAMB). Applied to EMS resources with their unique role in health care, annual emergency travel miles per ambulance is analogous to the number of persons per doctor. The measure has particular applicability to rural areas, as miles traveled incorporate both demands for EMS services and the distance an ambulance must drive to meet the demand.

Estimated Demand (Number of Emergency Trips)

An estimate of demand developed in the 1970s,[22] still in use today,[30] suggests that each 10,000 persons generate one EMS call per day. From a county population, we can calculate an estimated number of transports per day by dividing the total population for the county by 10,000. To estimate the number of transports per year we can multiply this number by 365. Because populations can differ in their level of actual need, the EXAMB adjusts for population characteristics; this process will be described below.

Estimated Travel Distances

For rural areas with low population density and large landmass, call estimates based on population alone are an inadequate measure of the requirements placed on each ambulance. A call with a round trip distance of 70 miles will, other things equal, require more time of the EMS ambulance than one of 35 miles. Translating anticipated demand (calls per 10,000 persons) into a measure of distance (miles traveled) is one way of taking into consideration the low population density of rural areas when assessing EMS resource availability. Details of the method used for determining the distance associated with an average call are provided in the box below.

The total county land area in square miles is used to estimate average distance traveled per transport. For example, consider County X with a total land area of 4000 square miles. If we assume the county has a circular shape, then the distance from the center of the county to its outer edge would be 35.7 miles (based on $A=\pi r^2$, where r=radius of a circle). A round-trip from the center of the county to the outer limits would be 71.4 miles. This estimate will be used as the average mileage per transport.

"Average mileage" is an approximation, as actual emergency transports will vary. Using the radius to measure travel distances also involves multiple approximations. First, it calculates the shortest distance possible between point A and point B and thus will underestimate road distances. On the other hand, if a service locates its ambulances at

multiple sites throughout a county to facilitate rapid response, the radius will over-estimate distance traveled.

Given population and land area, one can estimate the average number of miles per year for each ambulance in a county based on the expected annual number of emergency responses and transports and average miles per response and transport. This can be done by multiplying the number of responses and transports by the number of miles per response and transport (total mileage for a year) and dividing by the number of ambulances available for response and transport (see below).

Unadjusted annual mileage per ambulance: $= \frac{365 t_d m}{a} = \frac{365 * (p/10{,}000) m}{a}$ where

t_d is the expected number of emergency transports per day,

m is the expected round trip mileage per transport calculated from total land area,

p is the population of the area, and

a is the number of ambulances available for transport in the county.

Adjusting for Population Characteristics

An unadjusted calculation, such as the one call per 10,000 persons per day rule, neglects disease and access burdens known to predict higher rates of EMS utilization. If the population in a county is sicker, poorer, or has less access to health care providers than that of other counties in a state, then the number of emergency transports per day would be expected to increase. To take these measures into account, we base the expected number of transports on an adjusted population. The adjusted population takes into consideration the percent elderly, percent poverty, mortality and physician availability in the county. Details of the calculation are provided at the end of this section. First, the specific variables used to adjust total population are explained.

A State-Specific Adjustment Process

Adjustment is a comparative process, in which one county is compared to others. For the case studies used to demonstrate the EMS resource availability index, we adjust for county-specific differences within states. For each variable used, we express the value for a particular county as a percentage of that value for the state as a whole. For example, if the state death rate for cerebrovascular disease was 100 per 100,000 persons, and that for a county was 98 deaths per 100,000, the county value would be 98% of the state value. The adjustment process takes into consideration the degree to which an individual county differs from the state as a whole on each of the factors listed below.

Age

Increasing age is highly associated with utilization of EMS.[26,27,30-44] Several studies in particular have identified a noticeable rise in the odds of ambulance utilization by elderly patients compared to non-elderly.[40,41] Older persons are more likely to be repeat users of

EMS,[42] as well as utilize advanced life support services (e.g., ALS) more often than non-elderly persons.[33] To account for the burden of age, the percent elderly (age 65+) in a county relative to its state is included in the adjustment calculation.

Poverty

Low economic status[27,39] (e.g., living in poverty or covered by Medicaid) is another factor identified in many studies[25-27,30,36,39,45,46] as highly associated with utilization of EMS. Persons residing in poorer rural communities call on EMS more often compared to more affluent communities.[36] To account for the burden of poverty on EMS, the percent poverty in each county relative to the state is included in the adjusted calculation.

Population Health

Certain patient conditions, complaints and diagnoses are related to utilization of EMS, so that differences in the prevalence of these markers can affect EMS demand. The most commonly reported reasons for calling on EMS vary by age.[32,34-36,39,43,44,47,48] Among the elderly, transports are more likely to be due to medical conditions than to trauma (e.g., cardiovascular and/or respiratory conditions).[34,35,37,39,42] Among younger age groups, trauma and injury related complaints and conditions are more common.[34,47,48] To account for the both medical and trauma related burdens on EMS, the developmental EMS resource availability indicator incorporates annual death rates for cerebrovascular disease and motor vehicle crashes as proxies for trauma and medical demand.

We recognize that using a death rate, as a measure of disease burden, is an imperfect approach. Death rates, particularly for motor vehicle crashes, are an outcome of EMS availability as well as an element in demand. Crash deaths, for example, depend on driving behaviors and road infrastructure in the county (super-elevation on high speed turns, controlled access, speed limits, signing and signaling), both of which vary across communities and should be included in an index. However, mortality rates also reflect the availability of rapid EMS response, which can reduce the likelihood of death subsequent to a crash. Death rates are more widely available than disease rates or studies of driving behavior, however, leading to their incorporation into this developmental index.

Availability of Health Services Providers

The number of primary and preventive care service providers in rural and frontier areas is proportionately lower, on a per-person basis, than in urban areas.[17] Research shows use of emergency department services is inversely related to the availability of primary care practitioners.[49] It is believed that rural EMS utilization can be reduced with adequate access to primary care services or alternative means of transportation.[50] To account for access and availability of primary care services, the developmental indicator uses physician rate per 100,000 population for the state relative to physician rate per 100,000 for the county is included. This ratio (state-to-county) is the inverse of the previous ratios used, as it is greater than 1 if the rate in the county is less than the state average. Calculation of the ratio this way would indicate a lack of health care resources.

Mathematical Correction Factors

For counties with counts of zero practitioners, zero cerebrovascular deaths or zero motor vehicle crash deaths, a very small value of (0.5) has been used in place of zero as a correction factor.

Calculating the EXAMB Index

All adjustment factors were measured for the years closest to the date of data collection from the state EMS agencies. County data on population age, health and demographics, plusmotor vehicle crash deaths, were obtained from the Area Resource File. Information on ambulance availability in individual counties was obtained from State EMS agencies, either through their response to a specific request or, with permission, downloaded from state web sites. Construction of the developmental indicator includes the following:

- Cerebrovascular disease death ratio (CBDr): average 1998-2000 annual cerebrovascular disease death rate (per 100,000) in the county relative to the state death rate (per 100,000)
- Motor vehicle crash death ratio (MVCr): average 1998-2000 annual motor vehicle crash death rate (per 100,000) in the county relative the state death rate (per 100,000)
- Poverty ratio (POVr): 1999 percent poverty in the county relative to the state percent poverty
- Elderly ratio (ELDr): 2000-2001 percent elderly (65+ years) in the county relative to the state percent elderly
- Physician ratio (PHYr): 2001 physician ratio in the state relative to the physician ratio in the county.

The final indicator was calculated as follows:

$$\text{Adjusted annual mileage per ambulance: } = \frac{365 t_{d^*} m}{a} = \frac{365 * \left(p^* / 10{,}000\right) m}{a}$$

where t_{d^*} is the adjusted expected number of transports per day, m is the expected round trip mileage per transport calculated from total land area, p^* is the adjusted population of the area, and a is the number of ambulances available for transport in the county. The adjusted population is calculated as follows:

Adjusted Population = p^*= (Population 2000) * CBDr * MVCr * POVr * ELDr * PHYr

Interpreting the EXAMB Index

Because of the developmental nature of the current analysis, no cut points are provided to flag counties with “good” or “bad” EXAMB indicator values. Extremely low or high indicator values have very different interpretations. Very low EXAMB values could indicate low emergency transport volume per ambulance, which can negatively affect system

revenue. Very high EXAMB values could indicate high emergency transport volumes per ambulance, which could negatively affect system performance and quality (i.e., workforce retention, and ambulance availability). We use the extremely low or high indicators (EXAMB) to identify counties needing further assessment.

For each state where data were available [Mississippi, Oregon, South Carolina, Washington, and Wyoming], we performed correlation analyses of demographic factors to identify which indicators could be treated as independent variables and which combinations of factors may over-represent the same underlying factor. We also compared the average and median EXAMB indicators for rural and urban counties within each state.

Chapter Three: Applying the EMS Resource Availability Index, Case Studies

To begin the assessment of EMS resource availability, the South Carolina Rural Health Research Center requested information regarding EMS coverage from state EMS offices nationwide [Appendix A]. EMS resource information was obtained via survey or Internet resources from twenty state EMS regulatory agencies. Because EMS administration is not nationally standardized, not all states had information on all services and resources within those services available in a common format or in computerized form.

Five states, Mississippi, Oregon, South Carolina, Washington, and Wyoming, were able to supply the Center with information down to the number of ambulances functioning in a county. We use the data from those states to illustrate how the developmental EMS resource availability indicator could be implemented, and to demonstrate indicator results (see below).

Mississippi

In Mississippi, the median "Expected Annual Emergency Miles Per Ambulance" (EXAMB) across all counties is 8,435 miles and ranges from a low of 579 miles to 108,412 miles (see table below). The lowest six EXAMB values in Mississippi range from 579 miles in Tunica County to 1,880 miles in Montgomery County. These low values appear to be driven by higher than average physician availability, lower than average mortality rates from cerebrovascular disease and motor vehicle crashes, and younger populations in these counties as compared to other Mississippi counties.

The highest five EXAMB values range from 67,573 miles in Marshall County to 108,412 miles in Tallahatchie County. These high values are largely driven by low physician availability, reflected in the state-to-county MD ratios. If physician availability in Benton County were increased to meet the state average, for example, this change would decrease the EXAMB to 22,472. Alternatively, adding one additional ambulance to the available resources in Benton County would reduce the EXAMB to 48,316, a reduction in the expected annual emergency miles per ambulance by half.

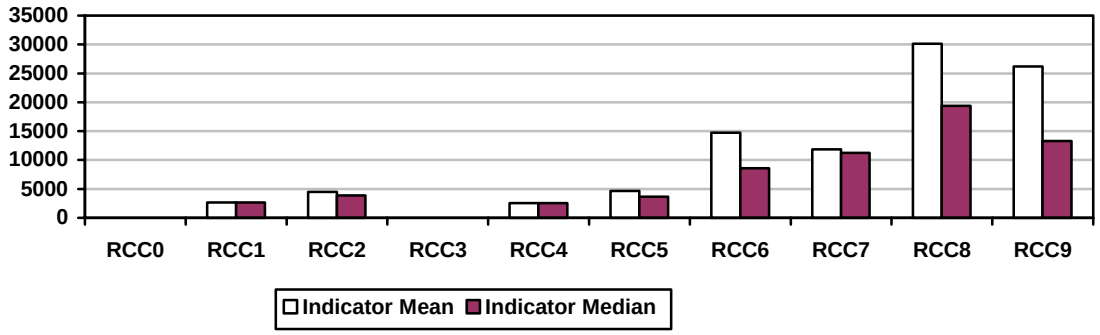
Across all urban Mississippi counties (n=7) the median EXAMB is 3,248 miles, while across all rural counties (n=74, minus one) the median EXAMB is 9,524 miles; almost three times larger. In general, as counties become more rural, based on the Rural-Urban Continuum Code, the EXAMB Index increases (see table and graph below).

Expected Annual Emergency Miles Per Ambulance Across Different Levels of the Rural-Urban Continuum Code

Rural – Urban Continuum Code Breakdown	# of counties	Indicator Average	Indicator Median
Urban	7	4,239	3,248
0 – Central counties of metro areas of 1 million or more	--	--	--
1 – Fringe counties of metro areas of 1 million or more	1	2,670	2,670
2 – Counties in metro areas of 250k – 1 million population	6	4,501	3,899
3 – Counties in metro areas of less than 250k population	--	--	--
Rural	74	16,280	9,524
4 – Urban pop of 20k or more, adjacent to a metro area	1	2,523	2,523
5 – Urban pop of 20k or more, not adjacent to a metro area	7	4,634	3,658
6 – Urban pop of 2.5k – 19,999, adjacent to a metro area	13	14,709	8,562
7 – Urban pop of 2.5k – 19,999, not adjacent to a metro area	30	11,877	11,269
8 – Completely rural (no places with a pop of 2,500 or more) adjacent to a metro area	5	30,111	19,402
9 – Completely rural (no places with a pop of 2,500 or more) not adjacent to a metro area	18*	26,207	13,309

* Issaquena County has indicated it has no ambulances and thus is excluded from this analysis.

Expected Annual Emergency Miles Per Ambulance Across Different Levels of The Rural-Urban Continuum Code



In Mississippi, the EXAMB appears to parallel measures used in other indicators of health care availability. For example, HPSAs use physician-to-population ratios to identify areas of low health access and practitioner availability. Findings from the current study provide similar indications of low availability. As the availability of physicians decreases in a county, the EXAMB increases, suggesting lower availability of primary and emergency health care services.

Another way of analyzing the EXAMB is by comparing the indicator across counties based on their Health Professions Shortage Areas (HPSAs) designation. When stratified, the EXAMB is higher in counties identified as whole HPSAs compared to partial or not HPSA counties.

Expected Annual Emergency Miles Per Ambulances Across Health Professional Shortage Designations (HPSAs)

HPSA	# of Counties	Indicator Average	Indicator Median
Not a HPSA	19	7,640	6,315
Partial County HPSA	11	7,602	4,550
Whole County HPSA	51*	19,718	11,387

* Issaquena County has indicated it has no ambulances and thus is excluded from this analysis.

Mississippi Simple Statistics

Variable	COUNTIES (N)	Mean	Std. Dev.	Median	Minimum	Maximum
EXAMB	81*	15,240	20,869	8,435	579.25	108,412
MD CO RATE	82	25.19	12.55	24.13	2.85	73.83
AMB / 100K	82	20.45	24.74	15.37	0	205.91
RUCCODE	82	6.71	1.95	7.00	1.00	9.00
TOTAL AREA	82	590.61	154.82	575.61	401.35	1,043
POP DENS	82	59.36	56.68	45.35	5.50	326.30
% MINORITY	82	41.50	19.76	39.60	5.10	86.90
% ELDERLY	82	12.87	1.98	12.98	8.68	17.08
CVD RATE	82	24.26	8.24	22.27	11.27	54.44
MVC RATE	82	12.81	4.11	12.75	5.43	26.35
% POVERTY	82	20.22	5.55	19.05	8.20	35.70
2000 CENSUS	82	34,691	38,538	22,375	2,274	250,800

***** Indicates a 0 value for the number of trucks.

SPEARMAN CORR	EXAMB	MD RATE	AMB / 100K	RUC-CODE	LAND AREA	POP DENS	% MINORITY	% ELDERLY	CVD RATE	MVC RATE	% Poverty
MD CO RATE	-0.521*	1.000									
AMB / 100K	-0.359*	0.030	1.000								
RUCCODE	0.441*	-0.267*	-0.058	1.000							
LAND AREA	0.113	-0.030	-0.168	-0.328*	1.000						
POP DENS	-0.441*	0.234*	-0.016	-0.770*	0.060	1.000					
% MINORITY	0.267*	-0.143	0.134	0.254*	0.115	-0.322*	1.000				
% ELDERLY	0.173	0.058	0.334*	0.263*	-0.246*	-0.244*	-0.234*	1.000			
CVD RATE	0.294*	0.143	0.319*	0.107	-0.153	-0.053	0.058	0.468*	1.000		
MVC RATE	0.493*	-0.155	0.187	0.277*	-0.274*	-0.404*	0.074	0.363*	0.196	1.000	
% POVERTY	0.361*	-0.112	0.118	0.398*	0.014	-0.490*	0.844*	-0.082	0.123	0.181	1.000
2000 CENSUS	-0.353*	0.217	-0.076	-0.817*	0.377*	0.932*	-0.252*	-0.303*	-0.077	-0.448*	-0.423*

***** Indicates significant at a p-value of 0.05.
Note: correlations are based on an N=81.

EXAMB – Expected Annual Emergency Miles Per Ambulance, **MD CO RATE** – Rate of general practitioners per 100,000 population, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **LAND AREA** – Total land area in square miles, **POP DENS** – Population density by square mileage, **% MINORITY** – County percent minority, **% ELDERLY** - County percent elderly (65+), **CVD RATE** – County annual cerebrovascular mortality rate per 100,000 (1998-2000), **MVC RATE** - County annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County percent poverty ratio, **2000 CENSUS** – 2000 Census population.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Mississippi)

COUNTY NAME	EXAMB	2000 CENSUS	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Tunica	579	9227	19	8	1	10.8	2.5	0.8	0.6	1.2	20.3	0.8
Adams	727	34340	35	7	0	40.8	0.7	1.4	0.6	1.2	74.6	1.3
Oktibbeha	1528	42902	5	7	0	35.0	0.8	0.8	0.5	0.9	93.7	0.7
Rankin	1581	115327	11	2	2	38.2	0.7	0.5	0.8	0.5	148.9	0.8
Forrest	1591	72604	14	5	2	59.2	0.5	1.1	0.7	1.0	155.6	0.9
Montgomery	1880	12189	6	7	1	73.8	0.4	1.7	1.2	1.1	30.0	1.3
Warren	2524	49644	12	4	2	28.2	1.0	1.2	0.6	0.9	84.6	0.9
DeSoto	2670	107199	15	1	1	12.1	2.2	0.6	0.9	0.4	224.3	0.8
Lafayette	2955	38744	4	7	0	36.1	0.7	0.8	0.8	0.7	61.4	0.8
Madison	2978	74674	5	2	1	49.5	0.5	1.0	0.6	0.7	104.1	0.9
Webster	3179	10294	3	9	1	48.6	0.6	1.8	0.9	0.9	24.4	1.4
Stone	3232	13622	1	6	0	29.4	0.9	0.6	0.7	0.8	30.6	1.0
Hancock	3248	42967	15	2	1	16.3	1.7	0.7	1.2	0.8	90.1	1.2
Lee	3250	75755	12	5	0	33.0	0.8	1.3	0.9	0.7	168.5	1.0
Lowndes	3475	61586	8	5	0	24.4	1.1	0.9	0.6	0.9	122.6	0.9
Jones	3659	64958	15	5	2	26.2	1.0	0.9	0.8	0.9	93.6	1.2
Tate	4214	25370	5	6	1	23.6	1.1	0.8	1.7	0.7	62.7	1.0
Lauderdale	4310	78161	15	5	2	33.3	0.8	0.9	1.0	0.9	111.1	1.2
Hinds	4550	250800	38	2	2	32.3	0.8	0.9	0.9	1.0	288.5	0.9
Tishomingo	4695	19163	5	6	0	47.0	0.6	1.6	1.6	0.7	45.2	1.4
Prentiss	4719	25556	5	7	1	19.6	1.4	0.9	1.1	0.7	61.6	1.1
Neshoba	5466	28684	12	7	1	24.4	1.1	1.4	1.4	0.9	50.3	1.2
Leake	5634	20940	8	6	1	19.1	1.4	1.0	1.3	1.0	35.9	1.2
Attala	5790	19661	5	6	0	55.9	0.5	1.5	1.2	1.0	26.7	1.4
Jackson	5925	131420	12	2	2	25.1	1.1	0.8	0.8	0.7	180.8	0.9
Choctaw	6154	9758	1	9	0	30.7	0.9	0.8	0.9	1.0	23.3	1.2
Clay	6252	21979	5	7	1	13.6	2.0	1.0	0.8	1.0	53.8	1.1
Pontotoc	6315	26726	2	7	0	33.7	0.8	0.9	1.1	0.6	53.7	1.1
Wayne	6409	21216	5	7	1	14.1	1.9	0.8	0.8	1.1	26.2	1.0
Jasper	6553	18149	9	9	1	11.0	2.4	1.2	1.0	0.9	26.8	1.1

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Mississippi)

COUNTY NAME	EXAMB	2000 CENSUS	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Noxubee	6584	12548	3	9	1	23.9	1.1	0.7	1.2	1.4	18.1	1.0
Tippah	6608	20826	4	7	1	28.8	0.9	1.3	1.3	0.8	45.5	1.2
Pike	6796	38940	7	7	0	25.7	1.0	1.0	1.0	1.2	95.2	1.2
Franklin	6901	8448	2	9	0	23.7	1.1	0.7	1.8	0.9	15.0	1.2
Lawrence	7141	13258	4	9	1	30.2	0.9	1.1	2.3	1.0	30.8	1.1
Humphreys	7452	11206	3	7	1	26.8	1.0	0.9	1.6	1.6	26.8	0.9
Bolivar	7530	40633	6	5	0	32.0	0.8	0.9	1.0	1.4	46.4	0.9
Wilkinson	7657	10312	2	9	1	29.1	0.9	1.0	0.9	1.5	15.2	1.1
Copiah	8014	28757	3	6	1	45.2	0.6	0.9	1.1	1.1	37.0	1.1
Union	8263	25362	3	7	0	27.6	1.0	1.5	1.1	0.6	61.0	1.2
Alcorn	8435	34558	6	7	0	28.9	0.9	1.6	1.2	0.8	86.4	1.2
George	8562	19144	3	6	1	20.9	1.3	0.9	1.7	0.8	40.0	0.9
Washington	8630	62977	15	5	0	19.1	1.4	1.0	1.0	1.4	87.0	0.9
Harrison	8726	189601	14	2	2	18.5	1.5	0.7	0.7	0.7	326.3	0.9
Perry	10418	12138	1	9	1	24.7	1.1	1.1	0.7	1.0	18.8	0.9
Pearl River	10698	48621	6	6	1	18.5	1.5	0.7	1.0	0.9	59.9	1.1
Greene	10751	13299	1	8	1	15.0	1.8	0.6	0.9	1.0	18.7	0.8
Itawamba	11151	22770	2	7	1	35.1	0.8	1.0	1.7	0.7	42.8	1.2
Scott	11324	28423	4	6	1	21.1	1.3	0.9	1.5	0.9	46.7	1.0
Lamar	11387	39070	3	7	1	15.4	1.8	1.0	0.9	0.7	78.6	0.8
Simpson	11562	27639	4	6	2	32.6	0.8	1.2	1.6	1.0	46.9	1.1
Quitman	11667	10117	2	9	1	29.7	0.9	0.9	2.4	1.4	25.0	1.0
Monroe	12052	38014	6	7	2	18.4	1.5	1.1	1.1	0.8	49.7	1.2
Chickasaw	12857	19440	3	7	1	15.4	1.7	1.0	1.2	0.9	38.8	1.1
Newton	12885	21838	4	7	1	18.3	1.5	1.2	1.2	0.9	37.8	1.3
Holmes	13279	21609	5	6	1	41.6	0.6	1.5	1.5	1.8	28.6	1.0
Covington	13559	19407	3	7	1	15.5	1.7	0.8	1.7	1.0	46.9	1.1
Leflore	14088	37947	4	7	0	18.4	1.5	1.2	0.6	1.4	64.1	0.9
Sunflower	14301	34369	2	7	1	37.8	0.7	1.0	1.0	1.5	49.5	0.8
Sharkey	14953	6580	3	9	1	15.2	1.8	1.6	1.8	1.7	15.4	0.9

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Mississippi)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Carroll	15219	10769	1	9	1	18.6	1.4	0.8	1.1	0.9	17.2	1.1
Grenada	15293	23263	5	7	0	17.2	1.6	2.5	0.9	0.9	55.2	1.2
Panola	15885	34274	5	7	1	26.3	1.0	1.4	1.4	1.1	50.1	1.0
Jefferson	16102	9740	1	9	1	20.5	1.3	0.9	1.2	1.3	18.8	0.9
Calhoun	17334	15069	3	9	1	26.5	1.0	2.4	1.2	0.9	25.7	1.4
Winston	17899	20160	3	7	1	24.8	1.1	1.4	1.3	1.0	33.2	1.2
Claiborne	19403	11831	1	8	1	16.9	1.6	1.0	1.0	1.3	24.3	0.8
Clarke	19676	17955	3	7	1	16.7	1.6	1.3	1.2	1.0	26.0	1.3
Walthall	22973	15156	1	9	1	26.4	1.0	1.1	1.2	1.2	37.5	1.2
Smith	23190	16182	1	8	1	24.7	1.1	1.2	1.1	0.8	25.4	1.2
Marion	25390	25595	3	7	1	23.4	1.1	1.6	1.2	1.2	47.2	1.2
Coahoma	27152	30622	5	7	2	13.1	2.1	1.2	1.3	1.5	55.3	1.0
Yalobusha	27816	13051	2	7	1	15.3	1.8	1.3	1.6	1.0	27.9	1.3
Lincoln	31121	33166	4	7	0	15.1	1.8	1.7	1.2	0.9	56.6	1.1
Yazoo	36641	28149	3	6	1	21.3	1.3	1.4	1.2	1.5	30.6	1.0
Jefferson Davis	39655	13962	1	9	1	14.3	1.9	0.8	1.7	1.2	34.2	1.1
Marshall	67573	34993	8	6	1	2.9	9.4	1.2	1.5	0.9	49.5	0.9
Amite	77903	13599	2	9	1	3.7	7.3	0.9	1.3	1.0	18.6	1.2
Kemper	92930	10453	1	9	1	4.8	5.6	0.9	1.1	1.1	13.6	1.2
Benton	96633	8026	1	8	1	6.2	4.3	1.7	1.5	1.0	19.7	1.3
Tallahatchie	108412	14903	1	9	1	6.7	4.0	1.0	1.2	1.4	23.1	1.0
Issaquena		2274	0	9	1	22.0	1.2	0.7	1.3	1.5	5.5	0.9

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

Oregon

In Oregon, the median "Expected Annual Emergency Miles Per Ambulance" (EXAMB) is 11,309 miles and ranges from a low of 1,146 miles to 63,801 miles (see tables below). The lowest five EXAMB values (1,146 – 4,583) are in counties with higher physician availability, lower cerebrovascular disease mortality rates, and lower poverty than the Oregon average. The highest five EXAMB values (34,808 – 63,800) are in counties where all factors contributing to the adjusted population calculation are worse compared to state values (i.e., all ratios except two are greater than 1.0).

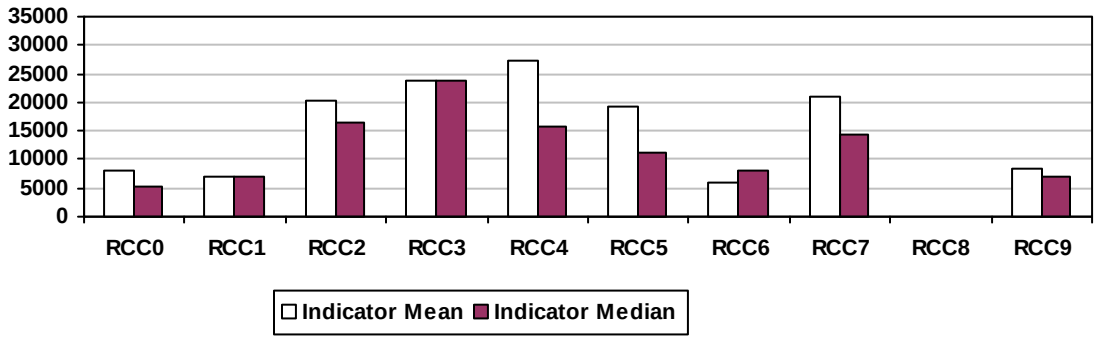
Malheur County, for example, has the highest EXAMB value in Oregon. However, if Malheur County were to increase physician availability to the state average, and to decrease the poverty to the state average, the EXAMB value for the county would drop to 26,583 miles. A similar decrease in the EXAMB could result with an increase in the number of available ambulances. By adding one ambulance, the EXAMB for Malheur County decreases from 63,800 miles to 57,420 miles per ambulance per annum.

Across all urban counties (n=9) the median EXAMB is 13,913 miles, while across all rural counties (n=27) the median EXAMB is 11,108 miles. Rural Oregon counties with an urban population of 20,000 or more, adjacent to a metropolitan area possess the highest average EXAMB at 27,180 and the second highest median value of 15,665 (see tables below).

Expected Annual Emergency Miles Per Ambulance Across Different Levels of The Rural-Urban Continuum Code

Rural – Urban Continuum Code Breakdown	# of counties	Indicator Average	Indicator Median
Urban	9	13,667	13,913
0 – Central counties of metro areas of 1 million or more	3	8,014	5,375
1 – Fringe counties of metro areas of 1 million or more	2	6,835	6,835
2 – Counties in metro areas of 250k – 1 million population	3	20,443	16,284
3 – Counties in metro areas of less than 250k population	1	23,956	23,956
Rural	27	17,550	11,108
4 – Urban pop of 20k or more, adjacent to a metro area	5	27,180	15,665
5 – Urban pop of 20k or more, not adjacent to a metro area	3	19,363	11,108
6 – Urban pop of 2.5k – 19,999, adjacent to a metro area	3	5,969	8,101
7 – Urban pop of 2.5k – 19,999, not adjacent to a metro area	10	21,124	14,204
8 – Completely rural (no places with a pop of 2,500 or more) adjacent to a metro area	---	---	---
9 – Completely rural (no places with a pop of 2,500 or more) not adjacent to a metro area	6	8,451	6,950

Expected Annual Emergency Miles Per Ambulance Across Different Levels of The Rural-Urban Continuum Code



In Oregon, the EXAMB appears to parallel measures used in other indicators of health care availability. For example, MUAs use percentage of population living below poverty in an index designed to identify areas medical under service. Findings from the current study correlate well with percent poverty. The significant correlation can be interpreted as: As the percentage of persons living below the federal poverty level increases, the EXAMB increases. This significant finding combined with the significance of total land area with EXAMB suggests certain areas of Oregon are likely to experience lower availability of primary and emergency health care services (see tables below).

Another way of analyzing the EXAMB is by comparing values across the Health Professions Shortage Area (HPSAs) designation. When stratified, the median EXAMB is higher in counties identified as non-HPSAs compared to whole or partial. This finding should be interpreted with caution because the non-HPSA and whole HPSA findings are based on 4 and 2 counties, respectively.

Expected Annual Emergency Miles Per Ambulances Across Health Professional Shortage Designations (HPSAs)

HPSA	# of Counties	Indicator Average	Indicator Median
Not a HPSA	4	14,640	14,986
Partial County HPSA	30	17,441	11,077
Whole County HPSA	2	7,527	7,527

See tables below for a county-level breakdown of the Expected Annual Emergency Miles per Ambulance (EXAMB) compared to:

- The Rural Urban Continuum Code
- Health Professions Shortage Designation
- State-to-County physician rate per 100,000 population
- County-to-State cerebrovascular disease death rate per 100,000 population
- County-to-State motor vehicle crash death rate per 100,000 population
- Population density
- County-to-State percent elderly population ratio

Oregon Simple Statistics

Variable	COUNTIES (N)	Mean	Std. Dev.	Median	Minimum	Maximum
EXAMB	36	16,580	15,084	11,309	1,146	63,801
MD CO RATE	36	37.53	19.22	33.95	9.09	112.68
AMB / 100K	36	45.56	56.50	25.08	5.61	258.56
RUCCODE	36	5.22	2.82	6.00	0.00	9.00
TOTAL AREA	36	2,733	2,490	1,934	465.65	10,226
POP DENS	36	97.85	266.75	21.95	0.80	1518
% MINORITY	36	10.71	6.76	8.25	3.20	31.00
% ELDERLY	36	15.56	3.73	15.17	9.16	26.10
CVD RATE	36	28.53	7.77	28.10	15.15	43.09
MVC RATE	36	7.01	3.56	5.86	2.99	17.53
% POVERTY	36	12.50	2.57	13.00	7.10	18.60
2000 CENSUS	36	95,039	143,656	39,595	1,547	660,486

SPEARMAN CORR	EXAMB	MD RATE	AMB / 100K	RUC-CODE	LAND AREA	POP DENS	% MINORITY	% ELDERLY	CVD RATE	MVC RATE	% Poverty
MD CO RATE	-0.259	1.000									
AMB / 100K	-0.217	0.131	1.000								
RUCCODE	-0.081	0.096	0.854*	1.000							
LAND AREA	0.500*	0.119	0.287	0.331*	1.000						
POP DENS	0.025	-0.153	-0.868*	-0.900*	-0.576*	1.000					
% MINORITY	0.011	-0.242	-0.290	-0.299	-0.147	0.314	1.000				
% ELDERLY	0.208	0.326	0.491*	0.531*	0.257	-0.498*	-0.589*	1.000			
CVD RATE	0.258	0.274	0.308	0.306	0.064	-0.216	-0.401*	0.760*	1.000		
MVC RATE	0.196	0.042	0.707*	0.665*	0.383*	-0.753*	-0.128	0.402*	0.232	1.000	
% POVERTY	0.447*	0.173	0.299	0.319	0.517*	-0.386*	0.027	0.430*	0.257	0.399*	1.000
2000 CENSUS	0.243	-0.162	-0.892*	-0.904*	-0.188	0.879*	0.308	-0.496*	-0.267	-0.668*	-0.213

***** Indicates significant at a p-value of 0.05.

EXAMB – Expected Annual Emergency Miles Per Ambulance, **MD CO RATE** – Rate of general practitioners per 100,000 population, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **LAND AREA** – Total land area in square miles, **POP DENS** – Population density by square mileage, **% MINORITY** – County percent minority, **% ELDERLY** - County percent elderly (65+), **CVD RATE** – County annual cerebrovascular mortality rate per 100,000 (1998-2000), **MVC RATE** - County annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County percent poverty ratio, **2000 CENSUS** – 2000 Census population.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Oregon)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Hood River	1146	20411	6	6	2	112.7	0.3	0.8	1.4	1.1	39.1	1.0
Gilliam	1267	1915	4	9	2	52.2	0.6	1.3	1.8	0.8	1.6	1.5
Wheeler	3546	1547	4	9	1	32.3	1.0	1.7	2.3	0.8	0.9	1.8
Lake	4573	7422	9	7	2	80.8	0.4	1.0	1.9	1.3	0.9	1.4
Multnomah	4583	660486	70	0	2	35.6	0.9	0.9	0.7	1.0	1517.6	0.9
Benton	5150	78153	5	4	2	40.9	0.8	0.8	0.7	0.8	115.5	0.8
Washington	5376	445342	25	0	2	23.8	1.4	0.7	0.6	0.6	615.3	0.7
Yamhill	5704	84992	14	1	2	31.8	1.1	0.9	1.2	0.8	118.8	0.9
Morrow	5845	10995	7	9	2	9.1	3.7	0.6	1.3	0.9	5.4	0.8
Baker	6233	16741	7	7	2	59.7	0.6	1.2	0.8	1.3	5.5	1.5
Columbia	7967	43560	13	1	2	9.2	3.7	0.8	1.1	0.8	66.3	0.9
Sherman	8056	1934	3	9	2	25.9	1.3	1.3	3.6	1.2	2.3	1.4
Clatsop	8102	35630	9	6	0	39.3	0.9	1.2	1.2	1.1	43.1	1.2
Tillamook	8661	24262	6	6	2	53.6	0.6	1.2	1.2	1.1	22.0	1.5
Union	9958	24530	6	7	2	24.5	1.4	0.8	0.9	1.1	12.0	1.2
Curry	10197	21137	11	7	2	42.6	0.8	1.6	1.0	1.1	13.0	2.0
Klamath	11047	63775	25	5	2	64.3	0.5	1.1	1.4	1.4	10.7	1.2
Deschutes	11108	115367	21	5	2	36.4	0.9	0.9	1.2	0.9	38.2	1.1
Grant	11510	7935	7	9	1	37.8	0.9	1.5	1.8	1.2	1.8	1.3
Umatilla	13384	70548	13	4	2	29.8	1.1	0.7	1.2	1.2	21.9	1.0
Polk	13913	62380	6	2	2	32.1	1.0	1.4	0.8	0.9	84.2	1.2
Clackamas	14085	338391	25	0	2	21.3	1.6	0.9	0.8	0.6	181.1	0.9
Jefferson	14101	19009	11	7	2	26.3	1.3	0.8	3.7	1.2	10.7	1.0
Crook	14307	19182	4	7	0	31.3	1.1	0.7	1.5	1.0	6.4	1.2
Linn	15666	103069	17	4	0	44.6	0.8	1.2	1.2	1.0	45.0	1.1
Marion	16285	284834	34	2	2	38.3	0.9	1.4	1.0	1.1	240.6	1.0
Wallowa	20488	7226	5	9	0	41.5	0.8	1.6	2.9	1.1	2.3	1.5
Lincoln	22026	44479	12	7	2	24.7	1.4	1.4	1.3	1.2	45.4	1.5
Jackson	23957	181269	36	3	2	30.3	1.1	1.3	1.0	1.2	65.1	1.3
Lane	31134	322959	28	2	2	41.8	0.8	0.9	1.1	1.1	70.9	1.0

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Oregon)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Wasco	31243	23791	7	7	2	21.0	1.6	1.3	1.5	1.1	10.0	1.3
Harney	34808	7609	3	7	2	39.4	0.9	1.0	2.8	1.2	0.8	1.2
Coos	35935	62779	12	5	2	27.1	1.2	1.3	1.2	1.3	39.2	1.5
Douglas	42599	100399	25	4	2	28.9	1.2	1.0	1.9	1.2	19.9	1.4
Josephine	59104	75726	9	4	2	38.3	0.9	1.5	1.5	1.4	46.2	1.6
Malheur	63801	31615	9	7	2	22.1	1.5	1.0	1.8	1.6	3.2	1.1

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

South Carolina

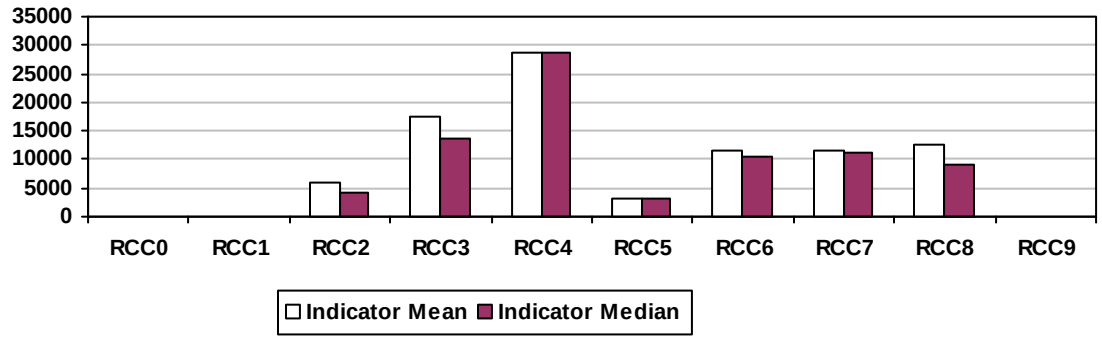
In South Carolina, the median "Expected Annual Emergency Miles Per Ambulance" (EXAMB) is 10,793 miles and ranges from a low of 1,177 miles to 48,762 miles (see tables below). The lowest five EXAMB values range from 1,177 to 2,535, and belong to counties with higher physician availability, lower motor vehicle crash deaths and lower poverty when compared to other South Carolina counties. The counties with the highest EXAMB values (McCormick, Lee, Williamsburg, Sumter and Orangeburg Counties) have low physician availability, and fall below the state average on several other measures.

Across all urban counties (n=16) the median EXAMB is 4,286 miles, while across all rural counties (n=30) the median EXAMB is 9,143 miles, a difference of 213%. Rural South Carolina counties with an urban population of 20,000 or more, and adjacent to a metropolitan area possess the highest average and median EXAMB (see tables below).

Expected Annual Emergency Miles Per Ambulance Across Different Levels of The Rural-Urban Continuum Code

Rural – Urban Continuum Code Breakdown	# of counties	Indicator Average	Indicator Median
Urban	16	7,948	4,286
0 – Central counties of metro areas of 1 million or more	---	---	---
1 – Fringe counties of metro areas of 1 million or more	---	---	---
2 – Counties in metro areas of 250k – 1 million population	13	5,778	4,191
3 – Counties in metro areas of less than 250k population	3	17,348	13,793
Rural	30	12,309	9,143
4 – Urban pop of 20k or more, adjacent to a metro area	2	28,800	28,800
5 – Urban pop of 20k or more, not adjacent to a metro area	2	3,082	3,082
6 – Urban pop of 2.5k – 19,999, adjacent to a metro area	19	11,615	10,576
7 – Urban pop of 2.5k – 19,999, not adjacent to a metro area	4	11,658	11,358
8 – Completely rural (no places with a pop of 2,500 or more) adjacent to a metro area	3	12,726	9,196
9 – Completely rural (no places with a pop of 2,500 or more) not adjacent to a metro area	---	---	---

Expected Annual Emergency Miles Per Ambulance Across Different Levels of The Rural-Urban Continuum Code



In South Carolina, the EXAMB appears to parallel other indicators of health care availability. For example, HPSAs use physician-to-population ratios to identify areas of low health access and practitioner availability. EXAMB is negatively associated with physician availability, i.e., as the availability of physicians decreases in a county, the EXAMB increases, suggesting lower availability of primary and emergency health care services (see tables below). The EXAMB is positively associated with the percentage of minorities, persons living in poverty and persons of elder age (65+) and both mortality rates of cerebrovascular disease and motor vehicle crashes. The indicator is negatively associated with population density and overall population.

Another way of analyzing the EXAMB is by comparing the indicator across the Health Professions Shortage Areas (HPSAs) designation. When stratified, the EXAMB is higher in counties identified as whole HPSAs compared to partial or no HPSAs.

Expected Annual Emergency Miles Per Ambulances Across Health Professional Shortage Designations (HPSAs)

HPSA	# of Counties	Indicator Average	Indicator Median
Not a HPSA	3	6,699	6,222
Partial County HPSA	32	9,936	7,842
Whole County HPSA	11	14,399	12,954

See tables below for a county-level breakdown of the Expected Annual Emergency Miles per Ambulance (EXAMB) compared to:

- The Rural Urban Continuum Code
- Health Professions Shortage Designation
- State-to-County physician rate per 100,000 population
- County-to-State cerebrovascular disease death rate per 100,000 population
- County-to-State motor vehicle crash death rate per 100,000 population
- Population density
- County-to-State percent elderly population ratio

South Carolina Simple Statistics

Variable	COUNTIES (N)	Mean	Std. Dev.	Median	Minimum	Maximum
EXAMB	46	10,793	9,349	8,282	1,177	48,762
MD CO RATE	46	31.91	15.62	27.57	11.917	102.60
AMB / 100K	46	25.28	12.22	25.34	8.297	68.78
RUCCODE	46	4.76	2.05	6.00	2.000	8.00
TOTAL AREA	46	696.09	253.45	677.80	392.34	1,358
POP DENS	46	123.11	107.79	74.20	27.500	480.50
% MINORITY	46	40.01	15.93	39.10	9.700	72.60
% ELDERLY	46	12.90	1.83	12.73	8.496	17.42
CVD RATE	46	26.44	7.44	24.93	13.552	48.02
MVC RATE	46	10.02	3.33	9.50	3.821	19.66
% POVERTY	46	15.54	4.43	14.50	9.500	28.50
2000 CENSUS	46	87,218	89,056	52,592	9,958	379,616

SPEARMAN CORR	EXAMB	MD RATE	AMB / 100K	RUC-CODE	LAND AREA	POP DENS	% MINORITY	% ELDERLY	CVD RATE	MVC RATE	% Poverty
MD CO RATE	-0.568*	1.000									
AMB / 100K	-0.214	-0.132	1.000								
RUCCODE	0.401*	-0.280	0.423*	1.000							
LAND AREA	0.092	0.128	-0.308*	-0.454*	1.000						
POP DENS	-0.447*	0.380*	-0.369*	-0.836*	0.414*	1.000					
% MINORITY	0.450*	-0.279	0.329*	0.595*	-0.270	-0.677*	1.000				
% ELDERLY	0.108	0.124	0.137	0.407*	-0.069	-0.313*	-0.020	1.000			
CVD RATE	0.256	0.089	0.216	0.250	-0.165	-0.164	0.351*	0.182	1.000		
MVC RATE	0.544*	-0.234	0.315*	0.522*	-0.178	-0.596*	0.431*	0.113	0.041	1.000	
% POVERTY	0.478*	-0.257	0.478*	0.609*	-0.280	-0.679*	0.886*	0.023	0.398*	0.556*	1.000
2000 CENSUS	-0.311*	0.365*	-0.453*	-0.837*	0.694*	0.929*	-0.642*	-0.290	-0.207	-0.527*	-0.645*

***** Indicates significant at a p-value of 0.05.

EXAMB – Expected Annual Emergency Miles Per Ambulance, **MD CO RATE** – Rate of general practitioners per 100,000 population, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **LAND AREA** – Total land area in square miles, **POP DENS** – Population density by square mileage, **% MINORITY** – County percent minority, **% ELDERLY** - County percent elderly (65+), **CVD RATE** – County annual cerebrovascular mortality rate per 100,000 (1998-2000), **MVC RATE** - County annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County percent poverty ratio, **2000 CENSUS** – 2000 Census population.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (South Carolina)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Abbeville	1177	26167	18	6	2	22.9	1.6	1.1	0.5	0.9	51.5	1.2
Greenwood	1638	66271	10	5	0	102.6	0.4	1.0	0.7	0.9	145.5	1.2
Lexington	1855	216014	71	2	2	30.6	1.2	0.8	0.9	0.7	308.9	0.9
Richland	2532	320677	39	2	2	48.6	0.8	0.8	0.6	0.9	423.9	0.8
Anderson	2535	165740	54	2	2	52.5	0.7	1.0	1.2	0.8	230.8	1.1
Florence	2934	125761	57	3	2	54.9	0.7	1.2	1.2	1.2	157.2	1.0
York	2998	164614	24	2	2	23.7	1.5	0.6	0.7	0.7	241.2	0.9
Cherokee	3139	52537	17	2	2	28.6	1.3	0.9	1.1	1.0	133.8	1.0
Pickens	3279	110757	18	2	2	48.8	0.7	1.0	1.0	0.8	222.9	1.0
Newberry	3970	36108	12	6	2	52.6	0.7	1.2	1.2	1.0	57.2	1.2
Greenville	4191	379616	38	2	2	42.4	0.9	0.7	0.8	0.7	480.5	1.0
Spartanburg	4381	253791	48	2	2	49.3	0.7	1.3	0.9	0.8	313.0	1.0
Dillon	4444	30722	12	6	2	26.0	1.4	0.9	1.0	1.6	75.9	1.0
Beaufort	4526	120937	38	5	2	24.8	1.5	0.8	0.9	0.8	206.1	1.4
Charleston	4994	309969	52	2	2	48.4	0.8	1.0	0.8	1.0	337.5	1.0
Allendale	6223	11211	4	7	0	35.7	1.0	0.9	1.4	2.0	27.5	1.1
Chester	6666	34068	12	6	2	23.5	1.6	1.1	1.3	1.0	58.7	1.0
Edgefield	6686	24595	4	2	1	24.4	1.5	0.6	1.5	1.1	49.0	0.9
Fairfield	7441	23454	8	6	1	34.1	1.1	1.2	1.4	1.2	34.2	1.1
Bamberg	7757	16658	5	7	2	42.0	0.9	2.0	1.0	1.5	42.4	1.1
Kershaw	7928	52647	11	6	2	26.6	1.4	1.1	1.1	0.8	72.5	1.1
Union	7955	29881	5	6	1	36.8	1.0	1.3	0.9	0.9	58.1	1.3
Calhoun	8011	15185	6	8	1	13.2	2.8	1.1	1.1	1.1	39.9	1.2
Oconee	8552	66215	8	6	2	40.8	0.9	0.9	1.3	0.7	105.9	1.3
Darlington	8839	67394	19	4	2	43.0	0.8	1.6	1.4	1.3	120.1	1.0
Dorchester	9022	96413	8	2	2	31.1	1.2	1.4	0.8	0.7	167.8	0.8
Aiken	9027	142552	23	2	2	19.6	1.9	0.8	0.8	0.9	132.9	1.1
Chesterfield	9091	42768	14	6	2	30.4	1.2	0.9	2.0	1.2	53.6	1.0
Jasper	9196	20678	5	8	1	24.2	1.5	0.9	1.4	1.2	31.5	0.9
Marion	10576	35466	14	6	2	22.6	1.6	1.3	1.5	1.5	72.5	1.0

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Expected Annual Emergency Miles Per Ambulance (EXAMB) (South Carolina)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Barnwell	11514	23478	8	6	2	17.0	2.1	1.4	1.0	1.2	42.8	1.1
Georgetown	11886	55797	16	6	2	32.3	1.1	0.9	1.6	1.1	68.5	1.3
Lancaster	12237	61351	10	6	0	24.4	1.5	0.9	1.6	0.9	111.8	1.0
Saluda	12954	19181	5	6	1	20.9	1.7	1.0	1.9	1.0	42.4	1.2
Horry	13793	196629	39	3	2	24.4	1.5	1.0	1.1	0.9	173.4	1.3
Laurens	14882	69567	9	6	2	31.6	1.2	1.4	1.1	0.9	97.3	1.1
Hampton	14959	21386	6	7	1	18.7	2.0	1.0	1.5	1.4	38.2	1.0
Clarendon	17295	32502	8	6	2	30.8	1.2	1.7	1.1	1.5	53.5	1.2
Marlboro	17696	28818	12	7	1	17.4	2.1	1.1	2.4	1.5	60.1	1.0
Colleton	19613	38264	7	6	2	23.5	1.6	0.8	1.4	1.4	36.2	1.1
Berkeley	20486	142651	13	2	2	11.9	3.1	0.6	1.1	0.9	130.0	0.7
McCormick	20973	9958	1	8	1	30.1	1.2	0.8	1.6	1.1	27.7	1.4
Lee	25973	20119	7	6	1	14.9	2.4	1.2	2.2	1.6	49.0	1.0
Williamsburg	26550	37217	10	6	1	24.2	1.5	1.4	1.5	1.7	39.9	1.1
Sumter	35319	104646	10	3	2	16.2	2.2	1.6	0.8	1.1	157.3	1.0
Orangeburg	48762	91582	12	4	2	25.1	1.5	1.6	1.3	1.4	82.8	1.1

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Washington

In Washington, the median "Expected Annual Emergency Miles Per Ambulance" (EXAMB) is 7,771 miles and ranges from a low of 708 miles to 46,772 miles (see tables below). The lowest values, in San Juan, Wahkiakum, Island, Thurston and Snohomish Counties, partially stem from lower mortality rates from cerebrovascular diseases and motor vehicle crashes, and lower poverty levels than the average Washington County.

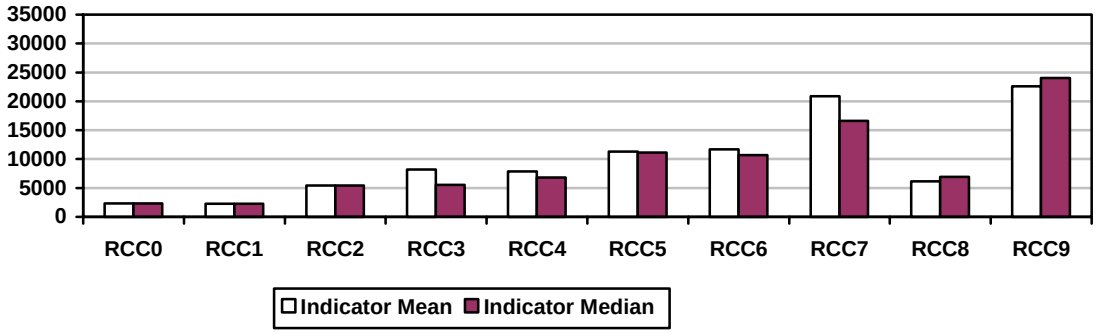
Washington counties with the highest EXAMB levels, Ferry, Garfield and Asotin Counties, have low physician availability and higher mortality rates than is typical in the state. A decrease in the mortality rate for motor vehicle crashes (a proxy for trauma related utilization) would result in a significant decrease in the EXAMB in Garfield County, for example.

Across all urban counties (n=12) the median EXAMB is 3,995 miles, while across all rural counties (n=27) the median EXAMB is 10,160 miles; a difference of 254%. Completely rural Washington counties with no places of 2,500 persons or more possess the highest average and median EXAMB (see tables below).

Expected Annual Emergency Miles Per Ambulance Across Different Levels of the Rural-Urban Continuum Code

Rural – Urban Continuum Code Breakdown	# of counties	Indicator Average	Indicator Median
Urban	12	5,765	3,995
0 – Central counties of metro areas of 1 million or more	2	2,349	2,349
1 – Fringe counties of metro areas of 1 million or more	2	2,249	2,249
2 – Counties in metro areas of 250k – 1 million population	2	5,437	5,437
3 – Counties in metro areas of less than 250k population	6	8,184	5,529
Rural	27	13,562	10,160
4 – Urban pop of 20k or more, adjacent to a metro area	4	7,839	6,814
5 – Urban pop of 20k or more, not adjacent to a metro area	4	11,313	11,110
6 – Urban pop of 2.5k – 19,999, adjacent to a metro area	6	11,712	10,665
7 – Urban pop of 2.5k – 19,999, not adjacent to a metro area	5	20,862	16,623
8 – Completely rural (no places with a pop of 2,500 or more) adjacent to a metro area	4	6,167	6,899
9 – Completely rural (no places with a pop of 2,500 or more) not adjacent to a metro area	4	22,577	24,042

Expected Annual Emergency Miles Per Ambulance Across Different Levels of The Rural-Urban Continuum Code



In Washington, our measure (EXAMB) shows higher values as the percentage of persons living below poverty increases (see tables below). The EXAMB also increases as the population density and overall population decreases. Higher mortality rates (i.e., death rate of cerebrovascular disease, and motor vehicle crash death rates) are associated with higher EXAMB values.

Another way of analyzing the EXAMB is by comparing the indicator across the Health Professions Shortage Areas (HPSAs) designation. When stratified, the EXAMB is higher in counties identified as whole HPSAs compared to partial HPSAs. This finding should be interpreted with caution, because the non-HPSA and whole HPSA findings are based on 2 and 5 Washington counties, respectively.

Expected Annual Emergency Miles Per Ambulances Across Health Professional Shortage Designations (HPSAs)

HPSA	# of Counties	Indicator Average	Indicator Median
Not a HPSA	2	23,740	23,740
Partial County HPSA	32	8,806	6,409
Whole County HPSA	5	21,211	10,160

See tables below for a county-level breakdown of the Expected Annual Emergency Miles per Ambulance (EXAMB) compared to:

- The Rural Urban Continuum Code
- Health Professions Shortage Designation
- State-to-County physician rate per 100,000 population
- County-to-State cerebrovascular disease death rate per 100,000 population
- County-to-State motor vehicle crash death rate per 100,000 population
- Population density
- County-to-State percent elderly population ratio

Washington Simple Statistics

Variable	COUNTIES (N)	Mean	Std. Dev.	Median	Minimum	Maximum
EXAMB	39	11,163	10,555	7,771	708.30	46,772
MD CO RATE	39	40.91	16.31	36.38	10.12	78.28
AMB / 100K	39	69.11	40.38	59.90	19.46	209.20
RUCCODE	39	5.10	2.58	5.00	0.00	9.00
TOTAL AREA	39	1,828	1,020	1,849	286.69	5,315
POP DENS	39	114.21	189.49	32.30	3.30	817.00
% MINORITY	39	13.89	8.54	11.70	3.50	38.10
% ELDERLY	39	14.17	3.79	13.44	8.53	22.02
CVD RATE	39	24.90	7.28	22.31	13.50	42.55
MVC RATE	39	6.49	3.50	5.68	2.36	16.40
% POVERTY	39	12.58	3.17	12.20	6.90	18.80
2000 CENSUS	39	151,131	305,164	49,405	2,397	1,737,034

SPEARMAN CORR	EXAMB	MD RATE	AMB / 100K	RUC-CODE	LAND AREA	POP DENS	% MINORITY	% ELDERLY	CVD RATE	MVC RATE	% Poverty
MD CO RATE	-0.303	1.000									
AMB / 100K	0.095	-0.000	1.000								
RUCCODE	0.413*	-0.139	0.689*	1.000							
LAND AREA	0.288	0.364*	0.058	-0.076	1.000						
POP DENS	-0.515*	0.107	-0.631*	-0.869*	-0.227	1.000					
% MINORITY	0.004	0.017	-0.464*	-0.505*	0.350*	0.293	1.000				
% ELDERLY	0.284	0.151	0.604*	0.600*	-0.141	-0.391*	-0.648*	1.000			
CVD RATE	0.424*	0.053	0.443*	0.459*	-0.052	-0.388*	-0.545*	0.775*	1.000		
MVC RATE	0.700*	-0.029	0.376*	0.575*	0.152	-0.654*	-0.072	0.274	0.289	1.000	
% POVERTY	0.687*	-0.054	0.241	0.371*	0.406*	-0.560*	0.163	0.067	0.299	0.620*	1.000
2000 CENSUS	-0.357*	0.200	-0.627*	-0.941*	0.172	0.877*	0.471*	-0.533*	-0.442*	-0.505*	-0.358*

***** Indicates significant at a p-value of 0.05.

EXAMB – Expected Annual Emergency Miles Per Ambulance, **MD CO RATE** – Rate of general practitioners per 100,000 population, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **LAND AREA** – Total land area in square miles, **POP DENS** – Population density by square mileage, **% MINORITY** – County percent minority, **% ELDERLY** - County percent elderly (65+), **CVD RATE** – County annual cerebrovascular mortality rate per 100,000 (1998-2000), **MVC RATE** - County annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County percent poverty ratio, **2000 CENSUS** – 2000 Census population.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Washington)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
San Juan	708	14077	13	8	0	56.8	0.8	1.0	0.6	0.8	80.5	1.7
Wahkiakum	1592	3824	8	9	2	26.2	1.7	1.7	1.1	0.9	14.5	1.7
Island	1853	71558	35	1	2	34.9	1.3	0.9	0.9	0.7	343.3	1.3
Thurston	2127	207355	92	3	2	52.6	0.9	0.9	1.2	0.8	285.2	1.1
Snohomish	2263	606024	259	0	2	33.7	1.3	0.8	0.8	0.7	290.1	0.8
King	2436	1737034	443	0	2	56.0	0.8	0.9	0.6	0.7	817.0	0.9
Clark	2647	345238	104	1	2	30.1	1.5	0.9	0.7	0.9	549.5	0.9
Whitman	2875	40740	32	5	2	39.3	1.1	1.0	1.0	1.3	18.9	0.8
Kitsap	3915	231969	51	3	2	34.5	1.3	1.0	0.9	0.8	585.8	1.0
Whatcom	4075	166814	82	3	2	52.2	0.9	1.0	1.0	1.1	78.7	1.1
Klickitat	4568	19161	17	7	2	78.3	0.6	1.0	2.1	1.5	10.2	1.3
Pierce	4587	700820	251	2	2	36.4	1.2	0.9	1.0	0.9	417.4	0.9
Chelan	4712	66616	46	5	2	58.5	0.8	1.1	1.2	1.2	22.8	1.2
Lincoln	5080	10184	11	8	2	49.1	0.9	2.1	0.8	1.1	4.4	1.7
Cowlitz	5283	92948	45	4	2	48.4	0.9	1.3	1.0	1.2	81.6	1.2
Skagit	5857	102979	67	4	2	58.3	0.8	1.3	1.6	1.0	59.3	1.3
Spokane	6287	417939	156	2	2	50.5	0.9	1.1	1.0	1.2	237.0	1.1
Kittitas	6532	33362	17	6	2	45.0	1.0	1.0	1.2	1.3	14.5	1.1
Benton	6983	142475	43	3	2	30.2	1.5	0.8	1.2	0.9	83.7	1.0
Walla Walla	7771	55180	25	4	2	45.3	1.0	1.4	1.0	1.3	43.4	1.3
Skamania	8720	9872	9	8	1	10.1	4.4	0.7	1.6	1.0	6.0	1.0
Jefferson	9094	25953	22	6	2	65.5	0.7	1.6	1.9	1.0	14.3	1.9
Mason	9972	49405	49	6	1	26.3	1.7	1.3	2.0	1.1	51.4	1.5
Pend Oreille	10161	11732	21	8	1	34.1	1.3	1.4	2.8	1.7	8.4	1.4
Stevens	11359	40066	24	6	2	57.4	0.8	1.1	2.2	1.4	16.2	1.2
Columbia	11513	4064	5	9	2	49.2	0.9	1.6	4.0	1.2	4.7	1.7
Grays Harbor	12445	67194	57	4	2	17.9	2.5	1.6	0.7	1.4	35.1	1.4
Franklin	15359	49347	21	3	2	24.3	1.8	1.2	1.6	1.6	39.7	0.8
Okanogan	16174	39564	37	7	2	73.3	0.6	1.0	3.7	1.8	7.5	1.3
Adams	16180	16428	6	6	2	30.4	1.5	1.1	1.5	1.5	8.5	0.9

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Washington)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Douglas	16624	32603	10	7	2	30.7	1.5	1.0	1.5	1.1	17.9	1.2
Yakima	16648	222581	107	3	2	42.2	1.1	1.1	1.5	1.7	51.8	1.0
Lewis	17139	68600	62	6	2	32.1	1.4	1.6	1.9	1.3	28.5	1.4
Grant	17510	74698	59	5	2	34.8	1.3	1.0	3.2	1.4	27.9	1.0
Clallam	20159	64525	29	5	2	63.5	0.7	2.0	1.4	1.1	37.1	1.9
Pacific	20175	20984	24	7	2	19.1	2.4	1.6	1.5	1.4	22.5	2.0
Ferry	36572	7260	5	9	1	13.8	3.3	0.9	2.2	1.7	3.3	1.2
Garfield	40631	2397	2	9	1	20.9	2.2	2.0	3.4	1.1	3.4	1.9
Asotin	46772	20551	4	7	0	34.1	1.3	1.6	2.0	1.4	32.3	1.5

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

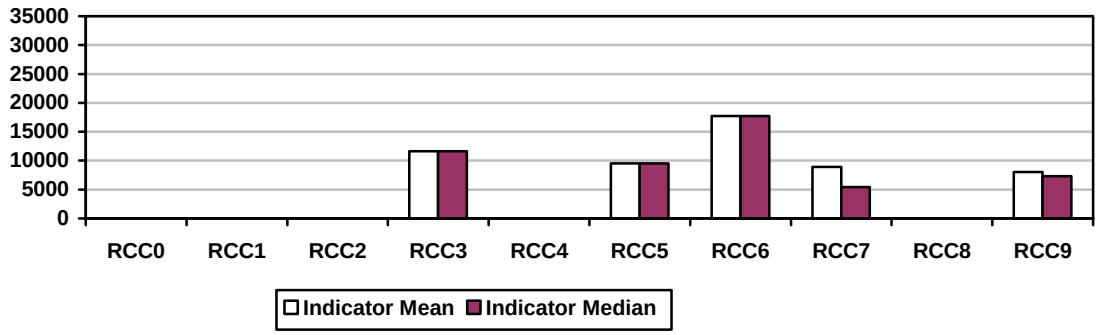
Wyoming

In Wyoming, the median "Expected Annual Emergency Miles Per Ambulance" (EXAMB) is 6,256 miles and ranges from a low of 802 miles in Sublette County to 32,887 miles in Fremont County (see tables below). Overall, EXAMB values in Wyoming tend to be lower compared to other states and did not increase with rurality. Across all urban counties (n=2) the median EXAMB is 11,640 miles, while across all rural counties (n=21) the median EXAMB is 5,895 miles; a difference of nearly six thousand miles per year per ambulance (see tables below). Our findings suggest that, unlike the situation in other states, EMS availability in Wyoming does not differ widely across counties.

Expected Annual Emergency Miles Per Ambulance Across Different Levels of the Rural-Urban Continuum Code

Rural – Urban Continuum Code Breakdown	# of counties	Indicator Average	Indicator Median
Urban	2	11,640	11,640
0 – Central counties of metro areas of 1 million or more	---	---	---
1 – Fringe counties of metro areas of 1 million or more	---	---	---
2 – Counties in metro areas of 250k – 1 million population	---	---	---
3 – Counties in metro areas of less than 250k population	2	11,640	11,640
Rural	21	9,207	5,895
4 – Urban pop of 20k or more, adjacent to a metro area	---	---	---
5 – Urban pop of 20k or more, not adjacent to a metro area	2	9,501	9,501
6 – Urban pop of 2.5k – 19,999, adjacent to a metro area	1	17,713	17,713
7 – Urban pop of 2.5k – 19,999, not adjacent to a metro area	14	8,891	5,413
8 – Completely rural (no places with a pop of 2,500 or more) adjacent to a metro area	---	---	---
9 – Completely rural (no places with a pop of 2,500 or more) not adjacent to a metro area	4	8,041	7,325

Expected Annual Emergency Miles Per Ambulance Across Different Levels of the Rural-Urban Continuum Code



There was a strong relationship between EXAMB and percent poverty (see tables below). Mortality indicators (i.e., death rate of cerebrovascular disease, and motor vehicle crash death rates) were positively associated with EXAMB.

Another way of analyzing the EXAMB is by comparing the indicator across the Health Professions Shortage Areas (HPSAs) designation. When stratified, the EXAMB medians are fairly similar across HPSA designations in Wyoming.

Expected Annual Emergency Miles Per Ambulances Across Health Professional Shortage Designations (HPSAs)

HPSA	# of Counties	Indicator Average	Indicator Median
Not a HPSA	5	9,628	5,447
Partial County HPSA	7	10,781	6,256
Whole County HPSA	11	8,457	7,778

See tables below for a county-level breakdown of the Expected Annual Emergency Miles per Ambulance (EXAMB) compared to:

- The Rural Urban Continuum Code
- Health Professions Shortage Designation
- State-to-County physician rate per 100,000 population
- County-to-State cerebrovascular disease death rate per 100,000 population
- County-to-State motor vehicle crash death rate per 100,000 population
- Population density
- County-to-State percent elderly population ratio

Wyoming Simple Statistics

Variable	COUNTIES (N)	Mean	Std. Dev.	Median	Minimum	Maximum
EXAMB	23	9,419	8,140	6,256	822.48	32,888
MD CO RATE	23	50.54	25.64	50.27	20.77	122.90
AMB / 100K	23	58.84	36.50	60.32	11.87	124.63
RUCCODE	23	6.78	1.59	7.00	3.00	9.00
TOTAL AREA	23	4,253	2,377	4,089	2,006	10,491
POP DENS	23	5.64	6.17	3.70	0.90	30.40
% MINORITY	23	6.20	4.59	5.30	2.00	23.50
% ELDERLY	23	13.31	4.05	13.55	5.45	19.86
CVD RATE	23	20.07	7.86	19.39	7.91	37.69
MVC RATE	23	10.13	3.74	9.42	5.47	16.75
% POVERTY	23	11.40	2.74	11.70	4.70	16.60
2000 CENSUS	23	21,469	19,848	14,573	2,407	81,607

SPEARMAN CORR	EXAMB	MD RATE	AMB / 100K	RUC-CODE	LAND AREA	POP DENS	% MINORITY	% ELDERLY	CVD RATE	MVC RATE	% Poverty
MD CO RATE	-0.389	1.000									
AMB / 100K	-0.344	0.156	1.000								
RUCCODE	-0.296	-0.055	0.619*	1.000							
TOTAL AREA	0.262	-0.076	-0.281	-0.237	1.000						
POP DENS	0.308	-0.108	-0.791*	-0.552*	-0.098	1.000					
% MINORITY	0.341	-0.037	-0.544*	-0.554*	0.205	0.493*	1.000				
% ELDERLY	0.061	0.376	0.592*	0.408	-0.504*	-0.375	-0.328	1.000			
CVD RATE	0.378	0.208	0.250	0.087	-0.330	-0.131	-0.105	0.640*	1.000		
MVC RATE	0.240	-0.047	0.524*	0.328	-0.129	-0.308	-0.061	0.474*	0.269	1.000	
% POVERTY	0.496*	0.130	0.150	0.042	-0.142	0.021	0.192	0.580*	0.293	0.400	1.000
2000 CENSUS	0.418*	-0.196	-0.825*	-0.709*	0.495*	0.761*	0.601*	-0.631*	-0.345	-0.299	-0.105

***** Indicates significant at a p-value of 0.05.

EXAMB – Expected Annual Emergency Miles Per Ambulance, **MD CO RATE** – Rate of general practitioners per 100,000 population, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **LAND AREA** – Total land area in square miles, **POP DENS** – Population density by square mileage, **% MINORITY** – County percent minority, **% ELDERLY** - County percent elderly (65+), **CVD RATE** – County annual cerebrovascular mortality rate per 100,000 (1998-2000), **MVC RATE** - County annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County percent poverty ratio, **2000 CENSUS** – 2000 Census population.

Expected Annual Emergency Miles Per Ambulance (EXAMB) (Wyoming)

COUNTY NAME	EXAMB	CENSUS POP	# OF AMB'S	RUC-CODE	HPSA	MD CTY RATE	ST/CTY MD RATIO	CTY/ST CBD RATIO	CTY/ST MVC RATIO	CTY/ST POV RATIO	POP DENSITY	CTY/ST 65+ RATIO
Sublette	822	5920	7	9	1	67.6	0.7	0.9	0.6	0.8	1.2	1.0
Teton	1280	18251	3	7	2	54.8	0.9	0.6	0.6	0.4	4.6	0.6
Hot Springs	1877	4882	3	7	1	122.9	0.4	1.1	0.8	1.1	2.4	1.7
Lincoln	2584	14573	15	7	2	54.9	0.9	0.8	1.8	0.8	3.6	1.0
Weston	3782	6644	7	7	0	60.2	0.8	1.1	1.7	1.0	2.8	1.4
Uinta	4207	19742	6	7	1	25.3	1.9	0.6	0.9	1.0	9.5	0.6
Crook	4463	5887	6	9	1	34.0	1.4	1.2	1.3	0.7	2.1	1.3
Johnson	5235	7075	6	7	0	98.9	0.5	2.1	1.1	1.0	1.7	1.6
Carbon	5379	15639	10	7	1	38.4	1.3	0.6	1.2	1.0	2.0	1.0
Goshen	5448	12538	9	7	0	63.8	0.8	1.2	1.2	1.3	5.6	1.5
Campbell	5895	33698	4	7	2	20.8	2.3	0.4	0.8	0.7	7.0	0.5
Laramie	6256	81607	13	3	2	53.9	0.9	0.8	0.7	0.9	30.4	1.0
Albany	6794	32014	6	5	0	46.9	1.0	0.8	0.7	1.2	7.5	0.7
Platte	7778	8807	9	7	1	45.4	1.1	1.4	1.7	1.1	4.2	1.4
Park	9542	25786	10	7	2	73.7	0.7	1.1	1.2	1.1	3.7	1.3
Niobrara	10188	2407	3	9	1	20.8	2.3	0.8	1.6	1.4	0.9	1.6
Washakie	11699	8289	5	7	1	60.3	0.8	1.8	1.8	1.0	3.7	1.4
Sweetwater	12208	37613	15	5	1	21.3	2.3	1.0	1.0	0.7	3.6	0.7
Big Horn	16694	11461	7	9	1	34.9	1.4	1.4	1.3	1.2	3.7	1.4
Natrona	17024	66533	8	3	2	66.1	0.7	1.0	0.8	1.1	12.5	1.1
Converse	17714	12052	5	6	1	24.9	1.9	1.5	0.9	1.0	2.8	1.0
Sheridan	26883	26560	8	7	0	22.6	2.1	1.9	0.7	1.0	10.5	1.3
Fremont	32888	35804	14	7	2	50.3	1.0	1.1	1.9	1.5	3.9	1.2

EXAMB – Expected Annual Emergency Miles Per Ambulance, **2000 CENSUS** – 2000 Census population, **# OF AMBULANCES** – Number of ambulances obtained from EMS data sources, **AMB / 100K** – Number of ambulances per 100,000 population, **RUCCODE** – Rural-urban continuum code, **HPSA** – Health Professions Shortage Area, **MD CTY RATE** – Rate of general practitioners per 100,000 population, **ST/CTY MD RATIO** – State to county rate of general practitioners per 100,000 population, **CTY/ST CBD RATIO** - County to state annual cerebrovascular mortality rate per 100,000 (1998-2000), **CTY/ST MVC RATIO** - County to state annual motor vehicle crash mortality rate per 100,000 (1998-2000), **% POVERTY** – County to state percent poverty ratio (1999), **POP DENS** – Population density by square mileage, **% ELDERLY** - County to state percent elderly (65+) ratio.

Chapter Four: Discussion and Policy Recommendations

Discussion

The field of emergency medical services is relatively new. Agreement on appropriate levels of service, and means for measuring "appropriate," may be years in the offing. Nonetheless, the time appears ripe for the development of analytic approaches that compare the need for and availability of emergency services across communities, so that vital resources can be deployed effectively. We have drafted a possible indicator, expected annual emergency miles per ambulance, or EXAMB, that allows planners to compare EMS resource availability across counties within a state.

Presenting the EXAMB as a possible indicator of EMS availability across communities is the first step in what will undoubtedly be an extensive developmental process. The authors are well aware that the EXAMB measure has multiple flaws, which we hope planners and administrators in the EMS field will note and correct. Several limitations are already known, and discussed below: the EXAMB focuses on emergency transports and not all ambulance use; an ambulance owned is not an ambulance staffed and operative; the elements used to adjust for population need may or may not be the best measures and weighting them all equally may or may not accurately reflect the contribution of each to overall emergency use; and the EXAMB indicator shows relative differences across counties but does not show how best to remove inequalities. In addition, we were only able to obtain data for "testing" the EXAMB indicator from five states.

Emergency Transport Versus All Ambulance Use

The EMS system in Allendale County, South Carolina possesses four licensed ambulances. According to the EXAMB formula, their Expected Annual Emergency Miles Per Ambulance is 6,223 miles. An EMS official from Allendale County informed study investigators that their annual actual mileage per ambulance is close to 40,000 miles. Much of the estimated 40,000 miles comes from non-emergent transfers or contract work with local health and detention facilities, using EMS as a means of medically supervised transportation. Contracts to perform non-emergent transports for local health and detention facilities are essential to the system's economic performance.

Many EMS systems have contracts with health and non-health related entities whereby EMS serves as a medically supervised transport service. In many rural and frontier areas, call volume alone does not provide enough revenue to sustain a full-time EMS system. Many different methods for financing EMS exist with no one method being better or worse than the other.[51] Thus, EMS systems may contract with various health care (e.g., physician offices) and non-health care entities (e.g., detention centers) in order to increase revenue and ensure the ability of maintaining full-time staff. Further, the provision of transport services is a valuable service in itself, beyond its financial applications. Critical Access Hospitals rely on referral agreements with larger institutions, which in turn require safe transport of referred patients.

Whether the EXAMB measure should account for all EMS transport, or be limited to emergency transport, is a policy decision. There may be techniques, such as assessment of the number and kind of local health care facilities such as hospitals, nursing homes, and other institutions that need patient transport, that can be used to modify the EXAMB to include all medically supervised transports, and not just emergency response.

Number of Ambulances

The EXAMB indicator is based on ambulances and assumes that the count of ambulances per county is representative of units in use at the time of data collection. However, the number of ambulances under a system's control may be greater than the number it can actually field on any given day after accounting for personnel shortages, down time for maintenance, and so on.

As the EXAMB indicator is refined, it may be appropriate to replace simple ambulance counts with a measure that takes into consideration of the number of EMS personnel available, the age of individual ambulance trucks, and other factors affecting unit availability. A better measure might be "unit hours," the time an ambulance is actually staffed and available for service. However, data collection requirements increase as measurements become more sophisticated.

In addition, the EXAMB does not capture services provided by air, which may be important in rural and remote areas. Additional research would be needed to ascertain the availability of air transport across rural areas and to ascertain how availability is best quantified.

Choice of Measures in the EXAMB

The EXAMB measure begins with the number of ambulances, the land area of a county as a proxy for distance, and county population. These "raw" statistics are then "adjusted" using the ratio of the county value to the state value for five county characteristics: physician availability, mortality rates from disease and motor vehicle crashes, poverty rate, and age distribution. It is possible that other factors may be equally important. While previous research has indicated that all of these factors importantly affect EMS use, other characteristics of a county may also be important. For example, perhaps quality of roads should be considered, as well as road miles. Among population characteristics, perhaps education level should be considered as well as poverty. The EXAMB offers a beginning, to which other researchers may wish to add improved measures.

All of the adjustment factors are given equal weight in the calculation, which means that a high degree of divergence from the state average on a single factor can sharply affect the EXAMB value. For example, Garfield County in the state of Washington had an EXAMB of 40,631 adjusted miles. If our measure did not take into account the high rate of MVC deaths in the county compared to the state (3.4 times higher than other counties) the EXAMB value would decrease to 11,950 miles. Similar examples can be derived for other counties. However, further research will be needed to determine which measures, if any, are most strongly linked to actual outcomes of EMS service.

Finally, the EXAMB does not deal with a variety of "special needs" that may be specific to individual states. For such cases, some of the measures of distance and population would need to be adjusted to develop a valid measure of resource availability. Several such special situations have already been suggested:

- Paramedic intercept. Some EMS systems may rely on first-responders to respond to an emergency incident initially, stabilizing the victim and waiting for Paramedics to arrive on the scene or meet first-responders while in route to the hospital. In such cases, mileage would likely be reduced for some systems. The developmental indicator does not account for Paramedic intercept. However, planners at the state level could adjust distance calculations downward if this service type is common in their state.
- Seasonal population shifts. Utilization of EMS services is affected by shifts in the local population, similar to that seen during vacation months in states possessing popular vacation destinations. Seasonal variations in populations have not been accounted for in the developmental indicator, but could be applied at the state level when developing comparisons across counties.
- Special events. Special events, like large sporting events and music concerts, require that additional manpower be allocated to the community or the event in order to maintain adequate staffing levels. The developmental indicator does not include a variable that factors in population shifts and utilization related to mass gatherings. Special circumstances such as this are probably best addressed locally. Although there is no one standard for staffing and covering mass gatherings, a "checklist" for preparation has been approved by the National Association of EMS Physicians (NAEMSP) and addresses the increase in human and equipment resources.[52]

The EXAMB Indicator Does Not Offer Solutions

The EXAMB indicator ranks counties within a state on potential miles of emergency service per ambulance. Differing EXAMB scores across counties do not mean that adding an ambulance to a county fleet is the appropriate response to conditions. County ranks could be changed at the level of need as well as at the level of service. Using the Garfield County example given above, one could reduce the EXAMB value by reducing MVC deaths. Crash deaths could be reduced by a variety of safety improvements, ranging from increased law enforcement through changes in signage and signaling, through restructuring of grades, curves and intersections on roadways. Public education campaigns might also be useful. Determination of whether improved EMS resources or a change in underlying indicator conditions is the most appropriate response to differing EXAMB values across counties is a policy decision to be made at the local level.

Limited Case Studies

As originally designed, our study would have compared the results of EXAMB calculations with other health service indicators across all 50 states. However, given differences in EMS administration across states and the absence of standardized, agreed upon data formats, only limited state data were available. As noted in Appendix A, 20 states

possessed all or most of the requested data at the time of data collection, but only five were able to provide sufficient information to allow a county-level assessment of EMS availability.

In four of the five states studied, the EXAMB indicator parallels other commonly used indicators of health services availability, such as physicians per capita. In these states, the EXAMB generally rises with rurality, with more rural counties having higher anticipated emergency miles per ambulance per year. This would occur both in response to distance, which is generally greater in rural than in urban counties, and in response to lower availability of services in rural areas. Wyoming constituted the exception among the five states, having EXAMB values that were relatively even across all counties. It cannot be ascertained whether the EXAMB indicator itself has limitations when applied to an extremely rural state such as Wyoming, or whether Wyoming currently has an EMS system that is evenly distributed across all counties with regard to expected emergency transport miles.

Policy Recommendations

Prehospital care has become an important element in the spectrum of health services. As the value of prehospital care grows, so does the need for accurate infrastructure information available on a national level. At present, such information is sparse.

The National Highway Traffic Safety Administration (NHTSA), was the initial Federal agency to support EMS research, because of the importance of response and transport for reducing morbidity and mortality due to trauma. NHTSA has funded many pilot projects and efforts designed to improve and enhance EMS systems of care, including the Uniform Prehospital Data Elements and Definitions Project.[53] The purpose of the project was to develop a common terminology and set of definitions for recording episodes of patient care, which could then be used in evaluation of EMS effectiveness.

Other Federal agencies are also involved in promoting or supporting EMS efforts. The Office of Rural Health Policy has funded the Rural Emergency Medical Service and Trauma Technical Assistance Center. States have used funding from the Centers for Disease Control and Prevention (CDCP), which addresses injury prevention as well as chronic illnesses such as cardiovascular disease, to implement training of EMS personnel. The Institute of Medicine, with funding from multiple Federal sources, is currently embarked on the preparation of a major report, *The Future of Emergency Care in the United States Health System*, to be completed in 2006.

Despite work such as the Prehospital Data Elements and Definitions Project, EMS experts have generally not addressed fundamental infrastructure issues. The IOM report may pose an exception, as it promises to address EMS funding and infrastructure development. At present, however, little consensus exists regarding how infrastructure itself should be defined and measured, or on appropriate levels of infrastructure at the community level. An analogy may clarify the relative lack of infrastructure definitions within EMS versus other sectors of medical care. When researchers refer to an "outpatient physician visit," the rough parameters of infrastructure are clear. The key personnel resource, the physician, is legally defined, and state regulations are likely to define equipment that must be present in the

outpatient office. Implicit recognition exists that a certain amount of physician FTE time is needed for population health, as embodied in the concept of Health Professional Shortage Areas. Considerable resources are expended tracking the number of licensed physicians, dentists, and mid-level practitioners within geographic areas. A similar situation is not present for EMS. Nationally uniform definitions and reporting of EMS infrastructure elements, and the relationship of these elements to populations, have not yet emerged. These are an essential prerequisite to defining "adequate" infrastructure.

The absence of consensus that could define infrastructure components and set minimum availability guidelines has the potential to impair public health response and policy development. *Trauma System Agenda for the Future*, a conference document produced by NHTSA, calls for the "development of consistent standards" as one of its vision statements [p. 15].[54] While the document principally uses "standards" in the context of quality and timing of care, a similar call for standards could be made regarding infrastructure, such as facilities and personnel.

For example, the *Local Public Health Preparedness and Response Capacity Inventory* issued by the CHCP in 2002 includes emergency medical services among the agencies with which local emergency response measures should be coordinated [p. 2].[55] Under the heading of Critical Capacity, local planners are advised to assess "mass casualty transportation" and "medical transport vehicles" [p. 6].[55] However, no guidelines are provided to assist local planners in determining whether local EMS resources could respond adequately to disaster or terrorism.

A consensus based set of definitions and standardized assessment of EMS infrastructure is needed before policy development can go forward. At present, individual states vary widely in the degree to which they obtain information about local EMS components and use such information for planning and resource allocation. It is therefore recommended that:

- The Secretary of the US Department of Health and Human Services, in collaboration with the Secretary of the US Department of Transportation, should convene a consensus conference to develop uniform terminology for defining and recording EMS infrastructure components, such as practitioners, dispatch services/communications, and transport vehicles.
- The Secretary of the US Department of Health and Human Services, in collaboration with the Secretary of the US Department of Transportation, should provide technical assistance to states in the development of data systems that support monitoring and tracking of EMS personnel and facility.

Research Recommendations

Development of a quantifiable and policy-relevant measure of EMS availability will require a significant research effort. Research along two directions is recommended. First, research is needed into the relationship between EMS infrastructure and time-critical health care outcomes. At the population level, this would require studies linking EMS availability to rates of death from sudden cardiac events and trauma. The measure developed in this report, expected annual emergency miles per ambulance (EXAMB), could be tested against

outcomes to see if it can serve as a relevant metric for infrastructure. Studies would need to go beyond single-hospital catchment areas to cover states, regions or the nation. Appropriate controls for patient morbidity and injury acuity would be needed. Second, development and refinement of the EXAMB indicator, or a similar metric, is required in order to assess the adequacy of EMS infrastructure across communities. It is therefore recommended that:

- The Secretary of the US Department of Health and Human Services should provide funding for research into the relationship between EMS infrastructure and population health outcomes, particularly across rural populations.
- The Secretary of the US Department of Health and Human Services should support research into the development of effective comparative measures of EMS infrastructure.

APPENDIX A: REQUESTED DATA

Data were gathered from multiple data sources. Specific EMS infrastructure information was requested from state EMS agencies via a mailed and Internet based survey instrument. The initial process of data source identification involved contacting state EMS directors. State EMS agency web sites were also used to obtain data. Prior to initiating contact with state directors, the National Association of State EMS Directors (NASEMSD) was approached. The association represents the interests of state EMS directors of state EMS agencies. Consultations between representatives of the NASEMSD and the study investigator were used in the gathering of EMS specific data (e.g., the number of EMS entities per county).

The initial request for data included:

- The **name** of all EMS entities licensed by the State Office of EMS to provide emergency medical service inside and potentially across state borders.
- Physical street **address**, city, state, and zip code of each EMS entity.
- **County** of physical location for each EMS entity.
- **Type** of EMS entity (falling into one of the following categories: County, City/Village/Township, Fire & EMS, Private, Hospital, 1st Responder, Rescue, Air, Special Purpose, Industry, or Other).
- Number of licensed **"trucks"** per EMS entity (if applicable).
- **Level** of service (e.g. Basic Life Support or Advanced Life Support).[†]

Provision of requested data proved problematic for the majority of respondents. In one case, the state EMS director was in the process of constructing and implementing a statewide data collection system, which when operational, would supply the information and data investigators requested. Given the unavailability of requested data, the state EMS director supplied information that was readily available, knowing it may not be accurate.

Reasons for failing to supply requested data from other states is not known. Non-response is likely the product of multiple reasons (e.g., inadequate data sources and barriers to data release for example). The design of the study may have contributed to the high level of non-response. As has been discussed, EMS information, data and tracking systems vary dramatically across states.[56,57] However, the study requested data using a single, uniform format. The commitment of time necessary for changing state specific EMS data to the requested data set may have been a deterrent to responding. The lack of follow-up mailings may have contributed to the lack of response. Follow-up mailings were not used due in part to constraints in time and funding.

[†] **NOTE:** In the original request for data, entities licensed as Intermediate Life Support (ILS) were to be grouped with ALS entities.

APPENDIX B: METHODS

County population data and statistics were used from the February 2003 release of the Area Resource File (ARF) and combined with county specific information for states supplying detailed EMS data. The ARF is made available by the National Center for Health Workforce Analysis, Bureau of Health Professions (BHP), Health Resources and Services Administration (HRSA), Department of Health and Human Services (DHHS).[58] The Area Resource File (ARF) includes over 6,000 variables on "health facilities; health professions; measures of resource scarcity; health status; economic activity; health training programs; and socioeconomic and environmental characteristics."[59]

The ARF information resource is comprised of data from over 50 different source files and is the result of processing millions of micro data records (e.g., NCHS detail mortality and natality records, AHA facilities, and AMA physician specialty data). All information contained in the file is derived from existing data sources, and presented at the county level.[59]

Variables:

- Age: 2003 ARF variables F12143-01 & F04530-00
- Poverty: 2003 ARF variable F13321-99
- Population Health: 2003 ARF variables F13164-98 & F11938-98
- Health Provider Availability: 2003 ARF variable F04610-01

Review of initial findings

A representative of the National Association of State Emergency Medical Services Directors (NASEMSD), as well as state directors for each of the five states highlighted, received a copy of the EXAMB report in draft form. State directors each received only the chapter highlighting their state. The authors of this report are grateful for the feedback and suggestions provided by reviewers.

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