

Is Rural Kansas Prepared? An Assessment of Resources Related to the COVID-19 Pandemic

Hannah Berland, B.A.¹, Dorothy Hughes, Ph.D.²

¹University of Kansas School of Medicine-Salina, Salina, KS

²University of Kansas School of Medicine, Kansas City, KS

Department of Population Health

Received Aug. 29, 2020; Accepted for publication Jan. 29, 2021; Published online April 19, 2021
<https://doi.org/10.17161/kjm.vol14i4.597>

ABSTRACT

Introduction. This cross-sectional study investigated rural Kansas healthcare resources relevant to COVID-19 at the county level in the context of population characteristics.

Methods. The federal Area Health Resource File was used to assess system capacity and critical care-related resources and COVID-19-related risk factors at the county level. Data were described with summary statistics, cross-tabulations, and bivariate tests to discern differences across county rurality categories (2013 Rural-Urban Continuum Codes).

Results. Kansas has 105 counties. Metropolitan counties had an average of 1.5 physicians (M.D. or D.O., any specialty) per 1,000 people, while rural counties had 0.8. A total of 63.5% of rural counties had no anesthesia providers and 100.0% of rural counties had no pulmonary disease physicians. While 96 counties have at least one hospital, nearly 90% rural counties had no intensive care unit (ICU) services. The percent of the population estimated to be over 65 was higher among rural counties (24.2%) than metropolitan counties (19.3%). On average, rural counties had nearly twice as many deaths per 1,000 people by cardiovascular disease and more chronic obstructive pulmonary disease deaths than metropolitan and nonmetropolitan/urban adjacent counties.

Conclusions. Kansas faced limited ICU capabilities and physician workforce shortages in rural counties, both in primary care and specialties such as anesthesia and pulmonology. In addition, nonmetropolitan/urban adjacent and rural population age structures and mortality rates potentially demonstrated an increased risk to overwhelm local healthcare systems. This may have serious implications for rural health, particularly in the context of the COVID-19 pandemic.

Kans J Med 2021;14:95-102

INTRODUCTION

With the evolution of coronavirus disease 2019 (COVID-19) into a worldwide pandemic, national concern originally focused on urban areas of the United States. Researchers tracking COVID-19 thought rural America was so isolated that the virus might not reach it. However, a Kaiser Family Foundation study found that in a two-week period between April 13 and 27, rural counties saw a 125% increase in coronavirus cases, on average, and a 169% increase in deaths.¹ Meanwhile, urban counties saw a 68% increase in cases and a 113% increase in deaths.

Then, between June 1 and 18, 2020, 18 of the top 25 COVID-19 hot spots were in rural counties.^{2,3} This trend was sustained in Kansas. The Kansas Department of Health and Environment (KDHE) reported an 86% increase in new cases between July 1 and July 31, 2020, and said it expected a spike in rural cases in mid-August while urban cases would be on the decline.⁴ Rural America is home to 60 million people, and it is a real possibility that it may become one of the hardest-hit areas.³

There are serious implications for mortality due to COVID-19 in rural Kansas, and it is important to understand the resources the state has available to fight this pandemic. To that end, a population-based study was conducted to evaluate three areas: (1) healthcare system capacity, (2) critical care-related resources, and (3) COVID-19-related risk factors at the population level. We aimed to fill a gap in knowledge around rural Kansas pandemic preparedness and better understand whether these areas may be overwhelmed by a surge in COVID-19 cases.

Rural America faces serious challenges due to reduced hospital capacity and large proportions of its population falling into high-risk categories. According to the U.S. Centers for Disease Control and Prevention (CDC), those at risk for severe illness from COVID-19 are patients over the age of 65 and patients of any age with severe underlying medical conditions such as heart disease, severe obesity, and diabetes.⁵ A report published by the U.S. Census Bureau in 2019 stated 17.5% of the rural population was 65 years or older compared to 13.8% in urban areas.⁶ Additionally, obesity and other chronic diseases occur at higher rates among adults in rural versus urban populations in the U.S.^{7,8} This study examined such population factors to provide insight into why rural areas may face a high incidence of severe COVID-19 illness and, therefore, may have their healthcare infrastructure overwhelmed.

Nationally, only 1% of the country's intensive care unit (ICU) beds are located in rural communities, significantly out of proportion with the potential need that about 17 - 20% of the population lives in rural areas, depending on the measure of rurality used.^{9,10} In addition, if larger hospitals become overwhelmed, patient transfers to these centers may not be possible. This is already happening in some areas of Kansas. Physicians in rural Kansas are facing a situation of having to call eight to ten hospitals in the region to find an open ICU bed.¹¹ Of the rural patients who are able to be transferred, two-thirds are in need of intensive care.¹²

If coronavirus cases continue to escalate in rural communities, there is the potential for critical care resources, already in short supply, to reach levels unsustainable for the care of rural populations. The characteristics of rural Kansas populations and the nature of their healthcare infrastructure form a perfect storm and yield the very real possibility of a rural surge in COVID-19 cases. It is imperative that we better understand Kansas's available critical care resources, capacity, and risk factors.

METHODS

Data Source. A cross-sectional, retrospective study was conducted to assess critical care-related resources and healthcare system capacity in rural Kansas. The federal Area Health Resource File (AHRF) 2018-2019 release was used.¹³ The AHRF is a county-level, national database maintained by the U.S. Health Resources and Services Administration.

It contains data from all 3,230 counties in the U.S. and more than 6,000 variables for current and historic measures of healthcare resources and population characteristics. It is updated annually and includes multiple years of data for many variables; however, due to lags in data collection, not all years were available for all variables in the 2018 - 2019 release. The most recent year available across all our variables of interest was 2017.

Fourteen variables of interest were selected. A full list of variables and detailed descriptions are located in the Appendix (Appendix is online only at journal.ku.edu/kjm). The 2013 Rural-Urban Continuum Codes (RUCCs) was used to describe rurality.¹⁴ RUCC is a scheme used by the U.S. Department of Agriculture that distinguishes counties by their population size and adjacency to a metro area; 2013 is the most recent year these classifications were updated. RUCC uses a scale of 1 - 9, with the lowest values representing the most metropolitan counties. Based on prior literature, the nine RUCCs were grouped into three categories (referred to as “rurality categories”) with the following labels: metropolitan (RUCC 1 - 3), nonmetropolitan/urban adjacent (4 - 6), and rural (7 - 9).¹⁵⁻²⁰

Variables related to rural health networks were included. In Kansas, critical access hospitals (CAHs) are organized into state-designated rural health networks (Figure 1).²¹ These networks are similar to regions and consist of one or more CAHs and a supporting hospital with higher-acuity care capabilities. Each network has a comprehensive plan regarding patient referrals and emergency and non-emergency transfers. There are ten counties that contain larger hospitals designated as supporting assigned CAHs. Four counties contain CAHs that are supported by out of state hospitals. There are 23 counties that do not contain either a supporting hospital or a CAH. These networks are included in our analyses to understand not only individual county resources but also collective resources within established patient transfer patterns.

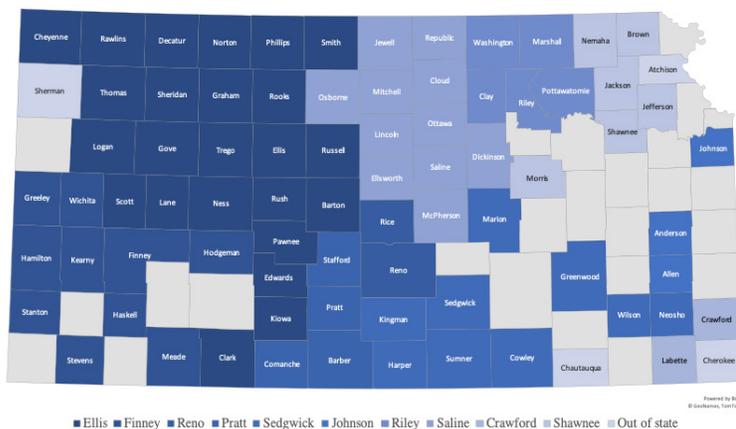


Figure 1. Kansas Rural Health Networks.
 *Gray counties are those without a CAH.

Based on reports of the impact of COVID-19 to date, three categories were established to organize the data, each relating to a different aspect of COVID-19 preparedness: (1) healthcare system capacity, (2) critical care-related resources, and (3) COVID-19-related risk factors at the population level.²²

The variables in the first category, healthcare system capacity, were: total number of hospitals, total number of CAHs, total active M.D. and

D.O. physicians, and active M.D.s and D.O.s per 1,000 people. The variables chosen to describe critical care-related resources (the second category of variables) in Kansas were: total primary care physicians, primary care physicians per 1,000 people, total anesthesia providers (M.D., D.O., and Certified Registered Nurse Anesthetists (CRNA)), total pulmonary disease M.D.s, total ICU beds, and ICU beds per 1,000 people. The providers were selected based on evidence of those most involved in the care of critically ill COVID-19 patients, specifically those needed in intensive care units.²³ While the data were variable, reports have shown 4.9 - 14.2% of COVID-19 hospitalized patients require ICU admission, making providers with pulmonary and critical care training important.^{24,25} There were no data available in the AHRF database on pulmonary physicians with a degree other than an M.D. To recognize the contributions nursing staff provide to COVID-19 patients, a future analysis dedicated specifically to this critical workforce is recommended at a later time.

To understand ICU beds beyond the raw number and number per 1,000 people, they were examined in the context of the Kansas rural health networks, which reflect established patient transfer patterns. Two binary indicator variables were created (0/1) to identify counties as a “CAH county” or a “supporting county.” A supporting county was any county that contained a hospital that received transfers from CAH counties. A categorical variable was created to establish groups of counties based on what supporting hospital their CAH fed into. See Appendix for detailed information on variable use and construction (Appendix is online only at journal.ku.edu/kjm).

The variables chosen to describe population-level COVID-19 risk factors (the third category of variables) were: percentage of the population eligible for Medicare, percent active physicians (M.D. and D.O.) over age 55, percent active physicians over age 65, and three-year mortality average per 1,000 people for cardiovascular disease, influenza and pneumonia, and chronic obstructive pulmonary disease (COPD). The variables for physician age demonstrated the proportions of the physician workforce who were, themselves, at higher risk for severe COVID-19 illness or death if they contracted the virus. The three-year disease mortality rates per 1,000 people were used as proxies for disease burden because individuals with chronic conditions are at higher risk for severe illness and death if infected with COVID-19.⁵

Data Analysis. Variables were analyzed descriptively to understand the range of resources, capacity, and risk across the state by rurality category. Using RUCC classifications, Kansas counties were grouped into three categories, referred to as rurality categories: rural (RUCC 7 - 9), nonmetropolitan/urban adjacent (4 - 6), and metropolitan (1 - 3). Summary statistics were calculated for each variable. These included frequencies and percentages for categorical variables and measures of central tendency for continuous variables. The AHRF is a ‘population’ dataset, representing all applicable data points used in each test, and is not a sample. While other published studies that have used the AHRF have used t-tests for continuous variables,^{26,27} we concluded that the best bivariate test to determine meaningful differences in resources,

capacity, and risk by rurality category (rural, nonmetropolitan/urban adjacent, and metropolitan) were two-tailed z-tests using standard deviations. Analyses were conducted using Stata/SE 15.

RESULTS

The AHRF database included 3,230 counties, which were narrowed to the 105 counties in Kansas. There were 63 (60.0%) counties designated as rural, 23 (21.9%) nonmetropolitan/urban adjacent counties, and 19 (18.1%) metropolitan counties. As noted above, variables of interest were grouped by relevance to healthcare system capacity, critical care-related resources, or population-level COVID-19 risk factors. Variables were cross tabulated by the rurality category (rural, nonmetropolitan/urban adjacent, and metropolitan) to describe differences. Table 1 summarizes the variables statewide. Table 2 summarizes average healthcare system capacity, critical care-related resources, and population-level COVID-19-related risk factors among counties in each rurality category.

Healthcare System Capacity. There were 96 counties with at least one hospital and nine counties without a hospital. Of the nine counties without a hospital, five were rural and four were metropolitan. The average number of hospitals per metropolitan county was 2.8. Nonmetropolitan/urban adjacent and rural counties had an average of 1.3 and 1.1 hospitals per county, respectively, with 65.2% of nonmetropolitan/urban adjacent counties and 74.6% of rural counties having one hospital per county. Both the nonmetropolitan/urban adjacent and rural categories fell below the state average of 1.5. Z-tests were conducted to determine if there were meaningful differences in the average number of hospitals per county between rural and metropolitan counties ($p = 0.053$) and between rural and nonmetropolitan/urban adjacent counties ($p = 0.109$). There was no statistically significant difference in average number of hospitals according to a county's rurality category.

There were 72 counties with at least one CAH and 33 counties with no CAH. Of the counties with at least one CAH, 55 (76.4%) were rural, 12 (16.7%) were nonmetropolitan/urban adjacent, and 5 (6.9%) were metropolitan. Nonmetropolitan/urban adjacent and rural counties had an average of 0.7 and 1.0 CAHs per county, respectively. Metropolitan counties had an average of 0.3 CAHs per county, which was below the state average of 0.8. This was expected given that the CAH program was designed for rural areas. A z-test found a statistically significant difference in the average number of CAHs in rural versus metropolitan counties ($p < 0.001$) and in rural versus nonmetropolitan/urban adjacent counties ($p = 0.032$).

The state of Kansas had an average of 73.7 physicians per county, with a range of 0 to 3,259 physicians per county (Figure 2). On average, metropolitan counties had 348.4 per county, nonmetropolitan/urban adjacent 34.0, and rural 5.3, indicating a statistically significant difference in the supply of physicians per county by rurality category. The metropolitan category had the widest variation of the three rurality categories, from a low of 1 to a high of 3,259. Z-tests found a statistically significant difference between the means of rural versus nonmetro-

politan/urban adjacent counties ($p < 0.001$), but no difference between rural and metropolitan counties ($p = 0.059$) since the test accounts for variation within the two groups being compared.

Table 1. Summary of variables of interest statewide.

Healthcare system capacity Kansas (n = 105)	Mean	Range
Total number of hospitals	1.5	0 - 14
Total number of CAHs	0.8	0 - 2
Total active M.D.s and D.O.s	73.7	0 - 3,259
Active M.D.s and D.O.s per 1,000 people	1.0	0 - 5.5
Critical Care-related Risk Factors	Mean	Range
Primary care physicians	21.4	0 - 725
Primary care physicians per 1,000 people	0.6	0 - 2.0
Anesthesia providers	9.8	0 - 335
Pulmonary disease M.D.s	1.0	0 - 64
Total ICU beds	4.3	0 - 97
ICU beds per 1,000 people	0.1	0 - 1.5
Population-level COVID-19 Risk Factors	Mean	Range
Percentage of population Medicare eligible	22.6%	10.3% - 34.0%
High-risk physician workforce population: age 55+	42.7%	100.0%
High-risk physician workforce population: age 65+	17.0%	100.0%
Three-year mortality from heart disease per 1,000 people	1.6	0.4 - 4.7
Three-year mortality from COPD per 1,000 people	0.7	0.2 - 0.8
Three-year mortality from influenza and pneumonia per 1,000 people	0.3	0.1 - 0.7

Metropolitan counties had an average of 1.5 physicians per 1,000 people. Nonmetropolitan/urban adjacent counties had an average of 1.2 physicians per 1,000 people, and rural counties had 0.8 physicians per 1,000 people. Only rural counties fell below the state average of 1.0. A z-test was conducted to compare the means between rural and metropolitan counties ($p = 0.043$) and between rural and nonmetropolitan/urban adjacent counties ($p = 0.10$). Rural counties had significantly smaller physician workforces compared to both other types of counties.

Critical Care-Related Resources. The variable, “primary care physicians (PCPs), non-federal,” combined family medicine, general practice, general internal medicine, and pediatric physicians, according to AHRF documentation. Metropolitan counties had an average of 89.6 PCPs, nonmetropolitan/urban adjacent counties had 14.6, and rural counties had 3.4. Z-tests were conducted to determine whether there were statistically significant differences in the mean supply of rural versus metropolitan PCPs ($p = 0.042$) and rural versus nonmetropolitan/urban adjacent PCPs ($p < 0.001$). Rural counties had fewer PCPs on average than either other type of county. The primary care workforce also was examined in terms of number of PCPs per 1,000 people. In metropolitan counties, there were 0.5 PCPs per 1,000 people, in nonmetropolitan/urban adjacent 0.6, and in rural 0.6. Z-tests showed no difference between average rural and metropolitan per-1,000-person rates ($p = 0.715$) or between the average PCPs per 1,000 people in rural versus nonmetropolitan/urban adjacent counties ($p = 0.671$).

Notably, there were four counties (out of 63) in the rural category with 10 or more PCPs. All four counties had RUCCs of 7, the “least rural” of the rural category. These outliers could have skewed these results, even though the z-tests used the groups’ standard deviations and should have controlled adequately for variation.

Table 2. Average healthcare system capacity, critical care-related risk factors, and population-level COVID-19 risk factors across Kansas counties in each rurality category.

	Metro (n = 19)	Nonmetro/ urban adjacent (n = 23)	Rural (n = 63)	Metro vs. rural comparison	Nonmetro vs. rural comparison
Healthcare system capacity (means/per county)					
Total number of hospitals	2.8	1.3	1.1	0.053	0.109
Total number of CAHs	0.3	0.7	1.0	< 0.001**	0.032*
Total active M.D.s and D.O.s	348.4	34.0	5.3	0.059	< 0.001**
Active M.D.s and D.O.s per 1,000 people	1.5	1.2	0.8	0.043*	0.010**
Critical care-related risk factors (means/county)					
Total primary care physicians	89.6	14.6	3.4	0.042*	< 0.001**
Primary care physicians per 1,000 people	0.5	0.6	0.6	0.715	0.671
Anesthesia providers	43.9	6.4	0.8	0.036*	< 0.001**
Pulmonary disease M.D.s	5.1	0.2	0.0	< 0.001**	0.475
Total ICU beds	15.9	5.0	0.5	0.017*	< 0.001**
ICU beds per 1,000 people	0.1	0.2	0.1	0.357	0.004**
Population-level COVID-19 risk factors (means/county)					
Percentage of population Medicare eligible	19.3%%	20.7%	24.2%	< 0.001**	0.003**
High-risk physician workforce population: age 55+					
Mean % of physicians aged 55+	39.7%	42.9%	49.3%	0.177	0.248
Proportion of counties with > 50% of physicians 55+	31.6%	30.4%	61.9%	0.016*	0.007**
High-risk physician workforce population: age 65+					
Mean % of physicians aged 65+	16.0%	16.5%	26.2%	0.123	0.056
Proportion of counties with > 50% of physicians 65+	5.3%	4.3%	28.6%	0.003**	< 0.001**
Three-year mortality from heart disease per 1,000 people	1.3	1.4	2.1	< 0.001**	0.004**
Three-year mortality from COPD per 1,000 people	0.6	0.8	0.9	< 0.001**	0.083
Three-year mortality from influenza and pneumonia per 1,000 people	0.2	0.3	0.5	0.041*	0.144

*Indicates significance at the 0.05 confidence level.

**Indicates significance at the 0.01 confidence level.

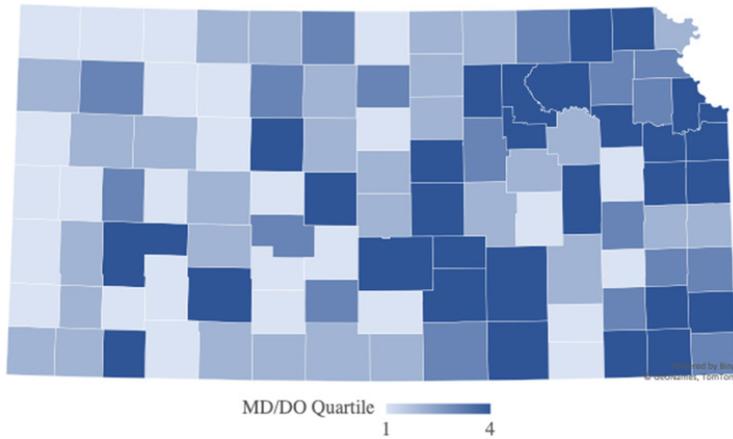


Figure 2. M.D./D.O.s per county.

Next, the supply of anesthesia providers was examined, which included M.D. and D.O. anesthesiologists as well as CRNAs. Eleven (57.9%) metropolitan counties and 17 (73.9%) nonmetropolitan/urban adjacent counties had two or more anesthesia providers. Forty (63.5%) rural counties had zero anesthesia providers. The mean number of anesthesia providers in metropolitan counties was 43.9, in nonmetropolitan/urban adjacent it was 6.4, and in rural 0.8. Both nonmetropolitan/urban adjacent and rural counties fell well below the state average of 9.8. Z-tests were used to determine whether there were statistically significant differences between the average number of anesthesia providers in rural versus metropolitan counties ($p = 0.036$) and in rural versus nonmetropolitan/urban adjacent counties ($p < 0.001$). In both cases, rural counties had significantly fewer anesthesia providers.

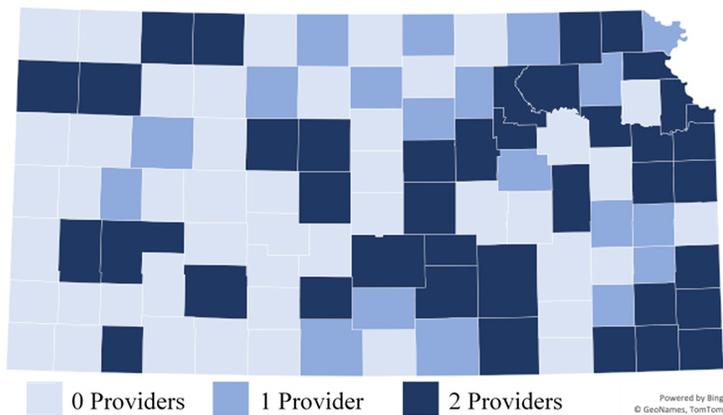


Figure 3. Anesthesia providers per county.

On average, both nonmetropolitan/urban adjacent and rural counties had fewer than the state average of 1.0 pulmonary disease M.D. (mean in nonmetropolitan/urban adjacent counties 0.2, in rural 0.0). In contrast, metropolitan counties had an average of 5.1. Z-tests were used to determine that the means in rural versus metropolitan counties were statistically significant with fewer pulmonary disease physicians than urban counties in Kansas ($p < 0.001$), but there were no differences between rural and nonmetropolitan/urban adjacent counties ($p = 0.475$).

The maximum number of ICU beds in any county was 97. There were no data available in the AHRF on surge capacity, or how far above their maximum ICU beds any hospital or county might be able to go. The majority of the state's available ICU beds were in the five most metropolitan counties (RUCC = 1), which collectively had 60% of all medical/surgical ICU beds in the state. Fifty-six (88.9%) rural and eight (34.8%) nonmetropolitan/urban adjacent counties had zero ICU beds. On average, metropolitan counties had 15.9 ICU beds, nonmetropolitan/urban adjacent had 5.0, and rural had 0.5. Although metropolitan and nonmetropolitan/urban adjacent counties were above the state average of 4.3, rural counties fell well below. Z-tests showed that the mean supply of ICU beds in rural counties was significantly different from the mean supply in metropolitan counties ($p = 0.017$), and it was different from the mean supply in nonmetropolitan/urban adjacent counties ($p < 0.001$). When analyzed in terms of ICU beds per 1,000 people, results were different. Metropolitan counties had 0.1 ICU beds per 1,000 people, nonmetropolitan/urban adjacent had 0.2, and rural had 0.1. Z-tests showed a statistically significant difference in this rate between rural and nonmetropolitan/urban adjacent counties ($p = 0.004$), but not between rural and metropolitan counties ($p = 0.357$).

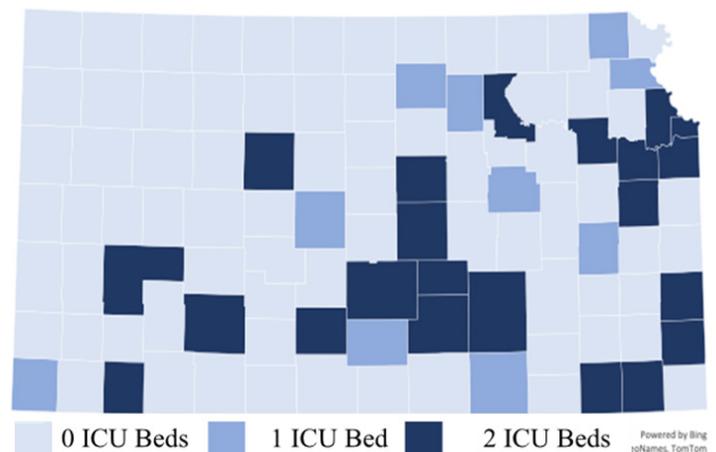


Figure 4. ICU beds by county.

The data available for ICU beds and the structure of the Kansas Rural Health Network allowed for assessing the availability of ICU beds within counties supporting CAHs. Using population estimates from 2017, the county populations in each individual network (the counties of a given supporting hospital and its supported CAHs) were summed. The number of ICU beds were calculated per 1,000 people in each individual network. There were, on average, 0.14 ICU beds per 1,000 people in each network.

Population-level COVID-19 Risk Factors. On average, 19.3% of metropolitan county populations, 20.7% of nonmetropolitan/urban adjacent county populations, and 24.2% of rural county populations were Medicare eligible. A z-test was conducted to compare these mean percentages across rurality categories. Rural and metropolitan counties were compared ($p < 0.001$), as were rural and nonmetropolitan/urban adjacent counties ($p = 0.003$), with both tests showing statistically significant differences. These findings indicated elderly individuals make up significantly greater proportions of the populations in rural counties.

Table 3. Counties supporting CAHs and corresponding populations and ICU capacity in Kansas.

Supporting county	Number of CAHs supported	Number of ICU beds in network	Population in network	ICU beds per 1,000 people	RUCC
Crawford	1	8	59,179	1.35	4
Ellis	23	12	137,367	0.87	5
Finney	9	8	64,928	1.23	5
Johnson	2	97	611,530	1.59	1
Pratt	3	6	20,130	2.98	7
Reno	1	13	72,170	1.80	4
Riley	4	8	121,268	0.66	3
Saline	10	18	143,850	1.25	5
Sedgwick	8	48	627,956	0.76	2
Shawnee	5	32	235,717	1.36	3
Out of state	4	4	45,740*	0.87	n/a

*This does not include the out of state county that supports the Kansas population.

DISCUSSION

This study investigated COVID-19-related healthcare system capacity, critical care resources, and population-based health risk factors in Kansas. Limited hospital presence in nonmetropolitan/urban adjacent and rural counties is problematic in the context of rising COVID-19 cases. Moreover, hospitals that are in nonmetropolitan/urban adjacent and rural counties tend to be CAHs, which are by nature limited in scope and acuity level.

There are approximately 69.1 primary care physicians per 100,000 people in the U.S. as of 2017.²⁸ According to the Organization for Economic Cooperation and Development (OECD), the U.S. average of 2.6 physicians per 1,000 is lower than the OECD average of 3.3. The Kansas average is even lower at 1.0 physician per 1,000, and the rural county level is 0.8 physicians per 1,000, highlighting the physician maldistribution in the U.S. Given that physician expertise is critical in COVID-19 prevention, monitoring, and treatment, the limited physician workforce in rural areas is alarming. While knowledge of a rural physician shortage is not new, understanding the shortage in terms of its criticality to COVID-19 or other similar, future public health threats is an important contribution to the rural health literature.

Most physicians in rural and nonmetropolitan/urban adjacent areas are primary care physicians; however, even among primary care specialties, the workforce is minimal in rural counties.²⁹ The primary care physicians who are practicing in rural areas are beneficial to these communities facing COVID-19, as they bring a wide skill set to the healthcare team. However, our data showed that these physicians do not exist in sufficient numbers; thus, rural Kansas is in a vulnerable position.^{30,31}

Further, rural and nonmetropolitan/urban adjacent counties have serious voids in anesthesia and pulmonary medicine physicians, hindering the treatment of severe COVID-19 cases in these areas. Nearly two-thirds of rural counties had no anesthesia providers of any kind. This is of particular concern because anesthesia providers bring a unique skill set to COVID-19 patient management, including intubation for mechanical ventilation. In critically ill patients, profound acute

hypoxemic respiratory failure from acute respiratory distress syndrome is the dominant clinical finding in COVID-19.²³ In a study of 5,700 hospitalized patients in New York, 1,151 (20.0%) required mechanical ventilation.²⁵ Our evidence of the lack of rural anesthesia providers was consistent with past findings relevant to the U.S. as a whole; a study of all U.S. counties from 2010 - 2015 found nonmetropolitan/urban adjacent counties had less than half the amount of anesthesia providers that non-nonmetropolitan/urban adjacent counties had, 7.72 versus 16.42 per 100,000 people, respectively.³² This relationship was especially significant for anesthesiologists, who were four times more likely to work in urban counties.

Our findings showed an overall shortage of pulmonary disease physicians in Kansas. Rural and nonmetropolitan/urban adjacent counties had averages of zero, and metropolitan counties had an average of one, with only the five most metropolitan counties having two or more. This finding was consistent with previous research. A 2017 study showed that approximately 5% (2.2 million) of adults living in rural areas do not have a pulmonologist available within 50 miles.³³ It also showed that among 12,392 U.S. self-identified pulmonologists, 92.9% were located in metropolitan areas, whereas only 2.1% practiced rural areas.

Particularly alarming was the limited ICU capacity in nonmetropolitan/urban adjacent and rural areas. Our results showed that while 96 of 105 Kansas counties had at least one hospital, 88% of rural counties had no ICU services. Although evidence on hospitalization rates varies, up to 25% of those hospitalized for COVID-19 may need ICU admission, representing approximately 5 - 8% of the total infected population.²³ Overall, the results from our study aligned with other national data on hospital and ICU beds. For example, in the Society of Critical Care Medicine's most up-to-date statistics on resources, 9% of U.S. hospitals with ICU services and 1% of ICU beds were located rural areas, defined as areas with fewer than 10,000 people.⁹

These results provided important context for rural Kansas. Without intensive care services in rural counties, many hospitals will need to rely on the closest supporting hospitals during the COVID-19 crisis in rural Kansas. Kansas Rural Health Networks provide coordinated alliances of supporting hospitals assigned to critical access hospitals,²¹ but the supporting hospitals cover up to 23 counties each. The ICU beds-per-1,000-people ratios were assessed to understand the potential for COVID-19 to overwhelm these supporting hospitals. Our results showed that the average ratio was 0.14 ICU beds per 1,000 people. While 0.14 is less than one ICU bed, the reason this variable was scaled to 1,000 people was because of the distribution of rural populations. Using the AHRF data, the majority of Kansas rural counties had an average population of 3,000 people, and this resource should be viewed in the context of rural counties' realities.

Older adults are affected more commonly and are more likely to have severe disease in the event of COVID-19 infection.^{25,34} Age is a risk factor to be considered not only among the general populace, but also among the physician workforce. Over one-third of the physician

workforce in metropolitan and nonmetropolitan/urban adjacent counties in Kansas and nearly half in rural counties could be at greater risk for COVID-19 due to being over age 55. In rural counties, one-fifth of their physician workforce was over age 65. The fact that these proportions were not statistically different from those found in metropolitan counties meant that all counties, regardless of rurality, should be concerned about the proportions of the physician workforce that could be at a higher risk for severe illness if exposed to COVID-19. The percent of the general population estimated to be over the age 65 was higher among rural counties (24.2%) than metropolitan counties (19.3%). This difference in age structures across Kansas counties has the potential to influence the severity of COVID-19 cases and the associated mortality. It is important that these facts are viewed in terms of practical significance, not only statistical significance.

This study sought to describe the burden of chronic underlying conditions that may increase a patient's risk for severe illness from COVID-19 by rurality. In a study assessing a COVID-19 outbreak across several long-term care facilities in the state of Washington, 94.0% of 101 facility residents affected had a chronic underlying condition, with hypertension and cardiac disease being most common.³⁵ On average, rural counties in Kansas had more deaths per 1,000 people by cardiovascular diseases and COPD than metropolitan and nonmetropolitan/urban adjacent counties. These higher mortality rates among nonmetropolitan/urban adjacent and rural populations in conditions associated with greater risk for severe COVID-19 illness, combined with the greater proportion of elderly individuals in rural counties, were important factors that nonmetropolitan/urban adjacent and rural counties should consider. While some of the differences in raw numbers may seem small, practical significance must again be taken into account. Even small increases in disease burden can mean serious complications for rural health systems given the shortages of healthcare resources we have described.

This study had several limitations. Our study utilized 2017 data to assess capacity, preparedness, and risk factors for a pandemic that began in 2020. While these data were valid for descriptive purposes, more recent data would provide a more accurate picture of the circumstances Kansas will face in the months to come. In addition, depending on how state policymakers choose to make resource-related decisions, it may be necessary to examine resources in the context of the state medical underservice schema, rather than the federally-established RUCC system.³⁶ Lastly, while the AMA Physician MasterFile has been found to be a valid and frequently-used source, it does rely on physician self-reporting and this is an important factor when considering study limitations.^{37,38}

The use of bivariate statistics was intended to be descriptive, as the entire population of Kansas counties was used rather than a sample. There would be value in completing a per capita analysis for all of these resources and more, and this is a suggested direction for future work. In addition, future research should include more conclusive evidence

on rural disease burden and broaden the scope to include other critical COVID-19 care providers, including nursing staff. We believe this analysis should be performed again, following the same or similar protocol, after 2020 Census data are available.

CONCLUSIONS

In this study, the Kansas healthcare system capacity and critical care-related resources important to the care of COVID-19 patients were investigated at the county level in the context of population health characteristics. This study found that the quantity of total physicians, primary care physicians, and specialty physicians needed for the care of COVID-19 patients decreased dramatically in nonmetropolitan/urban adjacent areas and especially in rural areas. In addition to the physician workforce shortage challenging rural Kansas, ICU bed scarcity was also problematic. Most rural counties had no intensive care units and when analyzed at the supporting-network level, there was an average of 0.14 ICU beds per 1,000 people. Lastly, there was significant risk for inundating the healthcare system due to the increased portion of the general population over the age 65 and the higher average three-year mortality for COVID-19-associated underlying chronic conditions in rural populations. This evidence cast light on rural Kansas and the threat it faces from COVID-19 and similar crises with limited healthcare system capacity and resources.

These findings should inform rural physicians, county public health officials, as well as other health professionals on the front lines of COVID-19 preparedness and response. Our study can educate rural Kansas healthcare professionals on the level of risk for severe COVID-19 cases within their populations. This information may be useful to other majority-rural states to the extent their rural counties are resourced similarly. Future research should examine these resources in a variety of rural contexts so that rural communities can prepare for future health crises.

ACKNOWLEDGEMENTS

The authors thank Dr. William Cathcart-Rake for his guidance and editorial assistance.

REFERENCES

- ¹ Fehr R, Kates J, Cox C, Michaud J. COVID-19 in Rural America - Is There Cause for Concern? May 5, 2020. <https://www.kff.org/coronavirus-covid-19/issue-brief/covid-19-in-rural-america-is-there-cause-for-concern/>. Accessed May 20, 2020.
- ² The New York Times. Coronavirus in the U.S.: Latest Map and Case Count. March 3, 2020. <https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html?auth=login-google&login=email>. Accessed June 18, 2020.
- ³ US Census Bureau. What is Rural America? May 23, 2019. <https://www.census.gov/library/stories/2017/08/rural-america.html>. Accessed June 18, 2020.
- ⁴ Kansas Department of Health and Environment. COVID-19 (2019 Novel Coronavirus) Summary. July 31, 2020. <https://www.coronavirus.kdheks.gov/DocumentCenter/View/1529/January-27-case-summary?bidId=>.
- ⁵ US Centers for Disease Control and Prevention. People Who Are at Higher Risk for Severe Illness. May 14, 2020. <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-higher-risk.html>. Accessed May 20, 2020.
- ⁶ US Census Bureau. The Older Population in Rural America: 2012-2016. September 23, 2019. <https://www.census.gov/library/publications/2019/acs/acs-41.html>. Accessed May 20, 2020.
- ⁷ Befort CA, Nazir N, Perri MG. Prevalence of obesity among adults from rural and urban areas of the United States: Findings from NHANES (2005-2008). *J Rural Health* 2012; 28(4):392-397. PMID: 23083085.

- ⁸ O'Connor A, Wellenius G. Rural-urban disparities in the prevalence of diabetes and coronary heart disease. *Public Health* 2012; 126(10):813-820. PMID: 22922043.
- ⁹ Society of Critical Care Medicine. United States Resource Availability for COVID-19. May 12, 2020. <https://sccm.org/Blog/March-2020/United-States-Resource-Availability-for-COVID-19>. Accessed June 15, 2020.
- ¹⁰ Bell MM. The two-ness of rural life and the ends of rural scholarship. *J Rural Stud* 2007; 23(4):402-415.
- ¹¹ Llopis-Jepsen C. Kansas hospitals seek help amid Midwest COVID surge. *Hays Daily News*. November 17, 2020.
- ¹² Smith A. Rural Areas Send Their Sickest Patients to the Cities, Straining Hospital Capacity. November 23, 2020. <https://www.npr.org/sections/health-shots/2020/11/23/933843172/rural-areas-send-their-sickest-patients-to-the-cities-straining-hospital-capacit>. Accessed January 28, 2021.
- ¹³ Fraher EP, Knapton A, Sheldon GF, Meyer A, Ricketts TC. Projecting surgeon supply using a dynamic model. *Ann Surg* 2013; 257(5):867-872. PMID: 23023203.
- ¹⁴ US Department of Agriculture. Economic Research Service. Rural-Urban Continuum Codes. October 25, 2019. <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>. Accessed June 14, 2020.
- ¹⁵ Puro NA, Feyereisen S. Telehealth availability in US hospitals in the face of the COVID-19 pandemic. *J Rural Health* 2020; 36(4):577-583. PMID: 32603017.
- ¹⁶ Zuniga SA, Lango MN. Effect of rural and urban geography on larynx cancer incidence and survival. *Laryngoscope* 2018; 128(8):1874-1880. PMID: 29238975.
- ¹⁷ Liao CJ, Quraishi JA, Jordan LM. Geographical imbalance of anesthesia providers and its impact on the uninsured and vulnerable populations. *Nurs Econ* 2015; 33(5):263-270. PMID: 26625579.
- ¹⁸ Feyereisen SL, Puro N, McConnell W. Addressing provider shortages in rural America: The role of state opt-out policy adoptions in promoting hospital anesthesia provision. *J Rural Health* 2020; Jul 2. Online ahead of print. PMID: 32613667.
- ¹⁹ Segel JE, Lengerich EJ. Rural-urban differences in the association between individual, facility, and clinical characteristics and travel time for cancer treatment. *BMC Public Health* 2020; 20(1):196. PMID: 32028942.
- ²⁰ Wang Z, Goodman M, Saba N, El-Rayes BF. Incidence and prognosis of gastroesophageal cancer in rural, urban, and metropolitan areas of the United States. *Cancer* 2013; 119(22):4020-4027. PMID: 23963864.
- ²¹ Kansas Department of Health & Environment: Office of Rural Health. State Designated Rural Health Networks. February 2013. https://www.khi.org/assets/uploads/news/13582/cah_map.pdf. Accessed June 14, 2020.
- ²² State of Kansas Executive Department. State of Disaster Emergency Proclamation. March 2020. <https://governor.kansas.gov/wp-content/uploads/2020/03/2020-03-12-Proclamation.pdf>. Accessed June 28, 2020.
- ²³ Anesi GL, Halpern SD, Delgado MK. Covid-19 related hospital admissions in the United States: Needs and outcomes. *BMJ*. 2020; 369:m2082. PMID: 32461214.
- ²⁴ CDC COVID-19 Response Team. Severe outcomes among patients with Coronavirus Disease 2019 (COVID-19) - United States, February 12-March 16, 2020. *MMWR Morb Mortal Wkly Rep* 2020; 69(12):343-346. PMID: 32214079.
- ²⁵ Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA* 2020; 323(20):2052-2059. PMID: 32320003.
- ²⁶ Shin DY, Weech-Maldonado R, Chang J. The impact of market conditions on RN staffing in hospitals: Using resource dependence theory and information uncertainty perspective. *Risk Manag Healthc Policy* 2020; 13:2103-2114. PMID: 33116990.
- ²⁷ Phillips WR, Dai M, Frey JJ 3rd, Peterson LE. General practitioners in US medical practice compared with family physicians. *Ann Fam Med* 2020; 18(2):127-130. PMID: 322152016.
- ²⁸ Petterson S MR, Klink K, Meyers D, Bazemore A. The State of Primary Care in the United States: A Chartbook of Facts and Statistics. Washington, DC: Robert Graham Center, 2018.
- ²⁹ [No authors listed] The family physician workforce: The special case of rural populations. *Am Fam Physician* 2005; 72(1):147. PMID: 18853529.
- ³⁰ Raffoul M, Moore M, Kamerow D, Bazemore A. A primary care panel size of 2500 is neither accurate nor reasonable. *J Am Board Fam Med* 2016; 29(4):496-499. PMID: 27390381.
- ³¹ Zhang D, Son H, Shen Y, et al. Assessment of changes in rural and urban primary care workforce in the United States from 2009 to 2017. *JAMA Netw Open* 2020; 3(10):e2022914. PMID: 33112401.
- ³² Martsof GR, Baird M, Cohen CC, Koirala N. Relationship between state policy and anesthesia provider supply in rural communities. *Med Care* 2019; 57(5):341-347. PMID: 30870391.
- ³³ Croft JB, Lu H, Zhang X, Holt JB. Geographic accessibility of pulmonologists for adults with COPD: United States, 2013. *Chest* 2016; 150(3):544-553. PMID: 27221645.
- ³⁴ Verity R, Okell LC, Dorigatti I, et al. Estimates of the severity of coronavirus disease 2019: A model-based analysis. *Lancet Infect Dis* 2020; 20(6):669-677. PMID: 32240634.
- ³⁵ McMichael TM, Currie DW, Clark S, et al. Epidemiology of Covid-19 in a long-term care facility in King County, Washington. *N Engl J Med* 2020; 382(21):2005-2011. PMID: 32220208.
- ³⁶ Kansas Department of Health and Environment. Rural Health Clinics. https://www.kdheks.gov/olrh/RHC_eligible_text.htm. Accessed January 28, 2021.
- ³⁷ Cherkin D, Lawrence D. An evaluation of the American Medical Association's Physician masterfile as a data source--one state's experience. *Med Care* 1977; 15(9):767-769. PMID: 578284.
- ³⁸ Shea JA, Kletke PR, Wozniak GD, Polsky D, Escarce JJ. Self-reported physician specialties and the primary care content of medical practice: A study of the AMA physician masterfile. *American Medical Association. Med Care* 1999; 37(4):333-338. PMID: 10213014.

Keywords: COVID-19, critical care, nonmetropolitan populations, health disparities, healthcare systems