Approaches to Physician Density Measurement and Implications

MJ Josey, MS[1,2]; JM Eberth, PhD[1,2,3]; LR Mobley, PhD[4]; M Schootman, PhD[5]; JC Probst, PhD[3,6]; SM Strayer, MD, MPH[7]; E Sercy, MSPH[1,2]
[1] Department of Epidemiology and Biostatistics, University of South Carolina; [2] Statewide Cancer Prevention and Control Program, University of South Carolina; [3] SC Rural Health Research Center, University of South Carolina; [4] School of Public Health and Andrew Young School of Policy Studies, Georgia State University; [5] Department of Epidemiology, St. Louis University; [6] Department of Health Services Policy & Management, University of South Carolina;

INTRODUCTION

- Estimating available physician resources has been a common practice and a topic of interest for health services and policy researchers, health system administrators, and commercial entities.
- This information is useful for intervention planning, resource allocation, and disparities research.
- Physician density is traditionally calculated as the number of physicians divided by the target population.
- However, the traditional calculation can give an unrealistic picture of the supply of available physicians, as it weighs all physicians the same, regardless of the volume of services.

Purpose

- To offer an alternative, more clinically-realistic measure of physician density. Specifically, our approach weights physicians by their actual procedure volume.
- We illustrate this method with physicians that perform colonoscopy in the United States.

METHODS

Study Population

- We used the Centers for Medicare & Medicaid Services (CMS) 2014 Medicare Provider Utilization and Payment database to obtain the supply of physicians performing colonoscopy in the United States.
- The CMS database consists of physicians that accepted Medicare Fee-for-Service (FFS) in the US and US territories during 2014 and contains aggregate information on physician/supplier Part B final-action claims for the Medicare FFS population.
- Physicians were included in our analysis if they:
  1) were classified as an individual provider,
  2) had a practice address located at a non-military location in the United States, and
  3) provided >10 colonoscopy procedures in 2014 (based on ICD-9, HCPCS, and CPT codes).
- Geolytics Inc. Estimates Professional data was used to estimate the 2014 state and county populations for persons aged 50 and older for the denominator for our density measures.

Analyses

To calculate the alternative volume-weighted provider density, we used the total number of colonoscopy procedures billed by each physician. The number of colonoscopies performed in 2014 was summed to create the total volume per unique provider, V_{ijk}, which was used to create the weight for each provider, W_{ijk}, where

$$W_{ijk} = \begin{cases} V_{ijk}/100 & V_{ijk} < 100 \\ 1 & \text{otherwise} \end{cases}$$

Each provider k is nested in county j, which is in state i. Let 100 represent the volume separation for those providing sufficient number of services per year from those that do not. Performing at least 100 colonoscopies per year is associated with higher adenoma detection rate (Bhangu et al., 2012) and procedure completion rate (Wexner, Barbus & Singh, 2001).

Then, let the density for each county, D_{ij}, be the ratio of the sum of the weights for providers in county j from state i and the population of adults aged 50 years and older. Let D_i be the corresponding density for each state i.

$$D_i = \frac{\sum_j \sum_k W_{ijk}}{population_i} \qquad D_{ij} = \frac{\sum_k W_{ijk}}{population_{ij}}$$

Additionally, we compared the traditional and volume-weighted density as predictors of county- and state-level colorectal cancer (CRC) incidence, mortality, and screening rates obtained from the 2009 – 2013 NCI State Cancer Profiles of adults aged 50 years and older.

We produced descriptive statistics for the utilization of colonoscopy over the study period by state and county. SAS Version 9.4 and R were utilized for data management and analyses. ArcGIS was used to extract and geocode the address of each physician (i.e., street, city, state and ZIP code) and mapping.

RESULTS

- In 2014, there were >2 million colonoscopies provided to the Medicare population by 16,886 physicians.
- These physicians were present in 1,717 US counties (55% of all US counties), including the District of Columbia.
- The average number of colonoscopies performed per physician was 159 (SD=142).
- At the state-level, Nevada had the lowest difference in the two density measures (1.08), and Wyoming had the largest difference (10.59).

Table 1. County-level summary statistics of the traditional and volume-weighted physician density per 100,000 population of adults age 50 years and older.

	Minimum[a]	Q1	Median	Mean[b]	Q3	Maximum
Traditional Density	Pinal (AZ) 0.61	0	Brunswick (NC) 6.98	16.8 (3.8)	17.82	Mitchell (KS) 231
Volume-Weighted Density	Warren (OH) 0.16	0	Hamilton (IN) 3.20	12.8 (2.6)	12.77	Fredericksburg City (VA) 195

Footnotes: [a] Denotes the non-zero minimum, as there were counties with no physicians. [b] The mean (standard deviation).

Figure 1. Standardized differences between the traditional and volume-weighted density for US counties for population of adults 50 years and older.

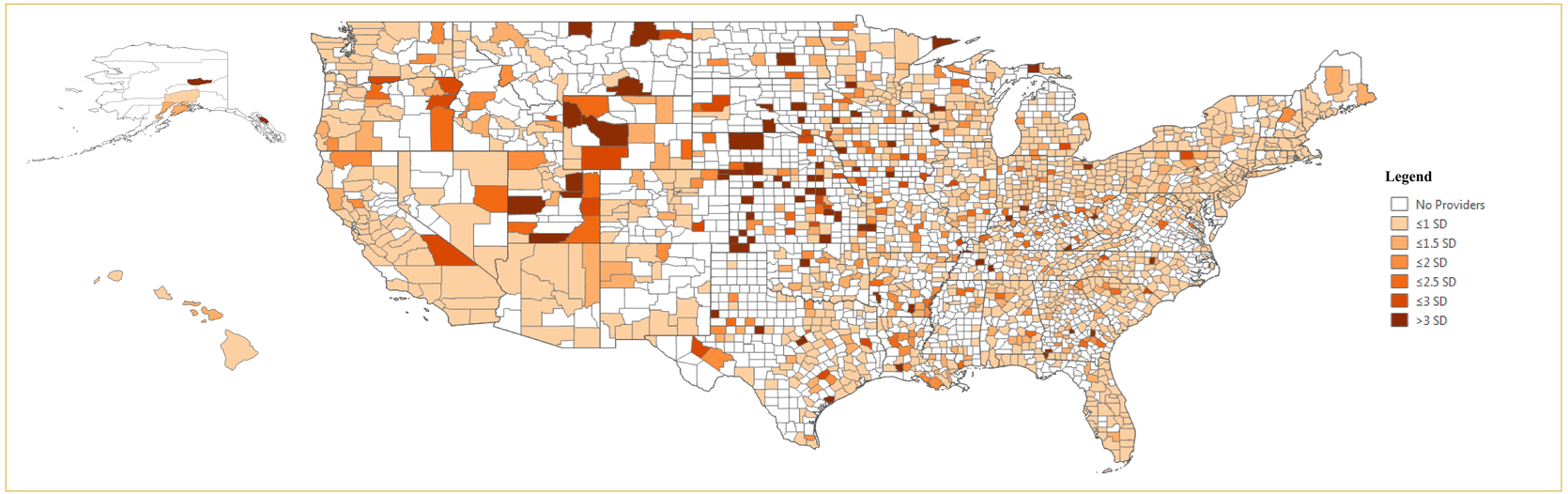

Table 2. Pearson correlations with CRC screening, incidence and mortality rates at state and county levels.

		Traditional Density *r (p-value)*	Weighted Density *r (p-value)*
CRC Screening Rate			
	State level	0.17 (0.229)	0.33 (0.017)
	County level	0.20 (<0.001)	0.24 (<0.001)
CRC Incidence			
	State level	0.41 (0.003)	0.38 (0.006)
	County level	-0.04 (0.040)	-0.06 (0.001)
CRC Mortality			
	State level	0.26 (0.069)	0.30 (0.033)
	County level	-0.09 (<0.001)	-0.15 (<0.001)

Footnotes: CRC screening, incidence, and mortality rates are based on population aged 50+. CRC screening is based on modeled estimates from 2008-2010, and incidence and mortality rates are based on 2009-2013 data from NCI State Cancer Profiles. Traditional density is measured by the number of physicians performing colonoscopy to CMS beneficiaries in a state divided by the population aged 50+. Volume-weighted density is measured by the weighted sum of physicians performing colonoscopy to CMS beneficiaries in a state divided by the population aged 50+.

CONCLUSION

- Incorporating physicians procedure volume resulted in improved associations between provider density and colorectal cancer screening rates.
- The associations between county provider density and colorectal cancer incidence and mortality were very low but in the expected negative direction, unlike the state-level correlations.
- Although this study focused on colonoscopy providers and colorectal cancer, the density calculation formula developed here may be useful for quantifying density of providers for other service types.
- This work lays the foundation for future studies aimed to determine geographic variation in unrealized capacity for colorectal cancer screening, and to explore the association of physician availability with cancer-related outcomes.

Future Directions

This study utilized county boundaries, which do not truly separate populations receiving services. This method can be improved by incorporating spatial accessibility measures, like catchment areas, to capture the spillover of populations.

About the SC Rural Health Research Center:
Website: http://rhr.sph.szc.edu/index.php
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