THE JOURNAL OF RURAL HEALTH

ORIGINAL ARTICLE

Who Performs Colonoscopy? Workforce Trends Over Space and Time

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Disclosures: The article contents are solely the responsibility of the authors and do not necessarily represent the official views of the funders. The authors have no financial conflicts of interest to disclose.

Funding: This publication was also made possible in part by grant numbers T32-GM081740 from NIH-National Institute of General Medical Sciences (Josey), MRSG-15-148-01-CPHPS from the American Cancer Society (Eberth, Mobley, Probst, Schootman), 5U1CRH0311-12-00 from the Federal Office of Rural Health Policy (Eberth, Probst), P30CA091842 from the NIH-National Cancer Institute (Jeffe), HL-38180, DK-56260, and Digestive Disease Research Core Center DK-52574 from the NIH, and R56AG049503 (Schootman, Davidson) from the NIH-National Institute on Aging.

Acknowledgment: The authors want to thank Ms. Erica Sercy for her editorial support.

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doi: 10.1111/jrh.12286

Abstract

Purpose: With the increased availability of colonoscopy to average risk persons due to insurance coverage benefit changes, we sought to identify changes in the colonoscopy workforce. We used outpatient discharge records from South Carolina between 2001 and 2010 to examine shifts over time and in urban versus rural areas in the types of medical providers who perform colonoscopy, and the practice settings in which they occur, and to explore variation in colonoscopy volume across facility and provider types.

Methods: Using an all-payer outpatient discharge records database from South Carolina, we conducted a retrospective analysis of all colonoscopy procedures performed between 2001 and 2010.

Findings: We identified a major shift in the type of facilities performing colonoscopy in South Carolina since 2001, with substantial gains in ambulatory surgery settings (2001: 15, 2010: 34, +127%) versus hospitals (2001: 58, 2010: 59, +2%), particularly in urban areas (2001: 12, 2010: 27, +125%). The number of internists (2001: 46, 2010: 76) and family physicians (2001: 34, 2010: 106) performing colonoscopies also increased (+65% and +212%, respectively), while their annual procedures volumes stayed fairly constant. Significant variation in annual colonoscopy volume was observed across medical specialties ($P < .001$), with nongastroenterologists having lower volumes versus gastroenterologists and colon and rectal surgeons.

Conclusions: There have been substantial changes over time in the number of facilities and physicians performing colonoscopy in South Carolina since 2001, particularly in urban counties. Findings suggest nongastroenterologists are meeting a need for colonoscopies in rural areas.

Key words ambulatory care, family medicine, health services research, hospitals, physician supply.

Colorectal cancer (CRC) is the third most common cancer, and the third leading cause of cancer death for both men and women in the United States.[1] Because of its effectiveness in reducing CRC incidence and mortality,[2] screening is recommended by the American Cancer Society and US Preventive Services Task Force (USPSTF) starting at 50 years of age for average-risk persons, and up to age 75.[3,4] Screening modalities for CRC are

numerous and include colonoscopy, the fecal immunochemical test (FIT), the fecal occult blood test (FOBT), flexible sigmoidoscopy, double-contrast barium enema, the stool DNA test, and CT colonography.[4] Use of flexible sigmoidoscopy and fecal occult blood testing for CRC screening have substantially declined in the past 2 decades in favor of colonoscopy,[5-8] due in part to growing reimbursement for average-risk colonoscopies, screening recommendations that favor endoscopic approaches for their cancer prevention potential,[4,9] and physician preferences and referral patterns.[10,11] In 2012, more than 60% of all persons aged 50-75 screened underwent a colonoscopy versus other modalities, with FOBT coming in second at 10%.[12]

With increasing use of colonoscopy,[7] there also has been increasing variability in the types of providers performing colonoscopies (eg, gastroenterologists, family medicine [FM], internal medicine [IM], general, and colorectal surgeons, as well as physician extenders such as physician assistants).[13] While studies have found that nongastroenterologist providers can provide safe and cost-effective colonoscopy,[14-24] other studies have reported increased risk of complications (particularly for complex colonoscopies), as well as lower adenoma detection rates, exam completion rates, and cecal intubation rates among nongastroenterologists.[25-31] These poor outcomes may be due in part to lower procedure volumes.[20,21,27,29,32-34]

The extent to which providers in different specialties perform colonoscopies in the general population is unknown. Yet, changes in the distribution of provider specialties performing colonoscopy, the complexity, duration and adequacy of supervised training, and the volume of colonoscopies performed could have a downstream influence on colonoscopy quality.[27,34,35] Our study aimed to examine the extent to which colonoscopy providers of different specialties perform colonoscopies in South Carolina (SC), a state that serves a large, rural population (34% based on 2010 Census[36]), which may present unique challenges to the provision of high-quality colonoscopies. We also examined geographic and temporal variation in practice settings (hospital vs ambulatory surgery centers [ASCs]) and annual procedure volume by physician medical specialty.

Methods

South Carolina has mandatory, population-based reporting for all visits to emergency departments, hospitals, and ASCs. Because reporting of all visits is required by legislation, data are not restricted to specific payers or age groups. To determine the number and type of providers providing colonoscopy, we used outpatient data from the SC Ambulatory Surgery Discharge database (which includes hospitals and free-standing ASCs), restricted to individuals 50-74 years of age who underwent a colonoscopy between 2001 and 2010, in order to identify average-risk individuals eligible for population-based CRC screening.[3] All indications for colonoscopy were included due to difficulty disentangling the test purpose from the available discharge records, without corresponding medical record data,[37] and a primary focus on workforce shifts based on total colonoscopy utilization among persons 50-74 years. Nationally, studies show that approximately 38%-45% of all colonoscopies are done for screening purposes.[38-40]

We defined a colonoscopy center as a facility (hospital or ASC) performing ≥1 colonoscopy in any particular year. Centers were identified using a unique facility ID. One key facility-level characteristic, county urban/rural status, was defined based on 2003 Rural-Urban Continuum Codes developed by the US Department of Agriculture[41] (metropolitan categories collapsed to represent urban, and nonmetropolitan categories collapsed to represent rural).

Colonoscopy providers were defined as physicians who performed ≥1 colonoscopy to individuals aged 50-74 years in any particular year. Providers were identified using a unique provider ID in the SC Ambulatory Surgery Discharge Database. Medical specialty is self-reported during the physician licensing process required by the SC Board of Labor and Licensing, and it is directly linked to the discharge data. Additional information from the National Provider Identifier Registry was used to supplement the database where medical specialty information was missing in the database, as well as to validate the medical specialty reported in the discharge database. Only 0.24% of physicians in the data set had missing specialty information over the time period under examination. We focused on 5 physician specialties: gastroenterology (GE), general surgery (GS), IM (including Geriatric IM), colon and rectal surgery (CRS), and FM (including Geriatric FM) because they perform nearly all colonoscopies. Other specialists performing colonoscopy were excluded due to the low volume of procedures performed annually (ie, <1% of procedures in 2010). Colonoscopies provided by these "Other" specialties were included, however, in all aggregate descriptive statistics. Records without a designated provider (ie, discharge record with only center-level information) were excluded from our provider-level analyses (n = 1,803; 0.22%). When multiple providers were included on a single discharge record (13% of records), only the characteristics of the first provider listed on the discharge record were used for our analy-

sis, as he/she was assumed to be the patient's attending physician/provider.

The most comprehensive list of codes associated with colonoscopy was included (Appendix A, available online only) to try to capture all facilities and providers performing colonoscopy in the screening-eligible population, and explore procedure volume patterns. Analysis of variance and the Kruskal-Wallis rank sum test were used to examine statistical differences in the physician/center volume, and the chi-square and Fisher's exact test were used to examine the differences in proportions. Statistical significance was based upon an alpha level of 0.05. Subsequently, to examine whether the growth rate of colonoscopy centers and providers outpaced the population eligible for CRC screening, we standardized the number of colonoscopy centers, colonoscopy providers, and the population aged 50-74 by year, plotted the variables on a scatterplot, and fit a linear trend line to the data. All analyses were performed in SAS Version 9.3 (SAS Institute Inc., Cary, North Carolina) and R (The R Foundation for Statistical Computing, Vienna, Austria). This study was reviewed and deemed exempt from oversight by the University of South Carolina Institution Review Board (Protocol No. 00032542).

Results

Characteristics of Colonoscopy Centers

In 2010, there were 93 unique colonoscopy centers located in SC, 79 of which had at least 1 gastroenterologist practicing there as their primary office location. This represented a 27% increase in the number of colonoscopy centers and a 46% increase in those with practicing gastroenterologists compared to 2001, when Medicare began covering colonoscopy for people of average risk. Most of the change over time in availability of colonoscopy centers occurred in urban counties (Urban: 34% change, Rural: 15% change). Using linear trend analysis, we found the growth of colonoscopy centers and the population aged 50-74 exhibited a strong, positive linear relationship over time (Figure 1A). This linear trend occurred in both urban and rural settings; however, both slopes were slightly <1.00 ($\beta_{urban} = 0.96$, $\beta_{rural} = 0.89$), indicating that the population aged 50-74 is growing slightly faster (although not significantly) than the number of associated colonoscopy centers. A linear relationship was also found between the number of individual colonoscopy providers and the population aged 50-74 (Figure 1B), with both urban and rural slopes <1.00 ($\beta_{urban} = 0.85$, $\beta_{rural} = 0.92$), indicating faster growth (although not significant) of the population aged 50-74 compared to individual providers.

The number of hospitals providing colonoscopies remained fairly constant over time, while the number of ASCs increased more than 125% (Figure 2A). Growth of ASCs performing colonoscopy was most pronounced in urban counties. The percent change in annual colonoscopy volume in hospitals between 2001 and 2010 was -7% in urban areas and +12% in rural areas, and in ASCs, it was +58% in urban areas and +33% in rural areas (Figure 2B).

Characteristics of Colonoscopy Providers

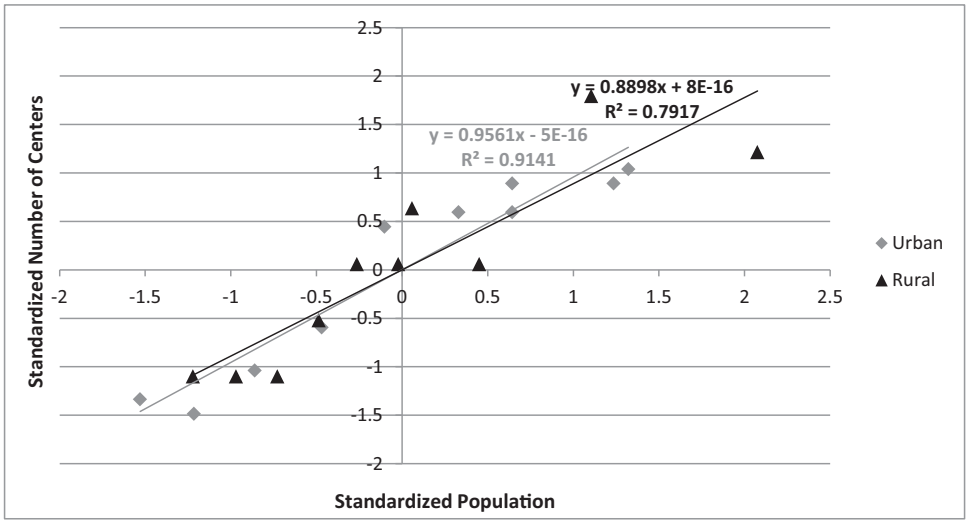
There were 583 unique colonoscopy providers in 2010, up from 448 in 2001 (+30%). In most urban and rural counties, the density of providers per 100,000 persons aged 50-74 declined. Only a few counties saw marked improvements (eg, Greenwood County, Chesterfield County, Jasper County).

In 2010, 78% of providers performed the majority of their colonoscopy procedures at a hospital (Table 1) compared to 91% in 2001. Gastroenterologists were more likely to work in ASC settings than nongastroenterologists. From 2001 to 2010, the number of providers performing colonoscopy primarily in ASCs more than tripled from 41 to 127, while the number of providers performing colonoscopy in hospitals as their primary office setting increased only 12%, indicating a major shift in where colonoscopies were being performed over time. Providers in ASCs performed a mean of 323 colonoscopies in 2010 (up from 215 in 2001), compared to only 68 per provider in hospital settings (down from 93 in 2001).

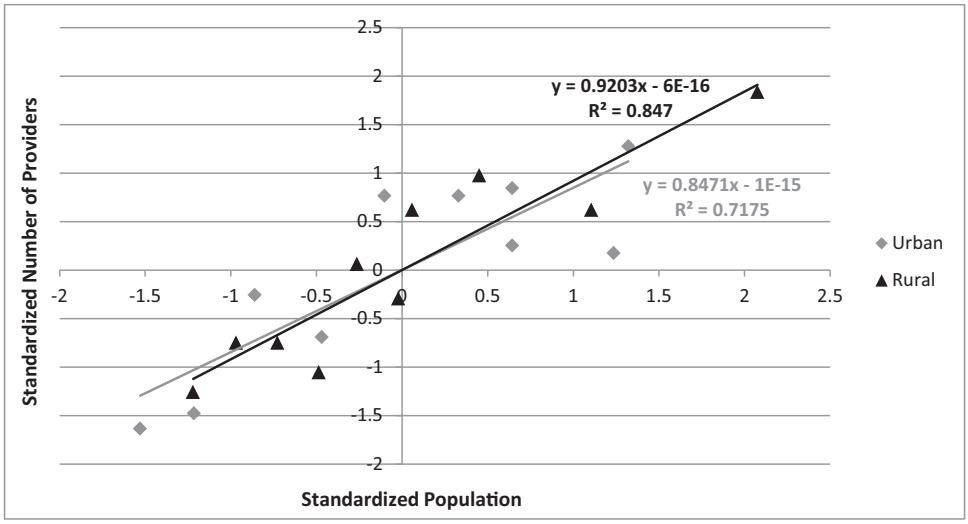
Overall, from 2001 to 2010, the total number of colonoscopy providers increased for all specialties, except for those classified as colon and rectal surgeons, which remained constant (Figure 3A). The number of family physicians that performed colonoscopies increased most, from 34 physicians in 2001 to 106 physicians in 2010. In both urban and rural areas, nongastroenterologists were the predominant type of provider; however, rural counties had fewer gastroenterologists (2001: n = 23; 2010: n = 20) compared to urban counties (2001: 114, 2010: n = 133) and experienced a 13% decline from 2001 to 2010 in gastroenterologist availability.

Despite an overall increase in the number of physicians performing colonoscopy, the mean annual volumes remained low for family practitioners (2001: 13, 2010: 14), internists (2001: 46, 2010: 38), and general surgeons (2001: 51, 2010: 83) compared to gastroenterologists (2001: 283, 2010: 426; Figure 3B). In both urban and rural counties, gastroenterologists had the highest annual volumes, followed by colon and rectal surgeons, general surgeons, internists, and family physicians with the lowest volumes. Interestingly, rural gastroenterologists and

Figure 1 Linear Growth of Standardized Measures of Colonoscopy Centers (A) and Individual Colonoscopy Providers (B) in Relation to Growth in the Population Aged 50-74, by Urban versus Rural Location, 2001-2010.



Panel A



Panel B

Note: Provider location is classified as "primarily" urban or rural based on where the majority of their colonoscopy procedures were performed in a particular year. Each marker (urban = diamond, rural = triangle) on the graph represents a particular year of the study period, 2001 to 2010.

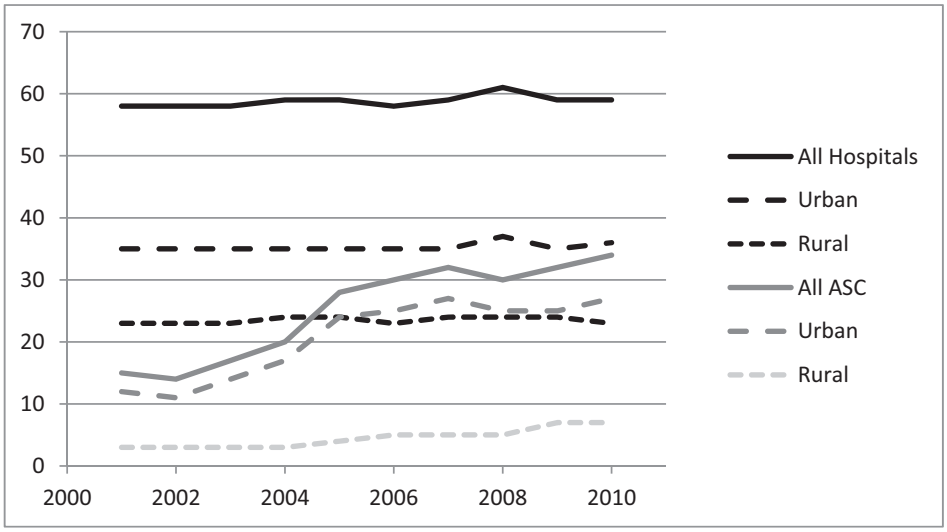
general surgeons had higher annual procedure volumes on average than their urban counterparts (Table 1).

Discussion

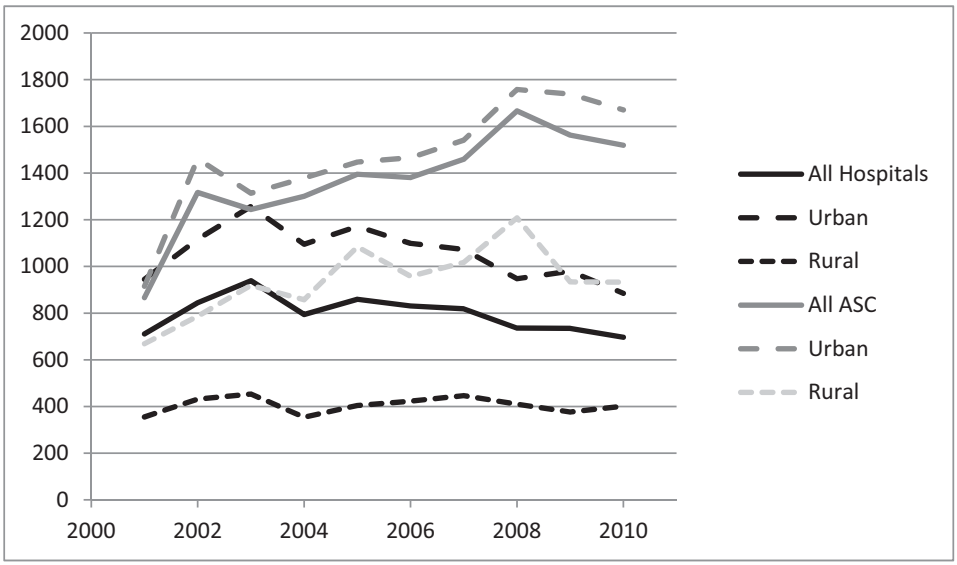
Since the Centers for Medicare and Medicaid Services began covering colonoscopy for average-risk individuals in 2001, the number of ASCs performing colonoscopies has climbed sharply. This rapid growth in market share also has been shown nationally among Fee-For-Service Medicare beneficiaries, with 58.6% of colonoscopies being performed in ASCs in 2000 compared to 83.7% in 2009.[42] This shift may offer significant savings for Medicare, as ASC payment rates are approximately half that paid to hospital outpatient departments.

From 2001 to 2010, the number of family physicians performing colonoscopy in SC has also increased, possibly resulting from colonoscopy training programs for SC family physicians.[43] A corresponding increase in the number of active family physicians was also noted nationally[44] and in SC[45] during this time period, although all but 2 of SC's counties are still considered primary care shortage

Figure 2 Changes in Colonoscopy Centers (A) and Average Procedure Volume (B) Between 2001 and 2010 in South Carolina, by Practice Setting and County Urban/Rural Designation.



Panel A



Panel B

areas (either whole or in part).[46] Despite the rise in the number of facilities and colonoscopy providers over time, some improvements have been limited to urban counties. For example, the number of gastroenterologists with a primary office location in rural SC has declined by 13%, whereas urban counties experienced a 17% increase.

Our study found that nongastroenterologists do indeed fill a gap in counties without a practicing gastroenterologist. Despite our finding that nongastroenterologists are more common in rural areas, lacking a gastroenterologist in one's own county may not necessarily translate to lower quality colonoscopies for rural residents. A recent study in Oregon found that nongastroenterologists performing colonoscopy in rural areas had comparable polyp detection rates compared to nonrural practices, but lower cecal intubation rates, retrieval of resected polyps, and submission of polyps to pathology.[47] Rural residents also often bypass local nongastroenterologists[48] to seek care from gastroenterologists in neighboring counties. Fewer opportunities may exist, however, for residents who lack transportation to travel for health care. More research is needed to determine the quality of care provided by nongastroenterologists in urban and rural settings, where procedure volumes are expected to vary.

Table 1 Provider Characteristics, by Physician's Medical Specialty, 2010

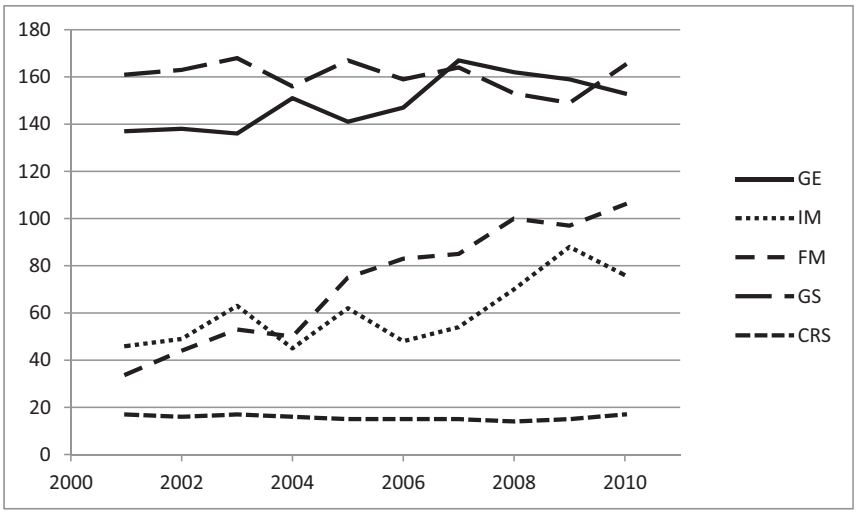
	All[a]	GE	GS	IM	FM	CRS	*P* value[b]
Overall distribution, n (%)	583	153	165	76	106	17	
	(100)	(26.2)	(28.3)	(13.0)	(18.2)	(2.9)	
Overall annual volume,[c] mean (SD)	152	426	83	38	14	275	<.001
	(240)	(268)	(102)	(197)	(38)	(192)	
Primary office setting, n (%)							
Urban county	399	133	117	50	40	17	<.001
	(68.4)	(86.9)	(70.9)	(65.8)	(37.7)	(100.0)	
Rural county	184	20	48	26	66	N/A	
	(31.6)	(13.1)	(29.1)	(34.2)	(62.3)		
Hospital	456	61	149	69	99	15	
	(78.2)	(39.9)	(90.3)	(90.8)	(93.4)	(88.2)	
Urban county	287	53	104	43	33	15	<.001
	(62.9)	(86.9)	(39.8)	(62.3)	(33.3)	(100.0)	
Rural county	169	8	45	26	66	N/A	
	(37.1)	(13.1)	(30.2)	(37.7)	(66.7)		
Ambulatory surgery	127	92	16	7	7	2	
	(21.8)	60.1	9.7	9.2	6.6	(11.8)	
Urban county	112	80	13	7	7	2	.699
	(88.2)	(87.0)	(81.3)	(100.0)	(100.0)	(100.0)	
Rural county	15	12	3	N/A	N/A	N/A	
	(11.8)	(13.0)	(18.7)				
Annual volume, mean (SD)	127	349	75	38	14	219	<.001
	(201)	(224)	(89)	(193)	(38)	(162)	
Urban county	154	345	40	50	29	219	
	(217)	(224)	(88)	(234)	(57)	(162)	
Rural county	61	377	86	14	5	N/A	
	(144)	(225)	(92)	(56)	(13)		

[a]Includes providers not classified in 1 of the 5 predominant medical specialties providing colonoscopies.
[b]*P* values calculated using analysis of variance and Kruskal-Wallis for volume and chi-square and Fisher exact test for proportion comparisons.
[c]Overall annual volume is based on data from any location where colonoscopy was provided by each provider, and annual volume at the primary office setting is based on data for all colonoscopies performed at the location in which the majority of procedures were performed. Volume calculations based on data from all patients served aged 50-74, including out-of-state patients and all colonoscopy indications (ie, surveillance, screening, and diagnostic).

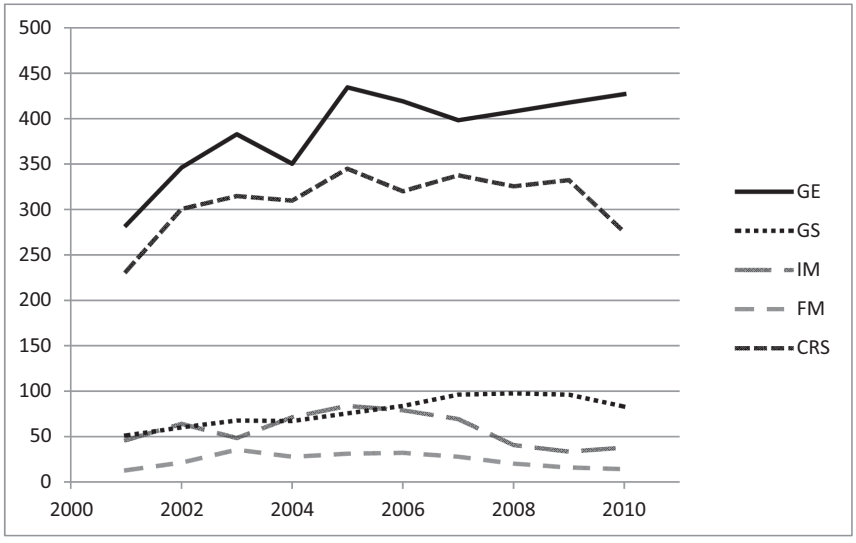
Our findings suggest that growth in the supply of providers following Medicare coverage of colonoscopy in 2001 has been heterogeneous across different provider types and care settings. As efforts are underway to screen 80% of the screening-eligible US population by 2018,[49] programs to address colonoscopy capacity limitations in rural America will be needed. In a survey of program directors of family medicine residency programs, only 18% of directors reported training one or more residents to perform colonoscopies.[50] When colonoscopy is incorporated into the residency training programs, indicators of success (eg, adenoma detection rate) increase with volume regardless of specialty.[32,51-54] A *minimum* threshold of 140 supervised colonoscopies for GE residents was previously recommended by the American Society for Gastrointestinal Endoscopy; however, new research suggests it takes 250+ procedures to achieve competence.[55] In contrast, the American Association of Family Physicians recommends a minimum threshold of 50 colonoscopies for basic competency.[56] More research is needed to determine the optimal number of procedure thresholds to maintain competency and success rates post training, particularly in nongastroenterologists who perform fewer colonoscopies. Furthermore, while the number of physicians performing colonoscopy is increasing over time, surveillance of quality measures including cecal intubation rates and complication rates, as well as long-term outcomes such as incident CRCs, will be critical metrics in view of the predominance of nongastroenterologists performing colonoscopies.

Notwithstanding the need for more research on quality of colonoscopies performed by nongastroenterologists, one must realize that using only gastroenterologists to perform colonoscopy in rural areas is not likely to be feasible, given their limited availability, and consider as a consequence that a broader range of CRC screening modalities might be necessary under these conditions.[57-59] Interventions with targeted outreach (eg, mailed FIT kits) and education in rural areas have shown high success rates for FIT[60-62] and FOBT[63] completion.

Figure 3 Changes in Colonoscopy Providers (A) and Their Average Procedure Volume (B) Between 2001 and 2010 in SC, by Physician Medical Specialty.



Panel A



Panel B

Primary care providers are uniquely situated to offer individuals less invasive screening tests such as FIT and FOBT without additional training and with minimal time commitment. Research is therefore warranted to further explore CRC screening capacity (using different combinations of testing approaches and provider types) in rural areas.

Limitations

Limitations of our study also exist. This was a purely descriptive study, which established considerable variation among provider types (employment settings and medical specialties) in the volume of colonoscopies performed over space and time, although the data were not very recent. Also, our results may not be generalizable to other states. However, our population-based study contributes important new knowledge to the existing literature that is largely limited to reports of single institutions, systems or payers, and lays the foundation for national studies using a similar framework.

Conclusion

In conclusion, we observed a major shift in practice settings for colonoscopy, whereby the number of ASCs

performing colonoscopy has substantially increased over time, particularly in urban counties. In spite of the considerable growth in the number of colonoscopies performed and of unique colonoscopy providers since 2001, the difference between urban and rural availability of colonoscopy facilities and providers has increased. Programs to increase use of FOBT/FIT, recruit additional gastroenterologists, or train nongastroenterologists to provide colonoscopies in underserved communities would help alleviate the disparities observed in CRC screening and mortality rates in rural communities.

References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2015. *CA-Cancer J Clin*. 2015;65(1):5-29.
2. Zauber AG, Landsdorp-Vogelaar I, Knudsen AB, Wilschut J, van Ballegooijen M, Kuntz DM. Evaluating test strategies for colorectal cancer screening: a decision analysis for the US Preventive Services Task Force. *Ann Intern Med*. 2008;149(9):659-669.
3. US Preventive Services Task Force. Screening for colorectal cancer: US preventive services task force recommendation statement. *J Amer Med Assoc*. 2016;315(23):2564-2575.
4. Levin B, Lieberman DA, McFarland B, et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. *CA-Cancer J Clin*. 2008;58(3):130-160.
5. Schenck AP, Peacock SC, Klabunde CN, Lapin P, Coan JF, Brown ML. Trends in colorectal cancer test use in the Medicare population, 1998–2005. *Am J Prev Med*. 2009;37(1):1-7.
6. Phillips KA, Liang SY, Ladabaum U, et al. Trends in colonoscopy for colorectal cancer screening. *Med Care*. 2007;45(2):160-167.
7. Klabunde CN, Cronin KA, Breen N, Waldron WR, Ambs AH, Nadel MR. Trends in colorectal cancer test use among vulnerable populations in the United States. *Cancer Epidemiol Biomarkers Prev*. 2011;20(8):1611-1621.
8. Fenton JJ, Cai Y, Green P, Beckett LA, Franks P, Baldwin LM. Trends in colorectal cancer testing among Medicare subpopulations. *Am J Prev Med*. 2008;35(3):194-202.
9. Rex DK, Bond JH, Winawer S, et al. Quality in the technical performance of colonoscopy and the continuous quality improvement process for colonoscopy: recommendations of the U.S. Multi-Society Task Force on Colorectal Cancer. *Am J Gastroenterol*. 2002;97(6):1296-1308.
10. Harewood GC, Lieberman DA. Colonoscopy practice patterns since introduction of Medicare coverage for average-risk screening. *Clin Gastroenterol H*. 2004;2(1): 72-77.
11. Ransohoff DF. Colon cancer screening in 2005: status and challenges. *Gastroenterology*. 2005;128(6):1685-1695.
12. Centers for Disease Control and Prevention (CDC). Vital signs: colorectal cancer screening test use–United States, 2012. MMWR *Morb Mortal Wkly Rep*. 2013;62(44):881-888.
13. van Putten P, Ter Borg F, Adang RP, et al. Nurse endoscopists perform colonoscopies according to the international standard and with high patient satisfaction. *Endoscopy*. 2012;44(12):1127-1132.
14. Wilkins T, LeClair B, Smolkin M, et al. Screening colonoscopies by primary care physicians: a meta-analysis. *Ann Fam Med*. 2009;7(1):56-62.
15. Newman RJ, Nichols DB, Cummings DM. Outpatient colonoscopy by rural family physicians. *Ann Fam Med*. 2005;3(2):122-125.
16. Pierzchajlo RP, Ackermann RJ, Vogel RL. Colonoscopy performed by a family physician. A case series of 751 procedures. *J Fam Prac*. 1997;44(5):473-480.
17. Edwards JK, Norris TE. Colonoscopy in rural communities: can family physicians perform the procedure with safe and efficacious results? *J Am Board Fam Med*. 2004;17(5):353-358.
18. Provenzale D, Ofman J, Grainek I, Rabeneck L, Koff R, McCrory D. Gastroenterologist specialist care and care provided by generalists—an evaluation of effectiveness and efficiency. *Am J Gastroenterol*. 2003;98(1):21-28.
19. McClellan DA, Ojinnaka CO, Pope R, et al. Expanding access to colorectal cancer screening: benchmarking quality indicators in a primary care colonoscopy program. *J Am Board Fam Med*. 2015;28(6):713-721.
20. Bhangu A, Bowley DM, Horner R, Baranowski E, Raman S, Karandikar S. Volume and accreditation, but not specialty, affect quality standards in colonoscopy. *Brit J Surg*. 2012;99(10):1436-1444.
21. Wexner SD, Garbus JE, Singh JJ, SAGES Colonoscopy Study Outcomes Group. A prospective analysis of 13,580 colonoscopies. Reevaluation of credentialing guidelines. *Surg Endosc*. 2001;15(3):251-261.
22. Mehran A, Jaffe P, Efront J, Vernava A, Liberman MA. Colonoscopy: why are general surgeons being excluded? *Surg Endosc*. 2003;17(12):1971-1973.
23. Wexner SD, Forde KA, Sellers G, et al. How well can surgeons perform colonoscopy? *Surg Endosc*. 1998;12(12):1410-1414.
24. Azzopardi J, DeWitt D. Quality and safety issues in procedural rural practice: a prospective evaluation of current quality and safety guidelines in 3000 colonoscopies. *Rural Remote Health*. 2012;12(3):1949.
25. Leyden JE, Doherty GA, Hanley A, et al. Quality of colonoscopy performance among gastroenterology and surgical trainees: a need for common training standards for all trainees? *Endoscopy*. 2011;43(11):935-940.

26. Jiang M, Sewitch MJ, Barkun AN, Joseph L, Hilsden RJ. Endoscopist specialty is associated with colonoscopy quality. *BMC Gastroenterol*. 2013;13(1):78.
27. Chukmaitov A, Bradley CJ, Dahman B, Siangphoe U, BouHaidar D, Warren JL. Polypectomy techniques, endoscopist characteristics, and serious gastrointestinal adverse events. *J Surg Oncol*. 2014;110(2):207-213.
28. Singh H, Penfold RB, DeCoster C, et al. Colonoscopy and its complications across a Canadian regional health authority. *Gastrointest Endosc*. 2009;69(3):665-671.
29. Spier BJ, Durkin ET, Walker AJ, Foley E, Gaumnitz EA, Pfau PR. Surgical resident's training in colonoscopy: numbers, competency, and perceptions. *Surg Endosc*. 2010;24(10):2556-2561.
30. Ko CW, Dominitz JA, Green P, Kreuter W, Baldwin LM. Specialty differences in polyp detection, removal, and biopsy during colonoscopy. *Am J Med*. 2010;123(6):528-535.
31. Bielawska B, Day AG, Lieberman DA, Hookey LC. Risk factors for early colonoscopic perforation include non-gastroenterologist endoscopists: a multivariable analysis. *Clin Gastroenterol H*. 2014;12(1):85-92.
32. Lee S-H, Chung I-K, Kim S-J, et al. An adequate level of training for technical competence in screening and diagnostic colonoscopy: a prospective multicenter evaluation of the learning curve. *Gastrointest Endosc*. 2008;67(4):683-689.
33. Harewood GC. Relationship of colonoscopy completion rates and endoscopist features. *Dig Dis Sci*. 2005;50(1):47-51.
34. Chukmaitov A, Bradley CJ, Dahman B, Diangphoe U, Warren JL, Klabunde CN. Association of polypectomy techniques, endoscopist volume, and facility type with colonoscopy complications. *Gastrointest Endosc*. 2013;77(3):436-446.
35. Lorenzo-Zúñiga V, Moreno de Vega V, Domenech E, Manosa M, Planas R, Boix J. Endoscopist experience as a risk factor for colonoscopic complications. *Colorectal Dis*. 2010;12(10):e273-e277.
36. South Carolina: 2010. Population and housing unit counts. 2010 Census of Population and Housing. US Census Bureau, US Department of Commerce, Economics and Statistics Division. Available at: https://www.census.gov/prod/cen2010/cph-2-42.pdf. Accessed December 5, 2016.
37. Fisher GA, Grubber JM, Castor JM, Coffman CJ. Ascertainment of colonoscopy indication using administrative data. *Dig Dis Sci*. 2010;55(6):1721-1725.
38. Vijan S, Inadomi J, Hayward RA, Hofer TP, Fendrick AM. Projections of demand and capacity for colonoscopy related to increasing rates of colorectal cancer screening in the United States. *Aliment Pharmacol Ther*. 2004;20:507-515.
39. Brown ML, Klablunde CN, Mysliwiec P. Current capacity for endoscopic colorectal cancer screening in the United States: data from the National Cancer Institute survey of colorectal cancer screening practices. *Am J Med*. 2003;115(2):129-133.
40. Seeff LC, Richards TB, Shapiro JA, et al. How many endoscopies are performed for colorectal cancer screening? Results from CDC's survey of endoscopic capacity. *Gastroenterology*. 2004;127(6):1670-1677.
41. Rural-Urban Continuum Codes. *United States Department of Agriculature, Economic Research Services*. Available at: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx. Accessed December 5, 2016.
42. Koenig L, Gu Q. Growth of ambulatory surgical centers, surgery volume, and savings to Medicare. *Am J Gastroenterol*. 2013;108:10-15.
43. Lloyd SC, Harvey NR, Hebert JR, Daguise V, Williams D, Scott DB. Racial disparities in colon cancer: primary care endoscopy as a tool to increase screening rates among minority patients. *Cancer*. 2007;109(S2):378-385.
44. Association of American Medical Colleges, Center for Workforce Studies. *2012 Physician Specialty Data Book*. 2013. Available at: https://www.aamc.org/download/313228/data/2012physicianspecialtydatabook.pdf. Accessed December 12, 2016.
45. Office for Healthcare Workforce Analysis and Planning. *South Carolina Health Professions Data Book*; 2014. Available at: http://officeforhealthcareworkforce.org/bigDocs/ohw_cdb2014.pdf. Accessed December 12, 2016.
46. South Carolina Department of Health and Environmental Control. *South Carolina Primary Care HPSA by Type*; 2014. Available at: http://www.scdhec.gov/Health/docs/HPSA_Primary.pdf. Accessed December 12, 2016.
47. Holub JL, Morris C, Fagnan LJ, et al. Quality of colonoscopy performed in rural practice: experience from the Clinical Outcomes Research Initiative and the Oregon Rural Practice-Based Research Network. [epub ahead of print] *J Rural Health*. Available at: https://doi.org/10.1111/jrh.12231. Accessed January 3, 2017.
48. Eberth JM, Josey M, Trivedi T, Hibbert J, Probst JC. *Colonoscopy Access and Utilization - Rural Disparities in the Carolinas, 2001—2010*; 2016. SC Rural Health Research Center: Columbia, SC. Available at: http://rhr.sph.sc.edu/report/(14-5)Colonoscopy_study_brief.pdf. Accessed December 12, 2016.
49. Paskett ED, Khuri FR. Can we achieve an 80% screening rate for colorectal cancer by 2018 in the United States? *Cancer*. 2015;121(13):2127-2128.
50. Wilkins T, Jester D, Kenrick J, Dahl J. The current state of colonoscopy training in family medicine residency programs. *Fam Med*. 2004;36(6):407-411.
51. Selvasekar CR, Holubar SD, Pendlimari R, et al. Assessment of screening colonoscopy competency in colon and

rectal surgery fellows: a single institution experience. *J Surg Res*. 2012;174(1):e17-e23.
52. Spier BJ, Benson M, Pfau PR, Nelligan G, Lucey MR, Gaumnitz EA. Colonoscopy training in gastroenterology fellowships: determining competence. *Gastrointest Endosc*. 2010;71(2):319-324.
53. Munroe CA, Lee P, Copland A, et al. *A* tandem colonoscopy study of adenoma miss rates during endoscopic training: a venture into uncharted territory. *Gastrointest Endosc*. 2012;75(3):561-567.
54. Marshall JB. Technical proficiency of trainees performing colonoscopy: a learning curve. *Gastrointest Endosc*. 1995;42(4):287-291.
55. Sedlack RE, Coyle WJ, ACE Research Group. Assessment of competency in endoscopy: establishing and validating generalizable competency benchmarks for colonoscopy. *Gastrointest Endosc*. 2016;83(3):516-523.e1.5
56. American Association of Family Physicians. *Colonoscopy (Position Paper)*. 2013. Available at: http://www.aafp.org/about/policies/all/colonoscopy.html. Accessed January 5, 2016.
57. Ballew C, Lloyd BG, Miller SH. Capacity for colorectal cancer screening by colonoscopy, Montana, 2008. *Am J Prev Med*. 2009;36(4):329-332.
58. Seeff LC, Manninen DL, Dong FB, et al. Is there endoscopic capacity to provide colorectal cancer screening to the unscreened population in the United States? *Gastroenterology*. 2004;127(6):1669-1669.
59. Faruque FS, Zhang X, Nichols EN, et al. The impact of preventive screening resource distribution on geographic and population-based disparities in colorectal cancer in Mississippi. *BMC Res Notes*. 2015;8:423.
60. Charlton ME, Mengeling MA, Halfdanarson TR, et al. Evaluation of a home-based colorectal cancer screening intervention in a rural state. *J Rural Health*. 2014;30(3):322-332.
61. Crosby RA, Stratdman L, Collins T, Vanderpool R. Community-based colorectal cancer screening in a rural population: who returns fecal immunochemical (FIT) kits? *J Rural Health*. 2016;33(4):371-374.
62. Kluhsman BC, Lengerich EJ, Spleen AM, et al. A pilot study for using fecal immunochemical testing to increase colorectal cancer screening in Appalachia, 2008–2009. *Prev Chronic Dis*. 2012;9:E77.
63. Briant KJ, Espinoza N, Galvan A, et al. An innovative strategy to reach the underserved for colorectal cancer screening. *J Cancer Educ*. 2015;30(2):237-243.

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's Web site.

Appendix A. CPT, HCPCS, and ICD-9 Codes Used to Identify Colonoscopy in Outpatient Data Set