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Disparities in recommended preventive care usage among persons living with diabetes in the Appalachian region

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ABSTRACT

Objective: To examine disparities in the receipt of preventive care recommended by the American Diabetes Association (ADA) between Appalachian and non-Appalachian counties and within Appalachian counties.

Research design and methods: Behavioral Risk Factor Surveillance System (BRFSS) data for 2008–2010 were used to identify individuals with diabetes and their preventive care usage. Each Appalachian respondent county of residence was categorised into one of the five economic levels: distressed, at-risk, transitional, competitive and attainment counties. Competitive and attainment counties were combined and designated as competitive counties. We used logistic regressions to compare receipt of ADA preventive care recommendations by county economic level, adjusting for respondent demographic, socioeconomic, health and access-to-care factors.

Results: Compared to the most affluent (competitive) counties, less affluent (distressed and at-risk) counties demonstrated equivalent or higher rates of self-care practices such as daily blood glucose monitoring and daily foot checks. But they showed 40–50% lower uptake of annual foot and eye examinations and 30% lower uptake of diabetes education and pneumococcal vaccinations compared to competitive counties. After adjusting for demographic factors, significant disparities still existed in the uptake of annual foot examinations, annual eye examinations, 2 or more A1c tests per year and pneumococcal vaccinations in distressed and at-risk counties compared to competitive counties. Appalachian counties as a whole were similar to non-Appalachian counties in the uptake of all recommendations with the absolute differences of ≤3%.

Conclusions: Our results show that there are significant disparities in the uptake of many recommended preventive services between less and more affluent counties in the Appalachian region.

Key messages

- Significant disparities by county economic level existed in the uptake of preventive care services that require visits to health professionals in the Appalachian region.
- However, the least affluent counties were not different from or often exceeded the most affluent counties in terms of self-care practices such as daily blood glucose check or daily foot check.
- After demographic, economic, and access-to-care factors were adjusted, disparities disappeared in all recommended care except for the uptake of annual foot exams.

INTRODUCTION

Diabetes currently affects over 9% of US adults and 26% of the elderly population aged 65 years or older.[1] The economic costs of diabetes are huge. Thirteen per cent of total national healthcare expenditures[2] and over 30% of Medicare expenditures are currently spent on persons with diabetes.[3]

Diabetes increases the risk of developing macro- and microvascular complications, which lead to substantial disease and economic burden.[4–7] In particular, the elderly are disproportionately affected by diabetic complications. Prevention of these complications is an important concern for the Centers for Medicare and Medicaid Services (CMS) since treatment for these complications account for a large proportion of diabetes-related medical expenditures.[8–11] According to a study by the American Diabetes Association (ADA), only about 14% of all healthcare expenditures attributed to diabetes were spent to treat diabetes itself and the remaining 86% were spent to treat diabetic complications.[2] A simulation study by Zhuo *et al*[10] attributed 48–64% of the lifetime medical costs of diabetes to diabetic complications, which may underestimate the true costs when considering that costs for foot ulceration and amputations were not included in Zhuo's estimates.

It has been shown that the incidence and progression of diabetic complications[12] and their associated costs can be reduced by preventive care.[13 14] For this reason, the ADA recommends annual preventive care,

including at least two A1c tests, a foot examination, an eye examination and cholesterol tests.[12] Preventive care is also a priority in the national health policy; Healthy People 2020 includes increased use of preventive services for persons with diabetes as its objectives (D4—D14). A recent study showed that use of these services had been increasing steadily in 2001–2010.[15] Despite these encouraging trends, there is a concern that the uptake of diabetes preventive care is suboptimal, especially in underserved populations and rural areas.[16–18]

Health disparities within the Appalachian region are a significant public health concern.[19–22] For example, this region is known to have disproportionately high rates of diabetes and other chronic diseases.[20 23] Almost 80% of the less affluent counties in the region were recently identified as part of the 'diabetes belt',[24] defined as having diabetes prevalence ≥11% compared to 9% in the rest of the country. With poor access to care, high poverty rates and poor education, less affluent counties in the region may be at a higher risk of not receiving care consistent with the ADA recommendations. A better understanding of health disparities in the Appalachian region with respect to diabetes can provide insights into more effective management of diabetes and prevention of diabetic complications for residents in this region.

Our objective in this study was to examine whether there are disparities in the uptake of diabetes preventive care between the Appalachian region and the rest of the country and, within the Appalachian region, between county economic levels designated by the Appalachian Regional Commission for economic and health planning.

RESEARCH DESIGN AND METHODS

Data sources and study sample

The Behavioral Risk Factor Surveillance System (BRFSS) is an annual random-digit dialing telephone survey of U. S. adults about their health-related risk behaviours, chronic conditions and preventive care usage. We used BRFSS data for 2008–2010, the latest 3 years when the 'Diabetes' module was administered to all states, to identify all respondents who answered 'Yes' to the question 'Have you ever been told by a doctor that you have diabetes?' Respondents who were not sure, or who refused to answer this question, were excluded from analysis (<0.1% of all respondents). Respondents with missing age or education (0.8% and 0.3% of respondents with diabetes, respectively) were too few to be meaningfully analysed in a separate 'missing' category and were excluded. We further excluded respondents who did not report county of residence because it is the key variable to determine the county economic level.

ADA guideline-recommended preventive services

We obtained all measures from the BRFSS surveys that were consistent with the ADA standards of medical care.[12] They included a minimum of two A1c tests in the past 12 months, daily blood glucose self-test, annual foot examinations, daily foot self-check, annual eye examinations, diabetes self-management education, annual influenza vaccination and pneumococcal vaccination. These are the same nine preventive care practices tracked by the Centers for Disease Control and Prevention (CDC).[25] For all of these practices other than A1c tests, respondents with 'Don't Know/Not Sure' answers were excluded from the analysis. For A1c tests, we coded 'Never heard of A1c test' and 'Don't know/Not sure' answers as evidence of not receiving care consistent with ADA guidelines, because over 12% of all persons with diabetes responded with either of these answers and their distribution across the county economic levels was not even, suggesting that health literacy might have affected responses. The parameterisation of these measures using BRFSS survey questions is summarised in online supplementary table A1. All preventive practices were included in the BRFSS in all 3 years, except for annual influenza vaccination that was asked only in 2010.

County economic status

The Appalachian Regional Commission (ARC), a federal agency composed of the governors of the 13 Appalachian states and a federal co-chair appointed by the President, publishes the county economic level to identify and monitor the economic status of Appalachian counties. Each county in the Appalachian region is classified into one of the five economic levels, based on its position in the national ranking in three economic indicators, including 3-year unemployment rate, per capita market income and poverty rate. Distressed counties rank in the lowest 10%, at-risk counties in the lowest 10–25%, transitional counties in the 25–75%, competitive counties in the 75–90% and attainment counties in the top 10%. We used the classification for 2013 because it best reflects the economic status of this region for the study period.[26] Because there were only three attainment counties sampled in the BRFSS during the study period, we decided to combine them with competitive counties and designate them as competitive counties in this study. Residents living outside the Appalachian region were placed into the fifth category (non-Appalachian).

Covariates

All covariates that can potentially affect patients' receipt of guideline recommended services were grouped into demographic, socioeconomic, health and access-to-care factors. Demographic factors included age, sex, race/ethnicity and marital status. Marital status indicates whether the patient lives with someone who can provide support for diabetes care.

For socioeconomic factors, we included annual household income, education and employment status.

Health factors included body mass index, smoking, exercise, disability, previous heart attack or stroke, coronary heart disease and diabetes severity indicated by current insulin use and diabetes duration. Diabetes duration was computed based on age at diabetes diagnosis and age at the survey. Exercise indicates whether a person was engaged in any physical activities or exercises in the past 30 days. Disability indicates whether a person had any activity limitations due to physical, mental or emotional problems.

Finally, access-to-care factors included whether the respondent had health insurance, whether the respondent had a personal doctor, whether the respondent perceives cost as a barrier to medical care and whether the respondent had a routine medical check-up in the past 1 year. From the 2014 Area Health Resources File, we also obtained indicators of availability of medical services in county, including the number of medical doctors, podiatrists, ophthalmologists and optometrists, the number of federally qualified health centres and the health professional shortage area designation.

Statistical analysis

To account for the complex sampling design, we conducted all statistical analyses using Survey suite of programs in Stata SE V.14. We used appropriate subpopulation methods to correctly calculate SEs of the estimates for exclusions as well as stratified analyses.[27]

Absolute rates were compared across county groups using weighted Pearson χ^2 tests in bivariate analyses. Relative differences were computed using multivariable logistic regression with the competitive counties as the reference group. We estimated a series of regression models to determine how each group of covariates affects disparities across county economic levels in preventive care practices. For example, 'gross' relative differences were estimated using unadjusted models and we added demographic factors, socioeconomic factors, individual health factors and access-to-care factors to the unadjusted model one group at a time. We used the competitive Appalachian counties as the reference group, because they were the most affluent counties and our bivariate analyses showed that they generally had the highest receipt of guideline-recommended practices.

Because Medicare provided coverage for diabetes-related preventive services since 2005,[28] financial incentives for patients to use these services may be different by Medicare eligibility. We performed stratified analyses of disparities by county economic levels for persons with ages ≥65 and those <65 years.

RESULTS

After exclusion, of about 1.3 million respondents to the 2008–2010 BRFSS surveys, we found that 138 832 respondents had diabetes, which represented 9.0% of the US adults aged ≥18 years. There were significant differences between county economic levels in all respondent characteristics we considered in this study (table 1). Striking disparities are found in socioeconomic status and access to care factors. While 42% in distressed counties had annual household income <$20,000, only 18% did so in competitive counties. In educational attainment, 30% of patients in distressed counties did not complete high school compared to only 9% in competitive counties. In distressed counties, 24% perceived cost as a barrier to medical care compared to 11% in competitive counties. Of respondents with diabetes in distressed counties, 57% and 76% resided in counties without any physicians and any podiatrists in their county, respectively, compared to 6.4% and 2.9% of those in competitive counties.

Table 2 presents weighted percentages of respondents who received services consistent with ADA recommendations for diabetes-related preventive care. Nationally, adherence to recommended services was the best for annual doctor visits at 88.0% of all respondents with diabetes and poorest for pneumococcal vaccination at 53.7%. Appalachian counties as a whole were similar to non-Appalachian counties in all nine recommendations with the absolute differences ≤3% for all but daily foot check in which Appalachian counties showed better uptake than non-Appalachian counties (p<0.001).

Disparities were more pronounced within Appalachia. Compared to competitive counties, distressed counties showed significantly lower uptake in annual foot examination (68.0% vs 77.8%), annual eye examination (59.6% vs 73.7%) and self-management education (46.0% vs 54.6%) (p<0.001, all comparisons). On the other hand, distressed counties exceeded competitive counties in self-care practices such as daily blood glucose self-test (71.2% vs 63.9%) and daily foot check (72.5% vs 69.7%). Similarly, at-risk counties also showed better receipt of preventive care recommendations than competitive counties in daily blood glucose self-test (64.2% vs 63.9%) and daily foot check (76.4% vs 69.7%).

Table 3 presents unadjusted and adjusted ORs of uptake consistent with nine guideline recommendations for each county economic level using competitive counties as the reference group. In unadjusted analyses, patients in distressed counties were almost 40% more likely to perform daily blood glucose check (OR=1.40; 95% CI 1.10 to 1.78) and those in at-risk counties were 41% more likely to perform daily foot check (OR=1.41; 95% CI, 1.11 to 1.79) compared to patients in competitive counties. Non-Appalachian counties were not different from competitive counties.

Significant disparities were also found in adherence to recommendations that require visits to health professionals such as A1c tests, foot and eye examinations. Most notably, patients in distressed and at-risk counties were 40–50% lower in the uptake of annual foot and eye examinations and about 30% lower in the uptake of diabetes self-management education and pneumococcal vaccination. When demographic factors such as age,

Table 1 Demographic, socioeconomic and access-to-care characteristics for respondents with diabetes by county economic level, 2008–2010*

Respondent characteristics	Distressed	At-risk	Transitional	Competitive	Non-Appalachian	p Value
Demographic factors						
Age in years	47.2	47.6	48.2	49.1	46.7	<0.001
Male	47.5%	47.2%	49.3%	52.4%	51.1%	<0.001
Race/ethnicity						
NH White	83.2%	86.3%	82.3%	78.9%	60.4%	<0.001
NH Black	9.6%	7.0%	10.0%	13.3%	15.8%	
Hispanic	1.2%	2.6%	2.6%	2.3%	15.5%	
Other/unknown	6.0%	4.1%	5.1%	5.5%	8.3%	
Married	61.7%	61.8%	63.7%	65.1%	61.5%	<0.001
Socioeconomic factors						
Household income (1000 dollars)						
<$20	41.9%	32.3%	25.2%	17.8%	24.6%	<0.001
$20–$35	21.3%	25.3%	24.5%	25.4%	21.1%	
$35–$75	14.4%	16.9%	22.8%	24.1%	24.8%	
$75 or more	5.4%	8.9%	11.7%	18.2%	17.2%	
Unknown	17.0%	16.7%	15.8%	14.6%	12.3%	
Educational attainment						
Some high school or lower	29.9%	25.4%	16.9%	9.0%	16.3%	<0.001
High school or GED	38.2%	39.0%	40.9%	38.6%	31.8%	
Some college	21.0%	23.3%	24.6%	27.3%	26.7%	
College or higher	10.9%	12.3%	17.7%	25.1%	25.3%	
Employed/self-employed	19.7%	27.9%	31.4%	37.7%	36.2%	<0.001
Health factors						
Body mass index (kg/m^2)						
<25	12.4%	14.8%	14.8%	12.1%	15.0%	<0.001
25–29.9	24.6%	27.9%	29.8%	32.5%	31.0%	
30 or higher	59.2%	53.0%	50.9%	50.4%	49.8%	
Unknown	3.7%	4.3%	4.5%	5.1%	4.2%	
Smoking						
Never	42.6%	44.9%	46.0%	50.5%	48.6%	<0.001
Past	35.2%	34.7%	36.2%	37.4%	36.2%	
Current	22.2%	20.4%	17.7%	12.1%	15.3%	
Physical exercise	50.0%	55.2%	57.5%	57.4%	61.8%	<0.001
Previous heart attack	18.0%	17.7%	15.9%	15.3%	14.3%	<0.001
Coronary heart disease	18.8%	15.6%	16.3%	16.6%	14.1%	<0.001
Stroke	11.1%	10.2%	9.1%	9.2%	8.7%	<0.001
Disability	48.4%	45.6%	42.6%	35.8%	38.4%	<0.001
Insulin use	32.1%	24.6%	29.3%	27.0%	28.5%	<0.001
Diabetes duration, year						
<5	28.1%	33.5%	26.6%	30.7%	28.1%	<0.001
5–9	24.7%	23.1%	25.0%	24.5%	25.7%	
≥ 10	47.2%	43.5%	48.4%	44.8%	46.2%	
Access to care factors						
Has health insurance	83.9%	86.0%	90.2%	93.7%	89.0%	<0.001
Has personal doctor	91.2%	91.9%	95.1%	95.6%	92.5%	<0.001
Cost is a barrier	24.0%	21.9%	15.5%	11.4%	16.3%	<0.001
Routine check-up, past 1 year	83.9%	86.8%	88.0%	86.9%	84.8%	<0.001
Urban residence	7.2%	22.7%	67.4%	97.7%	84.2%	<0.001
No MDs in county	57.2%	49.4%	20.2%	6.4%	12.4%	<0.001
No podiatrist in county	75.8%	45.0%	10.6%	2.9%	8.8%	<0.001
No eye doctor in county	10.7%	9.0%	1.3%	0.9%	1.3%	<0.001
FQHCs in county						
None	26.0%	34.7%	33.2%	9.5%	18.4%	<0.001
1	44.9%	38.9%	18.9%	8.8%	12.2%	
2 or more	29.1%	26.4%	47.9%	81.7%	69.4%	

Continued

Table 1 Continued

Respondent characteristics	Distressed	At-risk	Transitional	Competitive	Non-Appalachian	p Value
HPSA designation, 2010						
None	9.8%	25.8%	18.5%	9.9%	11.2%	<0.001
Whole county	46.9%	29.6%	31.6%	43.5%	45.9%	
Part county	43.3%	44.5%	50.0%	46.6%	42.9%	

*Numbers represent weighted percentages unless noted otherwise.
FQHC, federally qualified health centres; GED, general educational development; HPSA, health professional shortage area; NH, non-Hispanic.

race/ethnicity, sex and marital status were adjusted, differences between county economic levels within Appalachia in preventive care usage other than A1c tests, annual foot examination, annual eye examination and pneumococcal vaccination were not statistically significant any more. When the receipt of A1c tests were defined after excluding 'Don't know/Not sure' and 'Never heard of A1c test' answers, we found that the uptake of A1c tests was not different in distressed counties (OR=0.99; 95% CI 0.73 to 1.34) but was significantly lower in at-risk counties (OR=0.77; 95% CI 0.59 to 0.99) compared to competitive counties in the model adjusted for demographic factors.

When socioeconomic, health and access-to-care factors were further adjusted, disparities among Appalachian counties disappeared except for annual foot examination and pneumococcal vaccination. Compared to patients in competitive counties, those in distressed and at-risk counties were 26% (OR=0.74; 95% CI 0.56 to 0.99) and 41% (OR=0.59; 95% CI 0.46 to 0.77) less likely to receive annual foot examinations, respectively. Patients in at-risk counties were 28% (OR=0.72; 95% CI 0.56 to 0.92) less likely to receive pneumococcal vaccination compared to those in competitive counties.

Table 4 presents estimates for all covariates used in fully adjusted models for A1c test, foot examination and eye examination. We found that household income was significantly associated with annual receipt of eye examinations but not with A1c tests or foot examinations, while education was associated with foot and eye examinations. Neither was associated with annual uptake of two or more A1c tests. Access to care factors that were significantly associated with the uptake of these three services included health insurance, personal doctor, cost barrier and routine check-up in the past 12 months. Notably, respondents who had a routine check-up in the past 12 months also had 80–140% higher likelihood of meeting these recommendations than those who did not have one. In contrast, physicians per capita were not associated with the uptake of any of these services.

We conducted sensitivity analyses to test whether and how the availability of specialists such as podiatrists or eye doctors in county affected the receipt of annual foot or eye examinations. We found that adding one more eye doctor per 100 000 population in county was associated with about 0.5% increase in the uptake of annual eye examinations (data not shown). We did not find any significant association between the number of podiatrists per capita and the uptake of annual foot examination. More importantly, however, inclusion of either of these variables in the models did not substantially change the relative differences in the uptake of annual foot or eye examinations between county economic levels.

Because Medicare covers these three services with 20% copayment and deductibles, we estimated the same regressions shown in table 4 using only respondents aged 65 or older to examine whether Medicare payment policy on diabetes preventive care affected uptake of these services. We found significant disparities for annual foot examination among respondents in at-risk counties (OR=0.60; 95% CI 0.43 to 0.84) and for annual eye examination among those in distressed counties (OR=0.56; 95% CI 0.38 to 0.83) compared to respondents in competitive counties (see online supplementary table A3). Interestingly enough, 'cost barrier' was associated with 25–35% lower uptake of these services among this Medicare population.

CONCLUSIONS

Our results show that there were significant disparities in the uptake of preventive care services that require visits to health professionals, including annual foot examination, annual eye examination, two or more A1c tests per year and pneumococcal vaccination in the less affluent (distressed and at-risk) counties compared to competitive counties in the Appalachian region. However, they were not different from or often exceeded competitive counties in terms of self-care practices such as daily blood glucose check or daily foot check. Non-Appalachian counties were not different from competitive counties, except for daily foot check and pneumococcal vaccination.

After the differences in demographic composition in age, sex, race/ethnicity and marital status was adjusted, differences in annual foot and eye examinations persisted with patients in less affluent (distressed or at-risk) counties significantly less likely to use these services. After socioeconomic, health and access-to-care factors were additionally adjusted, disparities between county economic levels disappeared in all recommendations, except for annual foot examinations whose disparities between county economic levels could not be adequately explained with factors available in this study.

Table 2 Weighted percentages of respondents in receipt of ADA guideline recommendations for diabetes-related preventive care by county economic level, 2008—2010*

Preventive care	Nation				Appalachia				
	All (%)	Appalachia (%)	Non-Appalachia (%)	p Value	Distressed (%)	At-risk (%)	Transitional (%)	Competitive (%)	p Value
Self-care practices									
Daily BG self-check	64.2	65.9	62.9	<0.001	71.2	64.2	66.9	63.9	0.022
Daily foot check	66.1	70.4	62.9	<0.001	72.5	76.4	71.1	69.7	0.025
Annual clinical examinations									
≥2 A1c tests past year	64.2	65.2	64.0	0.093	63.4	62.2	65.7	67.8	0.091
Annual foot examination	72.6	72.9	72.3	0.318	68.0	63.7	72.6	77.8	<0.001
Annual eye examination	69.8	69.0	70.3	0.029	59.6	62.5	69.4	73.7	<0.001
Annual doctor visit	88.0	88.8	87.4	0.002	89.2	85.1	88.4	89.9	0.048
Annual influenza vaccination	59.3	58.3	59.6	0.136	52.0	56.8	59.6	59.5	0.143
Once in a lifetime									
Self-management education	56.1	54.4	57.4	<0.001	46.0	45.2	54.6	54.6	<0.001
Pneumococcal vaccination	53.7	54.7	53.0	0.004	52.1	52.3	57.9	61.6	<0.001

*Annual influenza vaccination was based on data for 2010 alone.
A1c, glycosylated haemoglobin; BG, blood glucose.

To the best of our knowledge, this is the first study that examined diabetes preventive care usage in the Appalachian region. This is an area that suffers from some of the most extreme geographic disparities in health outcomes in the United States.[22 29 30] Diabetes preventive care usage is especially important for patients in this region because of the higher prevalence of diabetes[24 29] and poorer access to healthcare[20] compared to the rest of the country. Our results on self-care practices are not consistent with the 'fatalism' hypothesis that is often used as an explanation for health disparities for residents in the Appalachian region.[31–34] Our data rather suggest that residents in the less affluent counties in Appalachia may have been practicing self-care as a compensatory behaviour for the lack of access to medical care.

A few previous studies examined disparities in the uptake of diabetes preventive care services. Persell *et al*[35] observed a graded relationship between age and the uptake of diabetes preventive services, except for annual foot examinations and A1c tests, using the 1999 BRFSS data. Our results based on 2008–2010 BRFSS are somewhat inconsistent with these earlier data in that the uptake of A1c tests, foot examinations and eye examinations all increased with age. Pu and Chewning[36] reported significant racial/ethnic disparities in the use of these three services based on the 2008 Medical Expenditure Panel Survey. However, using BRFSS data for 2001–2010, Chen *et al* reported significantly better uptake of foot and eye examinations by non-Hispanic blacks compared to non-Hispanic whites during the 10-year period. In contrast, Hispanics had about 20% lower uptake of A1c tests and foot examinations compared to non-Hispanic whites, but exceeded non-Hispanic whites in the uptake of eye examinations by about 15%. Our study based on the same BRFSS data for 2008–2010 shows almost identical results to the Chen *et al* study.

Annual eye examination showed the largest disparities among county economic levels of all diabetes preventive services. Only about 60% and 63% took annual eye examinations in distressed and at-risk counties, respectively, compared to 74% in competitive counties. One of our notable findings is that the availability of eye doctors in county is significantly associated with the uptake of annual eye examinations. This can be explained by the fact that, unlike foot examinations that can be performed by any qualified health professionals, eye examinations tend to require visits to eye doctors such as ophthalmologists or optometrists who need to dilate pupils. This suggests that improving access is a key to reducing disparities in the uptake of annual eye examinations. Retinal photography performed by primary care physicians is recognised as an alternative to direct examination by the ADA[12] and the American Academy of Ophthalmology[37] and can be a viable option for improving the uptake of annual eye examinations for people residing in areas with poor access to eye specialists. Medicare currently reimburses only preventive eye

Table 3 ORs (95% CIs) for county economic levels in guideline-recommended preventive care receipt compared to competitive counties

		Unadjusted		Adjusted for demographic factors*	
Preventive care	**Economic level**	**OR (95% CI)**	**p Value**	**OR (95% CI)**	**p Value**
Daily BG self-check	Distressed	1.399 (1.100 to 1.779)	0.006	1.115 (0.848 to 1.464)	0.436
	At-risk	1.015 (0.818 to 1.260)	0.893	0.932 (0.739 to 1.176)	0.554
	Transitional	1.145 (0.952 to 1.376)	0.151	1.019 (0.836 to 1.241)	0.855
	Non-Appalachian	0.994 (0.836 to 1.180)	0.941	0.908 (0.755 to 1.092)	0.304
Daily foot check	Distressed	1.145 (0.857 to 1.530)	0.360	1.105 (0.828 to 1.475)	0.497
	At-risk	1.410 (1.111 to 1.791)	0.005	1.445 (1.129 to 1.849)	0.003
	Transitional	1.072 (0.882 to 1.302)	0.486	1.061 (0.870 to 1.295)	0.557
	Non-Appalachian	0.807 (0.673 to 0.968)	0.021	0.781 (0.649 to 0.939)	0.009
≥2 A1c tests past year	Distressed	0.707 (0.519 to 0.964)	0.029	0.660 (0.481 to 0.908)	0.011
	At-risk	0.714 (0.542 to 0.940)	0.016	0.666 (0.503 to 0.881)	0.004
	Transitional	0.803 (0.635 to 1.016)	0.067	0.760 (0.598 to 0.966)	0.025
	Non-Appalachian	0.780 (0.626 to 0.971)	0.026	0.802 (0.641 to 1.003)	0.053
Annual foot examination	Distressed	0.608 (0.465 to 0.796)	<0.000	0.691 (0.521 to 0.918)	0.011
	At-risk	0.502 (0.394 to 0.641)	<0.000	0.577 (0.449 to 0.741)	<0.000
	Transitional	0.756 (0.609 to 0.939)	0.011	0.780 (0.626 to 0.973)	0.028
	Non-Appalachian	0.764 (0.622 to 0.938)	0.010	0.783 (0.636 to 0.965)	0.021
Annual eye examination	Distressed	0.528 (0.408 to 0.684)	<0.000	0.689 (0.513 to 0.925)	0.013
	At-risk	0.596 (0.472 to 0.753)	<0.000	0.726 (0.570 to 0.925)	0.009
	Transitional	0.811 (0.659 to 0.999)	0.049	0.878 (0.709 to 1.085)	0.228
	Non-Appalachian	0.837 (0.687 to 1.020)	0.078	0.863 (0.706 to 1.055)	0.150
Annual doctor visit	Distressed	0.930 (0.614 to 1.407)	0.730	1.024 (0.648 to 1.617)	0.920
	At-risk	0.646 (0.455 to 0.917)	0.015	0.732 (0.506 to 1.060)	0.099
	Transitional	0.856 (0.633 to 1.157)	0.312	0.885 (0.645 to 1.215)	0.450
	Non-Appalachian	0.823 (0.620 to 1.092)	0.177	0.808 (0.600 to 1.090)	0.163
Annual influenza vaccination	Distressed	0.738 (0.504 to 1.081)	0.119	1.001 (0.680 to 1.474)	0.996
	At-risk	0.863 (0.618 to 1.205)	0.387	1.025 (0.727 to 1.445)	0.890
	Transitional	1.009 (0.760 to 1.340)	0.951	1.056 (0.791 to 1.410)	0.713
	Non-Appalachian	1.000 (0.768 to 1.302)	0.999	1.073 (0.821 to 1.403)	0.606
Self-management education	Distressed	0.708 (0.558 to 0.897)	0.004	0.797 (0.609 to 1.042)	0.097
	At-risk	0.684 (0.558 to 0.839)	<0.000	0.814 (0.653 to 1.013)	0.065
	Transitional	1.000 (0.840 to 1.191)	0.999	1.074 (0.893 to 1.292)	0.449
	Non-Appalachian	1.093 (0.928 to 1.288)	0.288	1.105 (0.930 to 1.314)	0.257
Pneumococcal vaccination	Distressed	0.675 (0.532 to 0.857)	0.001	0.677 (0.503 to 0.911)	0.010
	At-risk	0.685 (0.553 to 0.848)	0.001	0.652 (0.514 to 0.828)	<0.000
	Transitional	0.858 (0.711 to 1.035)	0.109	0.800 (0.650 to 0.986)	0.036
	Non-Appalachian	0.710 (0.595 to 0.848)	<0.000	0.777 (0.639 to 0.946)	0.012

*Adjusted for age, sex, race/ethnicity and marital status.

examinations that include dilation of pupils by either ophthalmologists or optometrists.

Among the factors that affected preventive care usage, routine check-up in the past 12 months was one of the variables with the largest effect on preventive care use. Individuals with a routine check-up in the past 12 months were 1.8–2.4 times more likely to receive care consistent with guideline recommendations for annual foot and eye examinations and A1c tests. Individuals with an annual routine check-up may have better health behaviour and naturally have higher likelihood of following preventive care recommendations. Routine check-up may also have been a venue for patients to be informed of their annual preventive care needs among other things. This may suggest that, even for individuals who do not have routine check-ups, annual wellness visits Medicare started to cover without copayment and deductibles since 2011 can be used to inform and activate patients regarding their diabetes preventive care recommendations.

Discrepancies in reported rates of A1c monitoring between poor and affluent counties were complicated by the increased 'Don't know/Not sure' and 'Never heard of A1c test' responses in distressed and at risk counties. These responses may illustrate the lower level of health literacy that likely parallels the education level for persons living in these counties. Inadequate evaluation for A1c and understanding of its significance is a substantial barrier for identifying the highest risk patients in this population.

Another noteworthy finding was that individuals who reported that cost was a barrier to medical care had 20–

Table 4 Fully adjusted models for guideline-recommended care receipt for annual A1c test, annual foot examination and annual eye examination, all adults with diabetes in 2008–2010*

	≥2 A1c tests last year		Annual foot examination		Annual eye examination	
Variables	**OR (95% CI)**	**p Value**	**OR (95% CI)**	**p Value**	**OR (95% CI)**	**p Value**
County economic level [competitive]						
Distressed	1.046 (0.789 to 1.388)	0.755	0.740 (0.556 to 0.986)	0.040	0.784 (0.580 to 1.060)	0.114
At-risk	0.974 (0.766 to 1.238)	0.827	0.592 (0.457 to 0.768)	<0.001	0.791 (0.618 to 1.011)	0.061
Transitional	0.957 (0.782 to 1.171)	0.668	0.768 (0.615 to 0.959)	0.020	0.889 (0.719 to 1.099)	0.277
Non-Appalachian	0.920 (0.761 to 1.112)	0.390	0.798 (0.648 to 0.984)	0.035	0.893 (0.732 to 1.089)	0.264
Age, years	0.995 (0.991 to 0.998)	0.001	1.004 (1.001 to 1.008)	0.019	1.020 (1.017 to 1.023)	<0.001
Male	0.917 (0.860 to 0.977)	0.007	1.114 (1.039 to 1.194)	0.002	0.934 (0.872 to 1.001)	0.054
Race/ethnicity [NH White]						
NH Black	0.831 (0.758 to 0.911)	<0.001	1.416 (1.266 to 1.583)	<0.001	1.238 (1.119 to 1.370)	<0.001
Hispanic	0.680 (0.585 to 0.791)	<0.001	0.791 (0.675 to 0.927)	0.004	1.223 (1.040 to 1.4 39)	0.015
Other/unknown	0.877 (0.776 to 0.991)	0.035	1.034 (0.892 to 1.198)	0.657	1.066 (0.928 to 1.224)	0.364
Married	1.225 (1.148 to 1.307)	<0.001	1.080 (1.003 to 1.164)	0.041	1.076 (1.003 to 1.154)	0.040
Household income [<$20 000]						
$20 000–$34 999	1.019 (0.932 to 1.115)	0.677	0.943 (0.856 to 1.039)	0.236	1.117 (1.016 to 1.229)	0.022
$35 000–$74 999	1.147 (1.040 to 1.263)	0.006	0.959 (0.859 to 1.070)	0.450	1.170 (1.056 to 1.297)	0.003
≥$75 000	1.281 (1.130 to 1.451)	<0.001	0.960 (0.835 to 1.103)	0.561	1.215 (1.065 to 1.385)	0.004
Unknown	0.844 (0.766 to 0.930)	0.001	0.860 (0.770 to 0.960)	0.007	1.120 (1.005 to 1.247)	0.040
Education [<some high school]						
Some high school	1.147 (0.977 to 1.347)	0.094	1.207 (1.020 to 1.429)	0.029	1.079 (0.907 to 1.285)	0.390
High school graduate or GED	1.412 (1.231 to 1.619)	<0.001	1.201 (1.042 to 1.384)	0.011	1.195 (1.031 to 1.385)	0.018
Some college	1.647 (1.429 to 1.899)	<0.001	1.275 (1.099 to 1.478)	0.001	1.258 (1.080 to 1.465)	0.003
College graduate or higher	1.976 (1.698 to 2.299)	<0.001	1.377 (1.180 to 1.608)	<0.001	1.443 (1.228 to 1.695)	<0.001
Employed/ self-employed	0.996 (0.919 to 1.081)	0.929	1.017 (0.933 to 1.108)	0.705	0.933 (0.859 to 1.014)	0.101
BMI [<25 kg/m^2]						
25–29.9 kg/m^2	1.179 (1.078 to 1.289)	<0.001	1.215 (1.099 to 1.344)	<0.001	1.049 (0.947 to 1.162)	0.357
≥30 kg/m^2	1.280 (1.174 to 1.397)	<0.001	1.324 (1.200 to 1.461)	<0.001	0.992 (0.901 to 1.092)	0.874
Unknown	1.185 (1.018 to 1.381)	0.029	1.225 (1.030 to 1.457)	0.022	1.010 (0.860 to 1.187)	0.901
Smoking [never]						
Past	1.066 (1.000 to 1.137)	0.049	0.947 (0.882 to 1.017)	0.131	0.949 (0.885 to 1.017)	0.139
Current	0.876 (0.797 to 0.963)	0.006	0.854 (0.771 to 0.946)	0.002	0.722 (0.655 to 0.796)	0.000
Exercise	1.141 (1.072 to 1.215)	<0.001	1.234 (1.152 to 1.321)	<0.001	1.159 (1.084 to 1.239)	<0.001
History of heart attack	0.887 (0.806 to 0.976)	0.014	1.041 (0.940 to 1.153)	0.437	0.985 (0.888 to 1.094)	0.782
Coronary heart disease	1.156 (1.065 to 1.255)	0.001	1.093 (0.999 to 1.196)	0.053	1.024 (0.940 to 1.117)	0.585
Stroke	0.900 (0.814 to 0.996)	0.041	1.007 (0.898 to 1.129)	0.900	1.072 (0.968 to 1.188)	0.181
Activity limitations	1.218 (1.142 to 1.300)	<0.001	1.095 (1.018 to 1.179)	0.015	0.937 (0.874 to 1.005)	0.070
Insulin user	1.763 (1.634 to 1.903)	<0.001	1.998 (1.836 to 2.174)	<0.001	1.455 (1.343 to 1.576)	<0.001
Diabetes duration [<5 years]						
5–9 years	1.384 (1.274 to 1.503)	<0.001	1.326 (1.214 to 1.448)	<0.001	1.146 (1.051 to 1.250)	0.002
≥10 years	1.591 (1.474 to 1.717)	<0.001	1.646 (1.520 to 1.784)	<0.001	1.462 (1.348 to 1.586)	<0.001
Has health insurance	1.378 (1.217 to 1.560)	<0.001	1.343 (1.176 to 1.533)	<0.001	1.625 (1.434 to 1.841)	<0.001
Has personal doctor	2.152 (1.842 to 2.513)	<0.001	1.490 (1.276 to 1.740)	<0.001	1.052 (0.896 to 1.235)	0.536
Cost barrier to medical Care	0.759 (0.686 to 0.839)	<0.001	0.797 (0.716 to 0.888)	<0.001	0.683 (0.616 to 0.758)	<0.001
Routine check-up last 12 months	1.852 (1.692 to 2.028)	<0.001	2.390 (2.175 to 2.626)	<0.001	1.822 (1.656 to 2.004)	<0.001
Urban residence	1.053 (0.986 to 1.124)	0.126	1.036 (0.967 to 1.111)	0.312	1.107 (1.033 to 1.185)	0.004
Physicians per 100 000 population in County	0.961 (0.888 to 1.040)	0.323	0.987 (0.971 to 1.003)	0.108	0.987 (0.969 to 1.004)	0.134

Continued

Table 4 Continued

Variables	≥2 A1c tests last year		Annual foot examination		Annual eye examination	
	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
FQHCs in county [none]						
1	1.068 (0.973 to 1.171)	0.166	1.049 (0.952 to 1.156)	0.330	0.990 (0.901 to 1.087)	0.826
2 or more	1.003 (0.926 to 1.086)	0.938	1.075 (0.987 to 1.171)	0.096	1.021 (0.940 to 1.108)	0.624
County HPSA designation [none]						
Part county	0.935 (0.845 to1.036)	0.199	0.977 (0.878 to 1.088)	0.678	0.900 (0.808 to 1.003)	0.056
Whole county	1.026 (0.930 to 1.133)	0.610	1.025 (0.924 to 1.138)	0.637	0.954 (0.860 to 1.060)	0.381

*Reference categories are given in brackets.
BMI, body mass index; FQHC, federally qualified health centre; GED, general education development; HPSA, health professional shortage area; NH, non-Hispanic.

33% lower uptake of annual A1c tests, foot examinations and eye examinations compared to those who did not. This was also true of individuals aged ≥65 years, which suggests that the 20% copayment itself may be a barrier. After the enactment of the Affordable Care Act, Medicare eliminated copayments for many preventive care services since 2011, but diabetes preventive services were not part of a long list of those services. Our findings on the cost barrier may suggest that Medicare coverage for diabetes preventive care services may need to be reconsidered.

Our results show that demographic and socioeconomic differences between the economic levels were able to account for most of the differences in diabetes preventive recommendations other than annual foot examinations, annual eye examinations (for the elderly) and pneumococcal vaccination. For example, geographic accessibility to healthcare is often recognised as a significant factor in health disparities in Appalachia, but we could not adjust for this and do not know whether the disparities in the uptake of these three services would disappear with improved access to care in the less affluent counties.

This study has several limitations to consider when interpreting our results. First, BRFSS data are self-reported and so the uptake of these services may be affected by recall bias or other forms of response bias, including social desirability. Second, we did not have a more direct measure of access to medical care such as geographic distance to the nearest healthcare facility or physician office. Our measures of access to care that include physicians or specialists per capita and FHQC's in county may not be specific enough for measuring access to care. Finally, as noted above, the coding of 'Don't know/Not sure' and 'Never heard of A1c test' responses may have led to some patients being incorrectly categorised as not having received A1c tests as recommended by the ADA guidelines. The higher rate of these responses in distressed and at risk counties may have confounded comparisons between groups.

In conclusion, we found significant disparities in the uptake of annual foot and eye examinations as well as annual A1c tests between county economic levels in Appalachia, but no disparities in self-care practices such as daily A1c check or daily foot check. Improving access may reduce disparities in the uptake of annual eye examinations in Appalachia.

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