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Blood Pressure Control and Other Quality of Care Metrics for Patients with Obesity and Diabetes: A Population-Based Cohort Study

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Abstract

Introduction—There are no population-level estimates in the United States for achievement of blood pressure goals in patients with diabetes and hypertension by obesity weight class.

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Compliance with Ethical Standards

Conflict of interest
On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval
This article does not contain any studies with human participants or animals performed by any of the authors.

Aim—We sought to examine the relationship between the extent of obesity and the achievement of guideline-recommended blood pressure goals and other quality of care metrics among patients with diabetes.

Methods—We conducted an observational population-based cohort study of electronic health data of three large health systems from 2010–2012 in rural, urban and suburban settings of 51,229 adults with diabetes. Outcomes were achievement of diabetes quality of care metrics: blood pressure, A1c, and LDL control, and A1c and LDL testing. Two blood pressure goals were examined given the recommendation for adults with diabetes of 130/80 mmHg from JNC7 and the recommendation of 140/90 mmHg from JNC8 in 2014.

Results—Patients in obesity classes I, II, and III with diagnosed hypertension were less likely to achieve blood pressure control at both the 140/90 mmHg and 130/80 mmHg control levels. The patients from obesity class III had the lowest likelihood of achieving control at the 130/80 mmHg goal, and control was markedly worse for the 130/80 mmHg threshold in all weight classes. There were minimal to no differences by weight class in LDL and A1c control and LDL and A1c testing.

Conclusions—Although the cardiovascular risk for patients with obesity and diabetes is greater than for non-obese patients with diabetes, we found that patients with obesity are even further behind in achieving blood pressure control.

Keywords

Hypertension; Obesity; Diabetes; blood pressure; cardiovascular risk

Introduction

Diabetes has reached epidemic proportions in the United States; currently over 29 million [1] adults and children are living with the serious, potentially life-threatening disease that has significant impact on cardiovascular health [2]. Blood pressure control has been suggested as a means to reduce long-term cardiovascular complications of diabetes [3], and may be more important in patients with obesity and diabetes than in normal weight patients with diabetes as increasing obesity significantly increases cardiovascular morbidity and mortality [4]. The prevalence of other cardiovascular risk factors (e.g. hypertension, diabetes, dyslipidemia) is also increased in populations with overweight and obesity [5], potentially making this population a priority for more stringent attempts to achieve blood pressure control.

Both the American Diabetes Association and the European Association for the Study of Diabetes recommend aggressive management of cardiovascular risk factors in patients with diabetes given that diabetes amplifies cardiovascular morbidity and mortality [6]. However, there have been recent changes in recommended blood pressure goals from the Seventh Joint National Committee's (JNC7) previous recommendation for adults with diabetes of 130/80 mmHg [7] to 140/90 mmHg by the Eighth Joint National Committee (JNC8) in 2014 [8]. Most recently, the American College of Cardiology and American Heart Association Task Force on Clinical Practice Guidelines published a report reducing the threshold for high blood pressure to 130/80 mmHg [9].

Although a causal link between obesity and hypertension is well established [10–12], there are no population-level estimates in the United States on the extent to which patients with obesity, diabetes, and hypertension achieve blood pressure goals. An estimated 60% of all patients with diabetes have hypertension [1] and less than one-third achieve blood pressure control [13]. In a Swedish study, obesity was associated with an increase in unadjusted average systolic blood pressure among patients with diabetes (141 mmHg if normal weight vs. 148 mmHg if obese) [14]. However, that study did not examine achievement of blood pressure goals, assess blood pressure control among obesity weight classes (I, II, III), or adjust for confounders.

The objective of our study is to examine the relationship between the extent of obesity and the achievement of guideline-recommended blood pressure goals and other cardiovascular quality of care metrics among a cohort of patients with diabetes. Two blood pressure control thresholds were examined, 130/80 mmHg and 140/90 mmHg. Since obesity is associated with cardiovascular risk factors in patients with diabetes [15], we hypothesized that the extent of obesity would be associated with lower likelihood of blood pressure control compared to normal weight individuals, especially at the lower 130/80 mmHg goal. Interestingly, for patients with both obesity and diabetes compared to diabetes alone, studies have shown a greater achievement of diabetes quality metrics, including glycemic control and glycemic and low-density lipoprotein (LDL) testing [16, 17]. However, the reverse may be more likely for achieving blood pressure control since obesity is a significant contributor to uncontrolled hypertension [15, 18]. To examine these relationships, we acquired electronic health records data for over 50,000 patients from three large health systems that participate in a public reporting collaborative. These data represent the measures identified through routine clinical practice and thereby have substantial limitations,[19–21] but provide insight at a population level [22] and also represent the foundation on which health system improvement activities are based, including quality measurement, public reporting of quality, and pay-for-performance [23–25].

Methods

Design and Setting

We conducted an observational population-based cohort study of 51,229 patients using electronic health record data (July 1, 2010 – June 30, 2012) for three large health systems that participate in the Wisconsin Collaborative for Healthcare Quality (WCHQ). WCHQ is a voluntary consortium of Wisconsin healthcare organizations that publicly report healthcare performance measurement information. Health systems included in this analysis encompass both rural, urban, community and academic settings. The Minimal Risk Health Sciences Institutional Review Board (IRB) at the University of Wisconsin determined the project was exempt from IRB review.

Study Population

Using the standard WCHQ denominator definition for diabetes quality metrics, we included adult patients ages 18–75 with diabetes who received their primary care in ambulatory practices within one of the three health systems [26]. The approach to identify eligible patients required two years of electronic health record data, a baseline year (2011), and a quality measure reporting year (2012). The presence of diabetes was defined as having at least two face-to-face ambulatory visits using CPT-4 outpatient evaluation and management (E&M) codes [27] with any clinician (MD, DO, PA, NP) on different days of service with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code of 250.XX, 357.2, 362.0X, 366.41, or 648.0X over the two years of data. Patients were defined as receiving care in the health system if they had at least two face-to-face office visits to a primary care provider (PCP) or endocrinologist on different dates of service in the past two years, with at least one visit in the reporting year [28]. This population definition is consistent with publicly reported diabetes care quality measure guidelines for the three health systems contributing data. Patients who were pregnant during the baseline and reporting years were excluded. All eligible patients were included without further exclusions. Two subgroups of patients (diagnosed hypertension and diagnosed hyperlipidemia) were defined within the cohort based on established billing codes [27, 29].

Primary Outcomes

Our primary outcome variables were the achievement of four control and two testing diabetes care goals during the reporting year, 2012. All six outcomes were guideline-recommended publicly reported quality metrics in effect during the reporting year. The four control goals were blood pressure control at <130/80 mmHg, the recommended control goal during the reporting year, 2012 [7]; <140/90 mmHg, the current recommended control goal, 2014 [8]; hemoglobin A1c control <7% (<53 mmol/mol), or <8% (<64 mmol/mol) if 65–75 years old or with specific comorbidities [26, 30]; and LDL cholesterol control <100 mg/d. The two testing goals were A1c testing two or more times during the reporting year, and LDL cholesterol testing once during the reporting year. The primary variables were binary, representing care goal achievement or not in the reporting year.

Explanatory Variable

The main explanatory variable was weight class from body mass index (BMI) determined by the most recent patient height and weight in the patient electronic health record prior to the reporting year. Nearly all (>99%) of the BMIs are from the beginning of the baseline year (January 2011) or more recent. Weight classes were created using the World Health Organization (WHO) [31] definitions of obesity by patient BMI: overweight (25.0–29.9 kg/m^2), obese class I (30.0–34.9 kg/m^2), obese class II (35.0–39.9 kg/m^2), and obese class III (≥40.0 kg/m^2). We used the same definitions for all patients for consistency, including those of Asian descent who have different obesity cut-points [32].

Covariates

We included variables for patient socio-demographic characteristics, health status and health care utilization. Socio-demographic characteristics included age (at the beginning of the reporting year), gender, race (white or other), and insurance (commercial, Medicare, Medicaid, and uninsured/unknown). A total count of comorbid chronic conditions was created using an established methodology [33]. A healthcare resource utilization score was calculated using Ambulatory Care Groups (ACG) based on outpatient and inpatient diagnoses from the baseline year [33, 34]. We defined two socioeconomic status proxy variables by linking patient zip code tabulation areas (ZCTAs) to census tract data [35]. These variables represent the percent of the population in the patient's zip code who live below the poverty line (income) and the percent who have at least a high school education. Patient zip codes were used to assign urban status based on rural urban commuting area (RUCA) codes [36]. Extent of health care utilization was represented by the number of face-to-face office visits in the baseline year.

Statistical Analyses

Descriptive analyses summarized categorical variables using percentages and continuous variables using means with standard deviations. Logistic regression models were fit for the four control and the two testing goals to assess the relationship between obesity class and the achievement of each care goal, adjusted for covariates as described above. Models for all outcomes were fit using the entire population of patients, and then additional models were run for the blood pressure control outcome among diagnosed hypertension subgroup and for the LDL outcomes among the diagnosed hyperlipidemia subgroup in order to examine any impact of these diagnosed conditions on blood pressure and LDL care. Results were reported as adjusted predicted percentages and 95% confidence intervals (CIs). Adjusted predicted percentages were calculated based on the recycled predictions approach using the Stata margins command. Confidence intervals were calculated using a robust estimate of the variance. Significance was determined at $p<.05$. All analyses were conducted using Stata 13.1 (Stata-Corp, College Station, TX).

Results

Population characteristics

This population of 51,229 patients with diabetes was 49% female, 84% white, and the majority had either commercial insurance (52%) or Medicare (36%) (Table 1). The mean age was 58 years (standard deviation 11). Seventy-eight percent of patients had a diagnosis of hypertension and 82% had a diagnosis of hyperlipidemia. Seventy-two percent of patients classified as obese, with 27% in obese class I, 21% in obese class II, and 24% in obese class III.

Control (Outcome) Metrics

Patients in obese classes I, II, and III with diagnosed hypertension were less likely than normal weight counterparts to achieve blood pressure control at both the <140/90 mmHg and <130/80 mmHg control levels (Table 2). Among normal weight patients with diagnosed hypertension, 80% of patients achieved blood pressure control at the 140/90 mmHg goal (95% CI: 78–81%), in contrast to the 72% (95% CI: 71–73%) achievement amongst obese class III patients with diagnosed hypertension (P <.001). Blood pressure control among patients with diagnosed hypertension was markedly worse for the 130/80 mmHg goal in all BMI categories, with normal weight patients' achievement at 56% (95% CI: 54–58%) and obese class III patients at 42% (95% CI: 41–43%) (P <.001). A similar pattern was seen among the total population of patients (with or without a diagnosis of hypertension; data not shown). There was not a significant variation between BMI categories for A1c control or for

LDL control among patients with a diagnosis of hyperlipidemia or among the total population of patients (with or without a diagnosis of hyperlipidemia).

Testing (Process) Metrics

Among all patients with diabetes (N=51,229) LDL testing was less likely in normal weight patients than patients with overweight or obesity, though these differences were small (Table 3). We also looked at LDL testing in patients with a hyperlipidemia diagnosis (N=42,069), but found no significant difference in testing by BMI category. Among all patients with diabetes (N=51,229), A1c testing was similar for all BMI categories with a slight increase in normal weight patients compared to patients in obesity class III.

Discussion

We found that among patients with diabetes and diagnosed hypertension, patients with obesity were substantially less likely to achieve blood pressure control than normal weight patients at both blood pressure goals, with the patients in obese class III having the lowest likelihood of achieving control (42%; 72%) at the 130/80 mmHg and 140/90 mmHg goals. Blood pressure control was markedly worse for the 130/80 mmHg threshold in all weight classes. These findings are a major public health concern in a population with significant cardiovascular risks, particularly in light of the new blood pressure guidelines released by the American College of Cardiology and American Heart Association, which reduced the threshold for high blood pressure to 130/80 mm/Hg, down from 140/90 mm/Hg [9]. Although blood pressure control reduces cardiovascular morbidity and mortality among patients with obesity and diabetes [37], our results show that the opposite is occurring in practice, patients with obesity and diabetes are not achieving blood pressure control. There were minimal to no differences by weight class in LDL control, A1c control, LDL testing, and A1c testing.

The consequences of obesity’s effect on blood pressure control is substantial, with previous studies showing that the prevalence of high blood pressure among individuals with obesity is at least twice that of normal weight individuals [38] and another study suggesting that insufficient blood pressure control in patients with obesity is 50% higher than in patients with hypertension of normal weight [39]. Studies similar to ours have documented the association between increasing obesity and increasing blood pressure in non-diabetic children and adolescents. For example, in a retrospective cohort study of >100,000 non-hypertensive patients between the ages of 3–17 years, increases in BMI percentiles resulted in significant increases in blood pressure percentiles and an increased risk of developing hypertension [40]. In a similar study, looking at children 6–8 years, Wang et al.[41] found hypertension incidence to be markedly higher among overweight and obese groups compared to normal weight groups. Our study differs in that we examined adult patients with a diagnosis of diabetes and hypertension, though our results also show that increasing obesity is associated with increasing blood pressure. As elevated blood pressures in patients with diabetes are associated with higher rates of macrovascular and microvascular complications [42] and the combination of obesity and diabetes significantly increases the likelihood of adverse cardiovascular outcomes, achievement of blood pressure control should be a high priority among patients with obesity and diabetes.

Our results may partly reflect the recognition that hypertension in patients with obesity is more difficult to control than hypertension in normal weight patients [10, 11, 43]; patients with obesity may require more antihypertensive medication to achieve blood pressure control compared to normal weight patients [10]. A noted challenge in getting patients with obesity and hypertension to reach blood pressure goals is that both conditions require multiple treatment modalities (e.g. behavior and lifestyle modification) [11]. Additional reasons for the lack of blood pressure control in populations with obesity include increased salt and fluid retention, activation of the sympathetic nervous system, and stimulation of the renin-angiotensin-aldosterone system associated with obesity [10]. Lastly, lower rates of blood pressure control among patients with obesity could be an increased rate of resistant hypertension in this population as the combined presence of diabetes, obesity, and hypertension increases the likelihood for resistant hypertension [44, 45]. Resistant hypertension potentially explains why at the more relaxed threshold of 140/90 mmHg, only obese class III had reduced blood pressure control compared to normal weight patients[45].

A surprising result was the minimal to no differences by weight class for LDL and A1c control as we expected for LDL control and A1c control to be decreased as obesity increased due to the adverse impact obesity has on A1c and LDL control. A study that looked at LDL and A1c control in overweight adults with diabetes also found no association between degree of obesity and LDL control, though they did find an association between degree of obesity and A1c control [46]. For LDL control, there is the potential that patients in our sample in higher obese classes are having their hyperlipidemia more aggressively managed. A previous study [17] also found similar average A1c values across all weight classes, and a small but significantly worse level of control for normal weight individuals. The authors' hypothesized that patients who were normal weight might have a more severe disease than those who were overweight or obese. Our data shows similar levels of glycemic control across all weight classes, supporting the theory that normal weight individuals have more severe disease, despite their normal weight. Our finding of similar levels of glycemic control among overweight or obese individuals may be due to more obesity-induced insulin resistance than overweight or obese individuals. Our study demonstrates that glycemic control can be suboptimal no matter the individual's weight class, and clinicians should attend to each individual's glycemic control values rather than being overly influenced by a patient's weight when determining a treatment plan.

Typically, quality metrics such as blood pressure control are reported across all patients who have a condition such as diabetes, irrespective of whether they have other conditions [39, 42]. This approach is common as most quality metrics do not specifically address issues faced by patients with multiple conditions and offer only single-disease specific outcomes [39]. However, this approach assumes there are no additional factors that influence interpretation of the metrics. If there are subgroups of patients who are at elevated risk, it may not always be appropriate to group them as the aggregation may mask major gaps in the delivery of care and limit our ability to identify appropriate interventions. This may be the case for patients with obesity and diabetes as we found blood pressure control decreases with greater obesity. This is consistent with epidemiologic literature suggesting that stratification by obesity weight class is recommended when examining the effect that obesity has on mortality [44]. Stratification by weight class could support the targeting of prevention, treatment, and management of high blood pressure and other cardiovascular-related risk factors.

Limitations

This study has several limitations. First, the population was from one US state that may not be fully reflective of all patients across the US. However, the sample included a wide range of ages and payers, and patients from rural, urban and suburban settings. We also adjusted for multiple patient demographic and health care utilization factors. Second, we identified hypertension and hyperlipidemia by ICD-9 codes billed at office visits, an approach that could under-represent the prevalence of these conditions. However, the use of established diagnosis codes decreases this risk [27, 29]. Third, while we controlled for health care utilization with the number of E&M office visits in the baseline year, we were unable to control for phone calls and non-E&M visits [47] that might impact care goal achievement. Fourth, blood pressures were measured as part of routine clinical practice and could be subject to several biases including lack of standardized blood pressure measurement and lack of information on blood pressure treatment [21]. However, these do represent the blood pressures that are used to monitor the quality of care in healthcare delivery and for the diagnosis and treatment of hypertension[48]. Fifth, this is a secondary analysis on electronic health record data and therefore we do not have detailed information on medical history, physical examination, detailed dietary patterns, or behavioral and exercise evaluations. This is balanced by our ability to examine quality of care metrics for over 50,000 patients from multiple health systems. Lastly, we do not have medication data for this population, which limits our ability to determine whether those who are not under control are being treated or not with medications. Future work should examine these metrics for those who are and are not being treated with antihypertensive, antidiabetic, and lipid-lowering drugs.

Conclusions

Our findings show patients with obesity, diabetes, and hypertension were substantially less likely to achieve blood pressure goals, particularly at the recently recommended threshold of 130/80 mmHg [9]. Less than half of the patients with diabetes from obesity weight classes I, II, and III met the 130/80 mmHg threshold, comparatively than half of patients in the normal and overweight categories reached the 130/80 mmHg threshold. Although cardiovascular disease risk for patients with obesity and diabetes is greater than their normal weight peers, our findings show that these patients are further behind in achieving blood pressure control when compared to normal weight patients with diabetes at both 130/80 mmHg and 140/90 mmHg thresholds. Several approaches may support improved blood pressure control among these patients, including focused efforts on multiple treatment approaches and stratification of blood pressure attainment by obesity weight class in quality metric reporting. Further research is needed to identify the best treatments and interventions to apply to this population to lower their risk.

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Table 1.

Characteristics of patients with diabetes, overall and by weight class

	Total Population N=51,229	Normal (18.4–24.9 kg/m^2) N=3,457	Overweight (25–29.9 kg/m^2) N=10,629	Obese Class I (30–34.9 kg/m^2) N=14,031	Obese Class II (35–39.9 kg/m^2) N=10,978	Obese Class III (≥40 kg/m^2) N=12,134	
	%	%	%	%	%	%	p
Demographics							
Age, m (SD)	58 (11)	57 (14)	59 (11)	59 (10)	58 (11)	56 (11)	<0.001
Sex, female, %	49	50	42	43	50	60	<0.001
Race/ethnicity, %							
White	84	79	81	84	86	86	<0.001
African American	8	7	8	8	8	9	
Other/Unknown	8	13	10	8	6	5	
Insurance, %							
Medicaid	9	9	7	7	8	12	<0.001
Medicare	36	38	39	37	35	33	
Commercial	52	49	50	53	53	52	
Uninsured/Unreported	4	4	4	3	4	3	
RUCA, by patient's zip code,%							
Urban core	55	60	56	55	54	55	<0.001
Suburban	14	13	15	15	15	14	
Large Town	13	12	13	13	14	14	
Small Town and Rural	17	15	16	17	18	17	
Mean percent below poverty line in patient's zip code, mean (SD)	11.7 (8)	11.9 (9)	11.5 (8)	11.6 (8)	11.6 (8)	11.9 (8)	<0.005
Mean percent with at least a HS education in patient's zip code, mean (SD)	89 (6)	90 (7)	90 (6)	89 (6)	89 (6)	89 (6)	<0.001
Conditions and Health Care Utilization							
Number of total E&M visits in the baseline year, mean (SD)	4.6 (3.6)	4.4 (3.7)	4.2 (3.2)	4.4 (3.4)	4.6 (3.6)	5.1 (4.0)	<0.001
Number of total E&M visits in baseline year, %							
0 to 2	28	31	32	30	27	24	<0.001
3 to 4	32	31	33	33	32	29	
5 to 6	19	19	18	19	19	20	
7 or more	21	20	17	18	21	26	
Count of total Elixhauser conditions in baseline year, mean (SD)	1.7 (1.3)	1.6 (1.4)	1.6 (1.3)	1.6 (1.3)	1.8 (1.3)	2.0 (1.5)	<0.001
ACG Resource Utilization Score (young), mean (SD)	3.0 (2.9)	3.3 (3.6)	2.9 (2.8)	2.9 (2.7)	3.0 (2.8)	3.2 (2.9)	<0.001

	Total Population N=51,229	Normal (18.4–24.9 kg/m^2) N=3,457	Overweight (25–29.9 kg/m^2) N=10,629	Obese Class I (30–34.9 kg/m^2) N=14,031	Obese Class II (35–39.9 kg/m^2) N=10,978	Obese Class III (≥40 kg/m^2) N=12,134	
	%	%	%	%	%	%	p
BMI, mean (SD)	35 (8)	23 (2)	28 (1)	32 (1)	37 (1)	46 (6)	<0.001
% Diagnosed with Hypertension	78	59	72	79	83	86	<0.001
% Diagnosed with Hyperlipidemia	82	69	82	85	84	81	<0.001

[a]ACG = Johns Hopkins ACG® healthcare utilization score; BMI = body mass index; E&M = evaluation and management; RUCA = rural urban commuting area; SD = standard deviation

Table 2.

Achieving diabetes control metrics by weight class[b]

	BP Control among those with Diagnosed Hypertension (N=40,185)							LDL Control among those with Diagnosed Hyperlipidemia (N=42,069)				A1c Control (N=51,229)			
		Percent Achievement (130/80)			Percent Achievement (140/90)				Percent Achievement				Percent Achievement		
	% of pop.	Unadj	Adj	95% CI	Unadj	Adj	95% CI	% of pop.	Unadj	Adj	95% CI	% of pop.	Unadj	Adj	95% CI
Normal (18.4–24.9 kg/m^2)	5	57	56	(54, 58)	79	80	(78, 81)	5.7	64	64	(62, 66)	6.8	60	61	(60, 63)
Overweight (25–29.9 kg/m^2)	19	52	52	(51, 53)	78	78	(77, 79)	21	63	61	(60, 62)	21	65	64	(63, 65)
Obese Class I (30–34.9 kg/m^2)	28	49	49	(48, 50)	77	78	(77, 78)	28	63	62	(61, 63)	27	63	62	(62, 63)
Obese Class II (35–39.9 kg/m^2)	23	47	47	(46, 48)	77	77	(76, 78)	22	64	64	(63, 65)	21	61	61	(60, 62)
Obese Class III (≥40 kg/m^2)	26	43	42	(41, 43)	73	72	(71, 73)	23	64	66	(65, 67)	24	58	59	(58, 60)

[a] A1c = glycated hemoglobin; Adj = adjusted; BP = blood pressure; CI = confidence interval; LDL = low-density lipoprotein; pop. = population; Unadj = unadjusted

[b] Adjusted for age, gender, race (White/Black/Other), payer, RUCA, education, income, number of E&M visits in the baseline year (categorical), total number of Elixhauser comorbidities, and ACG Resource Utilization Score.

Table 3.

Unadjusted and adjusted percents for achieving each diabetes testing metric by weight class[b]

		A1c Testing (N=51,229)			LDL Testing (N=51,229)		
	% of pop.	**Unadj**	**Adj**	**95% CI**	**Unadj**	**Adj**	**95% CI**
Normal (18.4–24.9 kg/m^2)	6.8	77	79	(77, 80)	87	88	(87, 89)
Overweight (25–29.9 kg/m^2)	21	79	80	(79, 80)	91	91	(90, 91)
Obese Class I (30–34.9 kg/m^2)	27	81	81	(80, 82)	92	92	(92, 92)
Obese Class II(35–39.9 kg/m^2)	21	81	81	(81, 82)	92	92	(92, 93)
Obese Class III (≥40 kg/m^2)	24	82	82	(81, 83)	92	92	(92, 93)

[a] A1c = glycated hemoglobin; Adj = adjusted; CI = confidence interval; LDL = low-density lipoprotein; pop. = population; Unadj = unadjusted

[b] Adjusted for age, gender, race (White/Black/Other), payer, RUCA, education, income, number of E&M visits in the baseline year (categorical), total number of Elixhauser comorbidities, and ACG Resource Utilization Score.