

Characterizing Obesity in a Large Health Care Delivery System

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Obesity is a chronic disease associated with multiple comorbidities or complications, including cardiovascular disease, stroke, type 2 diabetes, certain types of cancers, osteoarthritis, mental health disorders, and sleeping disorders,¹⁻⁹ as well as an increased risk of mortality.¹⁰ Obesity has also been shown to increase the risk for COVID-19 complications, mortality, and hospitalizations.¹¹⁻¹³ Obesity poses a substantial burden on the health care system due to its association with increased health care utilization and medical costs.^{5,14-17}

Health care professionals, especially primary care providers, play an important role in helping patients manage obesity, which requires a multifactorial approach.¹⁸⁻²⁰ However, obesity is often not managed effectively in primary care settings²¹⁻²⁴ due to a variety of factors.^{22,25-27} Clinicians often lack the training or the appropriate tools or resources to educate patients about potential treatment options or the risks associated with obesity.²⁸⁻³⁰ Understanding the prevalence of obesity and its impact within a health care system, as well as the specific demographic and clinical characteristics of the population, can help inform the design of obesity management tools and approaches. Resources tailored to the needs of a specific population that can be efficiently introduced at the point of care may help clinicians better support patients with obesity and potentially improve their health outcomes.

The goal of this descriptive study was to better understand the prevalence of obesity within a racially diverse integrated health care delivery system, with a primary aim to quantify the prevalence of obesity and its variation across the system. A secondary aim was to describe patterns in health care utilization among patients with and without obesity.

METHODS

Study Design and Data Source

We conducted a cross-sectional study to examine obesity prevalence and health care utilization for patients receiving care at Sutter Health, a community-based, not-for-profit health care delivery network in Northern California. Sutter Health is an integrated, provider-based

ABSTRACT

OBJECTIVES: To characterize the prevalence of obesity and associated health care use within an integrated health care system in California.

STUDY DESIGN: Cross-sectional study using electronic health records.

METHODS: Primary care patients 18 years and older receiving care at Sutter Health between 2015 and 2020 were included in the study. Obesity was classified and health care utilization was ascertained at index and during the follow-up periods. Differences in prevalence by demographic and clinical characteristics among patients with and without obesity were assessed. Logistic regression was used to estimate the relationship between obesity class and health care utilization (outpatient encounters).

RESULTS: Of the 1,094,790 primary care patients included in the analysis, 35% were classified as having obesity, defined as a body mass index of 30 kg/m² or more or 25 kg/m² or more for Asian individuals. Obesity prevalence was greater in Hispanic patients (46%) than in non-Hispanic White patients (30%). Patients without obesity had fewer outpatient visits (mean [SD], 3.7 [3.8]) than those with class 1 (4.1 [4.0]), class 2 (4.6 [4.4]), and class 3 (5.2 [4.8]) obesity. In the fully adjusted regression model, the odds of being a high utilizer among patients with obesity were 1.1 (class 1), 1.2 (class 2), and 1.3 (class 3) times that of patients without obesity ($P < .001$).

CONCLUSION: Obesity prevalence is high among patients in the Sutter Health system, varying by race/ethnicity, and was associated with increased outpatient visit utilization. There is a need for greater awareness of the impact of obesity and the specific patient populations affected by the disease.

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network comprising more than 100 ambulatory clinic sites and 24 acute-care hospitals across diverse urban and rural communities within 22 counties. Sutter Health is organized into 5 regions: Central Valley, Sacramento Sierra, East Bay, San Francisco/West Bay, and South Bay/Peninsula (Palo Alto). Data were extracted from Sutter Health's electronic health record (EHR) system (Epic Systems) between January 1, 2015, and December 31, 2020. The study was reviewed and approved by the Sutter Health Institutional Review Board, which granted a waiver of Health Insurance Portability and Accountability Act authorization and informed consent to access the medical records for research purposes.

Study Population

The study population included all patients 18 years and older receiving care in the Sutter Health system who had at least 1 primary care visit between January 1, 2015, and December 31, 2019, and at least 12 to 24 months of activity prior to the patient's first in-person encounter (index date) during the study period. Patients with a pregnancy diagnosis or a documented childbirth 6 months prior to, or any time during, the study period, were excluded.

To classify patients' obesity status, clinical characteristics, and health care utilization patterns, we defined an index date and 3 time periods or "windows" relative to the index date ([eAppendix Figure](#) [eAppendix available at [ajmc.com](#)]). The baseline window was defined as the 12-month period prior to and including a patient's index date. This time period was used to identify all comorbid conditions using the problem list and/or encounter diagnoses and ensured patients' comorbid conditions were current. The activity window was defined as the 12-month period prior to the baseline window, ensuring that patients had any type of recorded activity in the EHR associated with the Sutter Health system. The follow-up window was defined as the 12-month period following the index date during which health care utilization was assessed.

Outcome Measures

The prevalence of obesity, comorbidities, and health care utilization (outpatient office encounters, emergency department [ED] visits, inpatient hospitalizations) were measured. Baseline demographic characteristics (eg, age, sex, health insurance, and self-identified race and ethnicity) and clinical characteristics (eg, body mass index [BMI], comorbidities, Charlson Comorbidity Index [CCI] score,³¹ and smoking status) were extracted from the EHR. BMI, which was assessed at the index encounter, is a structured field in the EHR (ie, it does not need to be calculated from height and weight measures). Obesity classifications were modified from the World Health Organization definition to adjust for the Asian-Pacific population ([eAppendix Table 1](#)).³² Obesity classes for the patients of Asian-Pacific descent were defined as class 1: BMI between 25 kg/m²

TAKEAWAY POINTS

Obesity is a chronic disease associated with many comorbidities. We conducted a study of patients receiving primary care at the Sutter Health system between 2015 and 2020 to assess the prevalence of obesity and health care utilization in patients with obesity.

- ▶ More than one-third of primary care patients had obesity, with variations in prevalence by geographic area, race/ethnicity, and health insurance type.
- ▶ Patients with obesity, particularly those with severe obesity and certain racial/ethnic backgrounds, had higher outpatient health care utilization.
- ▶ Greater awareness and resources are needed for health care professionals to help manage obesity and improve patient outcomes.

and less than 30 kg/m²; class 2: BMI between 30 kg/m² and less than 40 kg/m²; and class 3: BMI of 40 kg/m² or more. For all other patients, obesity classes were defined as class 1: BMI between 30 kg/m² and less than 35 kg/m²; class 2: BMI between 35 kg/m² and less than 40 kg/m²; and class 3: BMI of 40 kg/m² or more.

A combined race/ethnicity field was defined by self-identification of Hispanic identity, followed by racial group. Patients who did not self-identify as Hispanic were classified based on their race. Extracted health care utilization data included office visits, ED visits, and inpatient hospitalizations.

Statistical Analysis

We examined differences in the prevalence of obesity by geographic region and differences in demographic and clinical characteristics among patients with and without obesity. Summary statistics were calculated on categorical variables (percentages) and continuous variables (means, medians, SDs). When continuous variables were not normally distributed, they were categorized. Outliers and missing variables were set to missing and no imputation was conducted.

We assessed each patient's health care utilization during the 12-month follow-up window for outpatient encounters, ED visits, and inpatient hospitalizations. For each measure, we calculated the mean, median, percentile, and number of encounters of each type; this revealed a strong left-skewed distribution (data not shown), meaning most patients had 0 encounters during the follow-up window. Ambulatory outpatient encounters, while still left skewed, were a median of 3 per patient. Accordingly, we used outpatient encounters as our basis for modelling utilization. We used a logistic regression model to estimate the odds of outpatient encounters (fewer than 3 encounters = 0; 3 or more encounters = 1) based on obesity class. We then adjusted for demographic and clinical variables ([eAppendix Table 2](#)). Models were constructed sequentially, starting with obesity class and building to a final model that included all comorbidities ([eAppendix Table 2](#)).

All hypothesis tests were 2-sided with an α of 0.05. Point estimates and 95% CIs were generated for all end points. We used Tukey multiple comparison tests to estimate differences in means for continuous variables and χ^2 tests to estimate difference for categorical variables. Data analyses were performed in RStudio (Posit PBC).

TABLE 1. Baseline Demographic Characteristics Among Patients With and Without Obesity

	Patients without obesity ^a (n = 714,677)		Patients with obesity ^a (n = 380,113)		All patients (N = 1,094,790)	
	n	%	n	%	n	%
Age in years, mean and SD	49.2	18.5	50.4	15.7	49.6	17.6
Female	440,720	61.7	204,529	53.8	645,249	58.9
Race/ethnicity						
Non-Hispanic White	392,918	55.0	172,069	45.3	564,987	51.6
Hispanic	85,337	11.9	71,765	18.9	157,102	14.3
Non-Hispanic Black	18,165	2.5	17,348	4.6	35,513	3.2
Non-Hispanic Asian	88,829	12.4	69,120	18.2	157,949	14.4
Non-Hispanic American Indian/Alaska Native	1046	0.1	931	0.2	1977	0.2
Non-Hispanic Native Hawaiian/other Pacific Islander	2079	0.3	1813	0.5	3892	0.4
Other/unknown	126,303	17.7	47,067	12.4	173,370	15.8
Insurance						
Commercial	469,485	65.7	244,692	64.4	714,177	65.2
Medicare	137,121	19.2	71,441	18.8	208,562	19.1
Medicaid	11,671	1.6	8324	2.2	19,995	1.8
Other	55,500	7.8	33,863	8.9	89,363	8.2
Unknown/not reported	40,900	5.7	21,793	5.7	62,693	5.7
Smoking status						
Yes	42,679	6.0	26,688	7.0	69,367	6.3
Never	484,189	67.7	234,600	61.7	718,849	65.7
Quit	133,924	18.7	89,101	23.4	223,025	20.4
Passive ^b	4207	0.6	2556	0.7	6763	0.6
Not asked	224	<1.0	82	<1.0	306	<1.0
Missing	49,454	7.0	27,086	7.1	76,480	7.0

BMI, body mass index.

^aObesity was defined as a BMI ≥30 kg/m² for non-Asian patients and a BMI ≥25 kg/m² for patients of Asian-Pacific descent.

^bPassive smoking refers to second-hand smoking exposure.

non-Hispanic Whites (31%; all $P < .001$) and among those of unknown race (27%; $P < .001$). Forty-two percent of patients with Medicaid had obesity, more than patients with Medicare (34%; $P < .001$) or commercial insurance (34%; $P < .001$). Patients with a CCI score of 3 or more were more likely to have obesity (61%-78%) compared with those with a CCI score of 2 or less (24%-31%; all $P < .001$).

The proportion of patients by each characteristic within each obesity class is shown in **eAppendix Table 4**. Sixty-two percent of patients with obesity had class 1 obesity, 25% had class 2, and 13% had class 3. Females with obesity were more likely than males to have class 3 obesity (16% vs 9%; $P < .001$). Among patients covered by Medicaid, 21% had class 3 obesity. Class 3 obesity also was prevalent in 13% of patients covered by Medicare and 13% of those who had commercial insurance. Patients with obesity who had a CCI score of 5 to 6 or more were more likely to have class 3 obesity (47% and 37%, respectively) than those with a CCI score of 5 or less (0%-19%; all $P < .001$).

eAppendix Table 5 presents the patient characteristics by race/ethnicity. Across broad race/ethnicity categories, the non-Hispanic Black group had the highest proportion of patients in class 3 (24%), followed by non-Hispanic White (16%), Hispanic (14%), and non-Hispanic Other (14%). Non-Hispanic Asian patients had the lowest prevalence of class 3 obesity at 2%. These patients comprised the only racial subgroup with a higher proportion of males with obesity (55%, vs 35%-48% in all

other racial/ethnic subgroups). Both Hispanic and non-Hispanic Black patients with obesity had higher proportions on Medicaid (both 4%), whereas non-Hispanic White patients had the lowest proportion with commercial insurance (58%) and the highest proportion on Medicare (26%).

Among patients with obesity, the rural areas of the Central Valley and Sacramento Sierra region had the highest proportion of patients with class 3 obesity (**Figure 1**). The East Bay region, which tends to be more suburban, had the highest proportion of female patients with obesity (65% vs 49%-56%; $P < .001$ in all other regions). **eAppendix Table 6** presents the patient characteristics by region. The highest proportions of patients with obesity self-identifying as Hispanic were in the Central Valley (30%) and East Bay (19%) regions. The proportion of self-identified non-Hispanic Black patients with obesity was highest in the East Bay region (20%); all other regions ranged from 2% to 6%. The Central Valley region had the lower proportion of patients with commercial insurance (56% vs 60%-70%

RESULTS

Patient Characteristics

A total of 1,094,790 patients met eligibility criteria; 380,113 (35%) were classified as having obesity (BMI ≥30 kg/m² or ≥25 kg/m² for Asian individuals). **Table 1** and **Table 2** present the demographic and clinical characteristics of the study sample by obesity status, respectively. Less than 1% of patients with or without obesity were reported to have metabolic syndrome. The proportion of patients with hypertension was more than 1.5 times higher than that of patients without obesity; the proportion of patients with obesity and prediabetes or type 2 diabetes were 2 and 3 times higher, respectively.

eAppendix Table 3 shows the proportion of patients with obesity by each characteristic. Prevalence of obesity was high among Hispanics (46%), non-Hispanic Blacks (49%), non-Hispanic Native Americans (47%), non-Hispanic Asians (44%), and non-Hispanic Native Hawaiians/Other Pacific Islanders (47%) compared with

in all other regions) and, along with the urban San Francisco/West Bay region, the highest proportion with Medicaid (4% for both vs 2% in the other regions). Being a current smoker was more common in the Central Valley (9%) and Sacramento Sierra (9%) regions than in the other regions (5%-7%).

Health Care Resource Utilization

Office visits, ED visits, and inpatient admissions were more common among patients with obesity than those without obesity and were progressively more common with each higher obesity class (Figure 2). Patients without obesity had a mean of 3.7 office visits, lower than that seen for patients with class 1 (4.1 visits), class 2 (4.6 visits), and class 3 (5.2 visits) obesity (Appendix Table 7).

In the base (unadjusted) logistic regression model, there was a strong relationship between obesity class and high health care utilization (3 or more outpatient encounters). Compared with patients who did not have obesity, patients with class 1, 2, and 3 obesity had 1.21 (95% CI, 1.19-1.22), 1.50 (95% CI, 1.47-1.52), and 1.94 (95% CI, 1.90-1.99) times higher odds of being high utilizers, respectively (Appendix Table 8). In the fully specified model (Figure 3), this relationship was consistent, although the odds ratios (ORs) were attenuated (OR, 1.11 for class 1, 1.22 for class 2, and 1.32 for class 3; all $P < .001$). Patients who were Hispanic (OR, 1.18; 95% CI, 1.16-1.19), non-Hispanic Black (OR, 1.17; 95% CI, 1.14-1.20), and non-Hispanic Native American (OR, 1.4; 95% CI, 1.24-1.57) had greater odds of being high utilizers than non-Hispanic White patients. Non-Hispanic Asian patients were at significantly lower odds (OR, 0.76; 95% CI, 0.75-0.77) of being high utilizers than non-Hispanic White patients. Patients with obesity covered by Medicaid (OR, 1.51; 95% CI, 1.47-1.55), Medicare (OR, 1.46; 95% CI, 1.44-1.48), or other insurance (OR, 1.38; 95% CI, 1.26-1.51) were at significantly higher odds of being high utilizers than those covered by commercial insurance, whereas patients with self-pay or unknown coverage were at significantly lower odds (OR, 0.78; 95% CI, 0.74-0.82).

DISCUSSION

This study describes the prevalence of obesity and associated health care utilization in a population of patients within a large health system

in California. Of the primary care patients in the Sutter Health system included in our analysis, 35% were classified as having obesity; this total is slightly lower than that of the most recent national estimate of 42.4%,³³ but higher than the current overall obesity prevalence in California (27.6%).³⁴ One possible explanation is that the proportion of non-Hispanic Asian patients is 18% in the Sutter Health

TABLE 2. Baseline Clinical Characteristics Among Patients With and Without Obesity

	Patients without obesity ^a (n = 714,677)		Patients with obesity ^a (n = 380,113)		All patients (N = 1,094,790)	
	n	%	n	%	n	%
CCI score^b						
No score	544,854	76.2	247,965	65.2	792,819	72.4
1-2	142,326	19.9	45,239	11.9	187,565	17.1
3-4	19,794	2.8	66,087	17.4	85,881	7.8
5-6	4565	0.6	15,999	4.2	20,564	1.9
> 6	3138	0.4	4823	1.3	7961	0.7
General comorbidity^c						
Anxiety disorder	56,935	8.0	30,741	8.1	87,676	8.0
Any malignancy	36,750	5.1	16,805	4.4	53,555	4.9
Atherosclerotic cardiovascular disease	51,358	7.2	30,179	7.9	81,537	7.4
Asthma	45,524	6.4	36,386	9.6	81,910	7.5
Chronic kidney disease/end-stage liver disease	18,762	2.6	14,564	3.8	33,326	3.0
Chronic lung disease	67,504	9.4	50,374	13.3	117,878	10.8
Depression	78,373	11.0	51,582	13.6	129,955	11.9
Dyslipidemia	178,106	24.9	145,008	38.1	323,114	29.5
Gastroesophageal reflux disease	64,442	9.0	50,190	13.2	114,632	10.5
Hypertension (essential/primary)	139,556	19.5	138,674	36.5	278,230	25.4
Metabolic syndrome	927	0.1	2502	0.7	3429	0.3
Musculoskeletal pain	157,987	22.1	105,953	27.9	263,940	24.1
Nonalcoholic fatty liver disease/nonalcoholic steatohepatitis	3725	0.5	7474	2.0	11,199	1.0
Obesity	5503	0.8	76,817	20.2	82,320	7.5
Obstructive sleep apnea	11,373	1.6	22,300	5.9	33,673	3.1
Osteoarthritis, hip/knee	13,701	1.9	16,595	4.4	30,296	2.8
Polycystic ovary syndrome	2152	0.3	3662	1.0	5814	0.5
Prediabetes	53,649	7.5	56,555	14.9	110,204	10.1
Psoriasis	7900	1.1	5993	1.6	13,893	1.3
Type 2 diabetes	38,586	5.4	60,064	15.8	98,650	9.0
Urinary incontinence	9803	1.4	6625	1.7	16,428	1.5

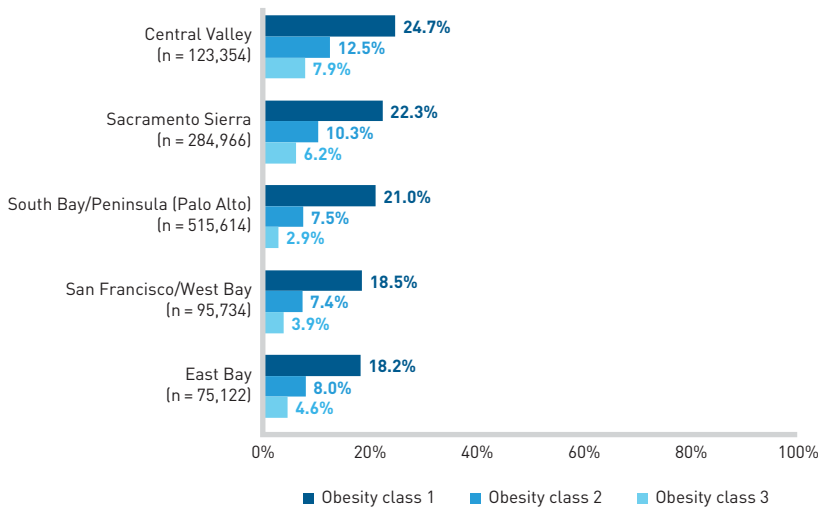
BMI, body mass index; CCI, Charlson Comorbidity Index.

^aObesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent.

^bCCI score is a categorization of patient comorbidities that are associated with a weight from 1 to 6 based on the adjusted risk of mortality or resource use; the sum of all the weights results in a single comorbidity score for a patient. A score of zero indicates that no comorbidities were found. The higher the score, the more likely the predicted outcome will result in mortality or higher resource use.

^cPercentages sum to > 100% due to patients having more than 1 comorbidity.

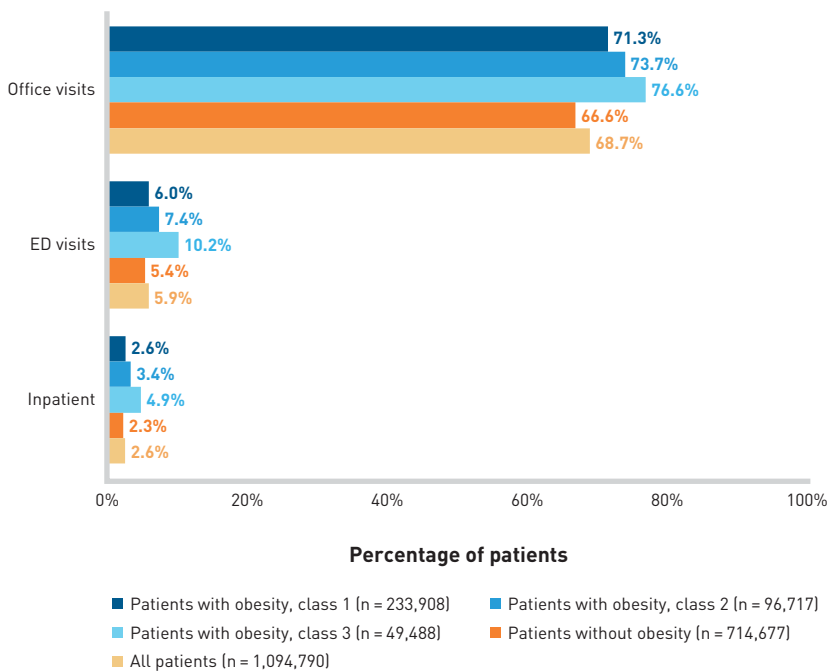
FIGURE 1. Obesity Class Among Patients With Obesity by Region*



BMI, body mass index.

*Obesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent [obesity class 1: BMI 30 kg/m² to < 35 kg/m² and BMI 25.0 kg/m² to < 30 kg/m², respectively; obesity class 2: BMI 35 kg/m² to < 40 kg/m² and BMI 30.0 kg/m² to < 40 kg/m²; obesity class 3: BMI ≥ 40 kg/m² and BMI ≥ 40 kg/m²].

FIGURE 2. Percentage of Patients With Health Care Resource Utilization by Obesity Status*



BMI, body mass index; ED, emergency department.

*Obesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent [obesity class 1: BMI 30 kg/m² to < 35 kg/m² and BMI 25.0 kg/m² to < 30 kg/m², respectively; obesity class 2: BMI 35 kg/m² to < 40 kg/m² and BMI 30.0 kg/m² to < 40 kg/m²; obesity class 3: BMI ≥ 40 kg/m² and BMI ≥ 40 kg/m²].

population, substantially higher than that of the US population (6%).³⁵ However, we used a lower threshold of obesity for patients of Asian descent, from a BMI of 25 kg/m² or more to a BMI of 30 kg/m² or more, which should more accurately reflect the prevalence of obesity in this group. Another possible explanation for the differences was our requirement of receiving primary health care. The US and California estimates likely include individuals who do not utilize the health care system as it was derived from a survey (the National Health and Nutrition Examination Survey).³⁵

Obesity prevalence in our study varied by race and ethnicity, very similar to that seen in the United States generally, except for non-Hispanic White individuals, for whom it was lower (31% vs 42%).³³ Almost a quarter of non-Hispanic Black patients in the Sutter Health sample had class 3 obesity, substantially more than any other racial/ethnic group. This is concerning as severe obesity is associated with increased morbidity³⁶ and is estimated to shorten life expectancy by as much as 14 years.³⁷ These findings highlight the importance of capturing race/ethnicity and other socioeconomic information in EHRs, which is often lacking and can lead to an incomplete picture of the health and health care utilization patterns in patient populations.³⁸⁻⁴¹

Our study found that 42% of patients with Medicaid insurance had obesity in the Sutter Health system compared with 34% of those with commercial insurance, potentially indicating a higher obesity rate among those with lower income. We also found differences in demographic and clinical characteristics across Sutter Health's broad geography. Among patients with obesity, the more rural regions of Sacramento Sierra and Central Valley with lower socioeconomic status had the highest proportion of individuals with class 3 obesity than the more urban regions with higher socioeconomic status.⁴² Patients in the Central Valley region were least likely to have commercial insurance. Resources for health care professionals in the region should consider the differences in socioeconomic status and the unique barriers they pose to obesity management in these patient populations.

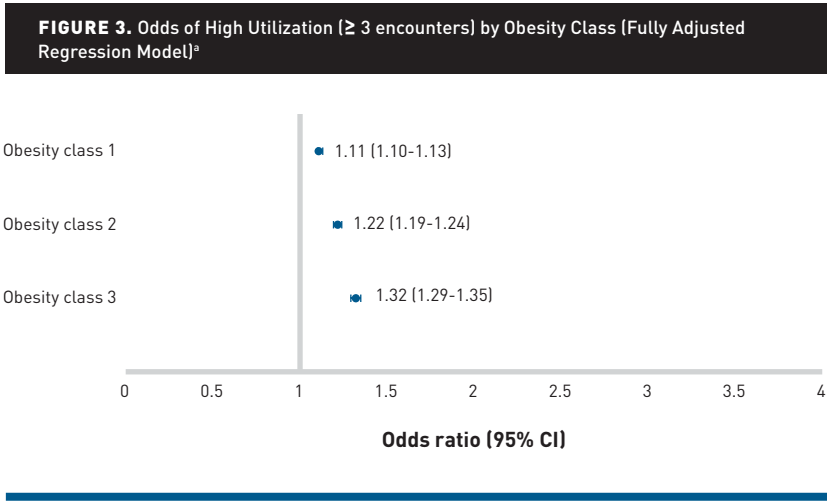
We found a very low proportion of patients in our study had metabolic syndrome, much

lower than the 2012 estimation of 34% in the US adult population.⁴³ This could be due to documentation patterns in the health system, or it could suggest infrequent screening for the condition, likely due to a lack of consensus regarding the clinical definition.^{43,44} We did find higher levels of prediabetes, type 2 diabetes, and hypertension among patients with obesity, indicating that clinicians may be more likely to identify individual risk factors among their patients. Because metabolic syndrome is related to a higher risk of developing cardiovascular diseases,^{45,46} it is important to identify the condition, including in younger populations.^{44,47}

In our study, more patients with obesity had office visits than patients without obesity, but there was less variability in health care utilization of ED visits and inpatient admissions, likely due to low counts in each of these categories. In multivariable models using outpatient utilization as a binary measure (ie, at or above vs below the median of 3 outpatient encounters), we found that high utilization was significantly associated with obesity, and the association got stronger with higher obesity class (OR, 1.3 for class 3 obesity vs patients without obesity). Our findings are similar to retrospective cohort studies examining the association between obesity and health care utilization in populations of patients with commercial insurance and Medicare, with similar odds of having an outpatient encounter increasing by obesity class.^{15,16} Compared with non-Hispanic White patients, patients who were Hispanic, non-Hispanic Black, and non-Hispanic Native American were at increased odds of being high utilizers. A large observational study in Italy showed that patients with obesity who did not receive treatment for their obesity had greater health care utilization and costs than patients of normal weight.⁴⁸ In a US population, a retrospective cohort study of adults with obesity found that nonsurgical weight loss was associated with health care cost savings.⁴⁹ Although we did not study costs or weight changes, nor did we assess the use of obesity treatments, we did find that higher classes of obesity were associated with greater odds of being a high utilizer. If the Italian cohort findings apply to our cohort,⁴⁸ we can expect an even greater utilization burden for our patients who do not receive treatment for their obesity.

Limitations

As this is an observational study, potential confounding factors cannot be ruled out. EHR data were collected as part of routine clinical practice rather than as mandatory assessments at prespecified time points, which is dependent on the documentation practices within the health system; this could have an impact on the amount of available data and its interpretation. Additional limitations include missing data and incomplete coding of diagnoses. Sutter



BMI, body mass index.

^aThe reference group is patients without obesity. Obesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent (obesity class 1: BMI 30 kg/m² to < 35 kg/m² and BMI 25.0 kg/m² to < 30 kg/m², respectively; obesity class 2: BMI 35 kg/m² to < 40 kg/m² and BMI 30.0 kg/m² to < 40 kg/m²; obesity class 3: BMI ≥ 40 kg/m² and BMI ≥ 40 kg/m²). The fully adjusted model included obesity class, age, sex, race/ethnicity, smoking status, health insurance coverage, and comorbidities.

Health is an open system and therefore, patients can receive their care outside the system, and some of that utilization will be invisible in the Sutter Health EHR. Finally, our findings represent the results at a single health care system. Although Sutter Health is large and diverse, the findings may not be generalizable for all health care systems.

CONCLUSIONS

Although the prevalence of obesity within the Sutter Health population is slightly lower than national US estimates, there are important differences by clinical and demographic characteristics in this population. Obesity rates can be different across a large health system with multiple locations, potentially requiring different approaches for managing the disease within the health system. Additionally, obesity is associated with higher utilization of outpatient visits, particularly for certain racial/ethnic subgroups and patients with Medicare and Medicaid, highlighting the importance of obesity management in these vulnerable populations. Further research is needed to understand the obesity management practices within the Sutter Health system to identify knowledge and practice gaps, ultimately with a goal to develop tools and resources to help health care professionals better support their patients with obesity. ■

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Authorship Information: Concept and design (AP, JBJ, SA, SW, ED); acquisition of data (JBJ, XX); analysis and interpretation of data (AP, JBJ, XX, AS, SA, SW); drafting of the manuscript (AP, JBJ, XX, AS, SA, SW); critical revision of the manuscript for important intellectual content (AP, JBJ, XX, SA, SW, ED); statistical analysis (AP, XX); provision of patients or study materials (XX); obtaining funding (AP, JBJ); administrative, technical, or logistic support (AS, SA); and supervision (JBJ, ED).

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REFERENCES

1. Avgerinos KI, Spyrou N, Mantzoros CS, Dalamaga M. Obesity and cancer risk: emerging biological mechanisms and perspectives. *Metabolism*. 2019;92:121-135. doi:10.1016/j.metabol.2018.11.001
2. Cancer and obesity. CDC. Updated October 1, 2019. Accessed November 17, 2020. <https://www.cdc.gov/vitalsigns/obesity-cancer/index.html>
3. Garg SK, Maurer H, Reed K, Selagamasetty R. Diabetes and cancer: two diseases with obesity as a common risk factor. *Diabetes Obes Metab*. 2014;16(2):97-110. doi:10.1111/dom.12124
4. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health*. 2009;9:88. doi:10.1186/1471-2458-9-88
5. Li Q, Blume SW, Huang JC, Hammer M, Ganz ML. Prevalence and healthcare costs of obesity-related comorbidities: evidence from an electronic medical records system in the United States. *J Med Econ*. 2015;18(12):1020-1028. doi:10.3111/1366998.2015.1067623
6. Massetti GM, Dietz WH, Richardson LC. Excessive weight gain, obesity, and cancer: opportunities for clinical intervention. *JAMA*. 2017;318(20):1975-1976. doi:10.1001/jama.2017.15519
7. Meurling LJ, Shea DO, Garvey JF. Obesity and sleep: a growing concern. *Curr Opin Pulm Med*. 2019;25(6):602-608. doi:10.1097/mcp.0000000000000627
8. Pereira-Miranda E, Costa PRF, Queiroz VAO, Pereira-Santos M, Santana MLP. Overweight and obesity associated with higher depression prevalence in adults: a systematic review and meta-analysis. *J Am Coll Nutr*. 2017;36(3):223-233. doi:10.1080/07315724.2016.1261053
9. Rajan TM, Menon V. Psychiatric disorders and obesity: a review of association studies. *J Postgrad Med*. 2017;63(3):182-190. doi:10.4103/jpgm.JPGM_712_16
10. Xu H, Cupples LA, Stokes A, Liu CT. Association of obesity with mortality over 24 years of weight history: findings from the Framingham Heart Study. *JAMA Netw Open*. 2018;1(7):e184587. doi:10.1001/jamanetworkopen.2018.4587
11. Földi M, Farkas N, Kiss S, et al. Obesity is a risk factor for developing critical condition in COVID-19 patients: a systematic review and meta-analysis. *Obes Rev*. 2020;21(10):e13095. doi:10.1111/obr.13095
12. Ktang E, Kassim G, Soffer S, Freeman R, Levin MA, Reich DL. Severe obesity as an independent risk factor for COVID-19 mortality in hospitalized patients younger than 50. *Obesity (Silver Spring)*. 2020;28(9):1595-1599. doi:10.1002/oby.22913
13. Sattar N, Valabhji J. Obesity as a risk factor for severe COVID-19: summary of the best evidence and implications for health care. *Curr Obes Rep*. 2021;10(3):282-289. doi:10.1007/s13679-021-00448-8
14. Cawley J, Biener A, Meyerhoefer C, et al. Direct medical costs of obesity in the United States and the most populous states. *J Manag Care Spec Pharm*. 2021;27(3):354-366. doi:10.18553/jmcp.2021.20410
15. Kamble PS, Hayden J, Collins J, et al. Association of obesity with healthcare resource utilization and costs in a commercial population. *Curr Med Res Opin*. 2018;34(7):1335-1343. doi:10.1080/03007995.2018.1464435
16. Suehs BT, Kamble P, Huang J, et al. Association of obesity with healthcare utilization and costs in a Medicare population. *Curr Med Res Opin*. 2017;33(12):2173-2180. doi:10.1080/03007995.2017.1361915
17. Waters H, Graf M. The costs of chronic disease in the U.S. 2018. August, 2018. Accessed October 20, 2021. <https://milkeninstitute.org/sites/default/files/reports-pdf/ChronicDiseases-HighRes-FINAL.pdf>
18. Garvey WT, Mechanick JL, Brett EM, et al; Reviewers of the AACE/ACE Obesity Clinical Practice Guidelines. American Association of Clinical Endocrinologists and American College of Endocrinology comprehensive clinical practice guidelines for medical care of patients with obesity. *Endocr Pract*. 2016;22(suppl 3):1-203. doi:10.4158/EP161365.GL
19. Jensen MD, Ryan DH, Apovian CM, et al; American College of Cardiology/American Heart Association Task Force on Practice Guidelines; Obesity Society. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *Circulation*. 2014;129(25 Suppl 2):S102-38. doi:10.1161/01.cir.0000437739.71477.e20. Semlitsch T, Stigler FL, Jeitler K, Siebenhofer A. Management of overweight and obesity in primary care—a systematic overview of international evidence-based guidelines. *Obes Rev*. 2019;20(9):1218-1230. doi:10.1111/obr.12889
20. Bardia A, Holtan SG, Slezak JM, Thompson WG. Diagnosis of obesity by primary care physicians and impact on obesity management. *Mayo Clin Proc*. 2007;82(8):927-932. doi:10.4065/82.8.927
21. Ferrante JM, Piasecki AK, Ohman-Strickland PA, Crabtree BF. Family physicians' practices and attitudes regarding care of extremely obese patients. *Obesity (Silver Spring)*. Sep 2009;17(9):1710-1716. doi:10.1038/oby.2009.62
22. Smith AW, Borowski LA, Liu B, et al. U.S. primary care physicians' diet, physical activity, and weight-related care of adult patients. *Am J Prev Med*. 2011;41(1):33-42. doi:10.1016/j.amepre.2011.03.017
23. Kahan SI. Practical strategies for engaging individuals with obesity in primary care. *Mayo Clin Proc*. 2018;93(3):351-359. doi:10.1016/j.mayocp.2018.01.006
24. Sabin JA, Marini M, Nosek BA. Implicit and explicit anti-fat bias among a large sample of medical doctors by BMI, race/ethnicity and gender. *PLoS One*. 2012;7(11):e48448. doi:10.1371/journal.pone.0048448
25. Croghan IT, Ebert JO, Njeru JW, et al. Identifying Opportunities for Advancing Weight Management in Primary Care. *J Prim Care Community Health*. 2019;10:2150132719870879. doi:10.1177/2150132719870879
26. Simon R, Lahiri SW. Provider practice habits and barriers to care in obesity management in a large multicenter health system. *Endocr Pract*. 2018;24(4):321-328. doi:10.4158/ep-2017-0221
27. Butsch WS, Kushner RF, Alford S, Smolarz BG. Low priority of obesity education leads to lack of medical students' preparedness to effectively treat patients with obesity: results from the U.S. medical school obesity education curriculum benchmark study. *BMC Med Educ*. 2020;20(1):23. doi:10.1186/s12909-020-1925-z
28. Butsch WS, Robison K, Sharma R, Knecht J, Smolarz BG. Medicine residents are unprepared to effectively treat patients with obesity: results from a U.S. internal medicine residency survey. *J Med Educ Curric Dev*. 2020;7:2382120520973206. doi:10.1177/2382120520973206
29. Orjuela-Grimm M, Butsch WS, Bhatt-Carreño S, Smolarz BG, Rao G. Benchmarking of provider competencies and current training for prevention and management of obesity among family medicine residency programs: a cross-sectional survey. *BMC Fam Pract*. 2021;22(1):132. doi:10.1186/s12875-021-01484-y
30. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373-383. doi:10.1016/0021-9681(87)90171-8
31. Romaneli RJ, Huang HC, Chopra V, et al. Longitudinal weight outcomes from a behavioral lifestyle intervention in clinical practice. *Diabetes Educ*. 2019;45(5):529-543. doi:10.1177/0145721719872553
32. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity and severe obesity among adults: United States, 2017-2018. *NCHS Data Brief*. Feb 2020;(360):1-8.
33. Adult Obesity Prevalence Maps. CDC. Updated March 17, 2023. Accessed October 17, 2022. <https://www.cdc.gov/obesity/data/prevalence-maps.html>
34. QuickFacts United States. United States Census Bureau. Accessed August 2, 2022. <https://www.census.gov/quickfacts/fact/table/US/PT04521>
35. Khan SS, Krefman AE, Zhao L, et al. Association of body mass index in midlife with morbidity burden in older adulthood and longevity. *JAMA Netw Open*. 2022;5(3):e222318. doi:10.1001/jamanetworkopen.2022.2318
36. Kitahara CM, Flint AJ, Berrington de Gonzalez A, et al. Association between class III obesity (BMI of 40-59 kg/m²) and mortality: a pooled analysis of 20 prospective studies. *PLoS Med*. 2014;11(7):e1001673. doi:10.1371/journal.pmed.1001673
37. Casey JA, Pollak J, Glymour MM, Mayeda ER, Hirsch AG, Schwartz BS. Measures of SES for electronic health record-based research. *Am J Prev Med*. 2018;54(3):430-439. doi:10.1016/j.amepre.2017.10.004
38. Yee K, Hoopes M, Giebutowicz S, Elliott MN, McConnell KJ. Implications of missingness in self-reported data for estimating racial and ethnic disparities in Medicaid quality measures. *Health Serv Res*. 2022;57(6):1370-1378. doi:10.1111/1475-6773.14025
39. Cook L, Espinoza J, Weiskopf NG, et al; N3C Consortium. Issues with variability in electronic health record data about race and ethnicity: descriptive analysis of the national covid cohort collaborative data enclave. *JMIR Med Inform*. 2022;10(9):e39235. doi:10.2196/39235
40. Polubriagof FCG, Ryan P, Salmasian H, et al. Challenges with quality of race and ethnicity data in observational databases. *J Am Med Inform Assoc*. 2019;26(8-9):730-736. doi:10.1093/jamia/ocz113
41. Azar KMJ, Nasrallah C, Szwerinski NK, et al. Implementation of a group-based diabetes prevention program within a healthcare delivery system. *BMC Health Serv Res*. 2019;19(1):694. doi:10.1186/s12913-019-4569-0
42. Moore JX, Chaudhary N, Akinyemiju T. Metabolic syndrome prevalence by race/ethnicity and sex in the United States, National Health and Nutrition Examination Survey, 1988-2012. *Prev Chronic Dis*. 2017;14:E24. doi:10.5888/pcd14.160287
43. Boisvenue JJ, Oliva CU, Manca DP, Johnson JA, Yeung RO. Feasibility of identifying and describing the burden of early-onset metabolic syndrome in primary care electronic medical record data: a cross-sectional analysis. *CMAJ Open*. 2020;8(4):E779-E787. doi:10.9778/cmaj.20200007
44. Li X, Zhai Y, Zhao J, et al. Impact of metabolic syndrome and its components on prognosis in patients with cardiovascular diseases: a meta-analysis. *Front Cardiovasc Med*. 2021;8:704145. doi:10.3389/fcvm.2021.704145
45. Shi TH, Wang B, Natarajan S. The influence of metabolic syndrome in predicting mortality risk among US adults: importance of metabolic syndrome even in adults with normal weight. *Prev Chronic Dis*. 2020;17:E36. doi:10.5888/pcd17.200020
46. Kim I, Kim KM, Sim DS, et al. Effect of the metabolic syndrome on outcomes in patients aged <50 years versus >50 years with acute myocardial infarction. *Am J Cardiol*. 2018;122(2):192-198. doi:10.1016/j.amjcard.2018.03.366
47. Colao A, Luchese M, D'Adamo M, et al. Healthcare usage and economic impact of non-treated obesity in Italy: findings from a retrospective administrative and clinical database analysis. *BMJ Open*. 2017;7(2):e013899. doi:10.1136/bmjopen-2016-013899
48. Ding Y, Fan X, Blanchette CM, Smolarz BG, Weng W, Ramasamy A. Economic value of nonsurgical weight loss in adults with obesity. *J Manag Care Spec Pharm*. 2021;27(11):37-50. doi:10.18553/jmcp.2020.20036

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Characterizing Obesity in a Large Health Care Delivery System Supplemental Material

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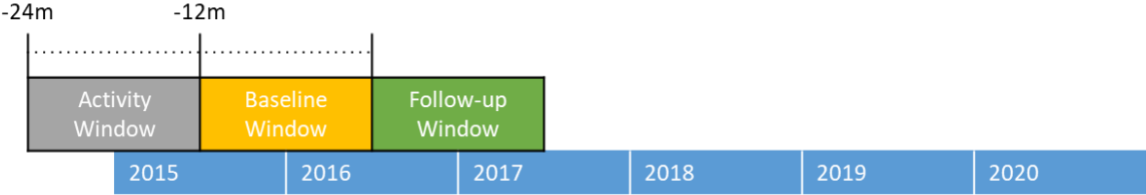
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eAppendix Table 1. Obesity Definitions – Modified From WHO Criteria

	BMI (kg/m²) for patients of non-Asian decent	BMI (kg/m²) for patients of Asian-Pacific descent
Underweight	< 18.5	< 18.5
Healthy weight	18.5-24.9	18.5-22.9
Overweight	25.0-29.9	23.0-24.9
Any obesity	≥ 30.0	≥ 25.0
Obesity class 1	30.0-34.9	25.0-29.9
Obesity class 2	35.0-39.9	30.0-39.9
Obesity class 3	≥ 40.0	≥ 40.0

BMI, body mass index; WHO, World Health Organization.

eAppendix Table 2. Sequential Regression Models

Outcome				
Obesity class	Obesity class	Obesity class	Obesity class	Obesity class
	Age at index	Age at index	Age at index	Age at index
	Sex	Sex	Sex	Sex
		Ethnicity	Ethnicity	Ethnicity
		Race	Race	Race
			Smoking status	Smoking status
			Health insurance	Health insurance
				Metabolic syndrome
				Hypertension
				Dyslipidemia
				Atherosclerotic cardiovascular disease
				Heart failure with preserved ejection fraction
				Psoriasis
				Urinary incontinence
				Prediabetes
				Type 2 diabetes
				Nonalcoholic fatty liver disease
				Chronic kidney disease
				Depression
				Anxiety disorder
				Obstructive sleep apnea
				Polycystic ovary syndrome
				Asthma
				Gastroesophageal reflux disease
				Musculoskeletal pain
				Osteoarthritis (hip/knee)
				Chronic lung disease
				Any malignancy
				Adenocarcinoma of the esophagus
				Breast cancer
				Colon/rectal cancer
				Gallbladder/extrahepatic bile duct cancer
				Kidney and other urinary organ cancer
				Liver and intrahepatic bile duct cancer
				Meningioma
				Multiple myeloma
				Ovarian cancer
				Pancreatic cancer
				Thyroid cancer
				Stomach cancer
				Uterine cancer

eAppendix Table 3. Proportion of Patients With Obesity by Each Characteristic

	Patients with obesity ^a	
	n	%
Among all patients		
Sex		
Female (n = 645,249)	204,529	31.7
Male (n = 449,541)	175,584	39.1
Race/ethnicity		
Non-Hispanic White (n = 564,987)	172,069	30.5*
Hispanic (n = 157,102)	71,765	45.7
Non-Hispanic Black (n = 35,513)	17,348	48.9
Non-Hispanic Asian (n = 157,949)	69,120	43.8
Non-Hispanic American Indian/Alaska Native (n = 1977)	931	47.1
Non-Hispanic Native Hawaiian/Other Pacific Islander (n = 3892)	1813	46.6
Other/Unknown (n = 173,370)	47,067	27.2*
Insurance		
Commercial (n = 714,177)	244,692	34.3
Medicare (n = 208,562)	71,441	34.3
Medicaid (n = 19,995)	8324	41.6**
Other (n = 89,363)	33,863	37.9
Unknown/not reported (n = 62,693)	21,793	34.8
Smoking status		
Yes (n = 69,367)	26,688	38.5
Never (n = 718,849)	234,600	32.6
Quit (n = 223,025)	89,101	40.0
Passive ^b (n = 6763)	2556	37.8
Not asked (306)	82	26.8
Missing (76,480)	27,086	35.4
CCI score ^c		
0 (n = 792,819)	247,965	31.3
1-2 (n = 187,565)	45,239	24.1
3-4 (n = 85,881)	66,087	77.0***
5-6 (n = 20,564)	15,999	77.8***
> 6 (n = 7961)	4823	60.6***

BMI, body mass index; CCI, Charlson Comorbidity Index.

^aObesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent.

^bPassive smoking refers to second-hand smoking exposure.

^cCCI score is a categorization of patient comorbidities that are associated with a weight from 1 to 6 based on the adjusted risk of mortality or resource use; the sum of all the weights results in a single comorbidity score for a patient. A score of zero indicates that no comorbidities were

found. The higher the score, the more likely the predicted outcome will result in mortality or higher resource use.

* $P < .001$ compared with Hispanic, non-Hispanic Black, non-Hispanic Asian, non-Hispanic American Indian/Alaska Native, non-Hispanic Native Hawaiian/Other Pacific Islander groups.

** $P < .001$ compared with those with Medicare or commercial coverage.

*** $P < .001$ compared with those with CCI score ≤ 2 .

eAppendix Table 4. Proportion of Patients by Each Characteristic Within Each Obesity Class

	Obesity Class 1 ^a		Obesity Class 2 ^a		Obesity Class 3 ^a	
	n	% / SD	n	% / SD	n	% / SD
Among patients with obesity (N = 380,113)	233,908	61.5	96,717	25.4	49,488	13.0
Age, mean years	50.9	15.9	49.7	15.4	48.8	14.9
Sex						
Female (n = 204,529)	116,114	56.8	55,465	27.1	32,950	16.1*
Male (n = 175,584)	117,794	67.1	41,252	23.5	16,538	9.4
Insurance						
Commercial (n = 244,692)	151,847	62.0	62,323	25.5	30,522	12.5
Medicare (n = 71,441)	44,558	62.4	17,431	24.4	9452	13.2
Medicaid (n = 8324)	4243	51.0	2332	28.0	1749	21.0
Other (n = 33,863)	20,355	60.1	8865	26.2	4643	13.7
Unknown/not reported (n = 21,793)	12,905	59.2	5766	26.5	3122	14.3
Smoking status						
Yes (n = 26,688)	15,699	58.8	7152	26.8	3837	14.4
Never (n = 234,600)	146,930	62.6	58,923	25.1	28,807	12.3
Quit (n = 89,101)	53,267	59.8	23,109	25.9	12,725	14.3
Passive ^b (n = 2556)	1407	55.1	696	27.2	453	17.7
Not asked (n = 82)	50	61.0	22	26.8	10	12.2
Missing (n = 27,086)	16,555	61.3	6815	25.2	3656	13.5
CCI score ^c						
0 (n = 247,965)	160,278	68.7	60,164	25.8	12,935	5.5
1-2 (n = 45,239)	45,239	100.0	0	0.0	0	0.0
3-4 (n = 66,087)	23,070	34.9	30,289	45.8	12,728	19.3
5-6 (n = 15,999)	3614	22.6	4953	31.0	7432	46.5**
≥ 6 (n = 4823)	1707	35.4	1311	27.2	1805	37.4**

BMI, body mass index; CCI, Charlson Comorbidity Index.

^aObesity classes for the patients of Asian-Pacific descent were defined as class 1: BMI 25 kg/m² to < 30 kg/m²; class 2: BMI 30 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m². For all other patients, obesity classes were defined as class 1: BMI 30 kg/m² to < 35 kg/m²; class 2: BMI 35 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m².

^bPassive smoking refers to second-hand smoking exposure.

^cCCI score is a categorization of patient comorbidities that are associated with a weight from 1 to 6 based on the adjusted risk of mortality or resource use; the sum of all the weights results in a single comorbidity score for a patient. A score of 0 indicates that no comorbidities were found. The higher the score, the more likely the predicted outcome will result in mortality or higher resource use.

**P* < .001 for % with class 3 compared with male patients.

***P* < .001 for % with class 3 compared with those with CCI score ≤ 2.

eAppendix Table 5. Baseline Demographics and Clinical Characteristics Among Patients With Obesity, by Race/Ethnicity

	Non-Hispanic White (n = 564,987)		Non-Hispanic Black (n = 35,516)		Non-Hispanic Asian (n = 157,949)		Hispanic (n = 157,102)		Non-Hispanic Other (n = 179,239)	
	n	% / SD	n	% / SD	n	% / SD	n	% / SD	n	% / SD
Patients with obesity ^a	172,069	30.5	17,348	48.8	69,120	43.8	71,765	45.7	49,811	27.8
Obesity class ^b										
Class 1	101,895	59.2	8528	49.2	51,484	74.5	41,269	57.5	30,732	61.7
Class 2	43,229	25.1	4719	27.2	16,528	23.9	20,264	28.2	11,977	24.0
Class 3	26,945	15.7	4101	23.6	1108	1.6	10,232	14.3	7102	14.3
Age, mean years	54.5	14.5	50.4	14.8	45.8	14.4	46.3	15.3	48.5	15.5
Sex										
Female	95,174	55.3	11,303	65.2	31,185	45.1	41,088	57.3	25,779	51.8
Male	76,895	44.7	6045	34.8	37,935	54.9	30,677	42.7	24,032	48.2
Insurance										
Commercial	99,183	57.6	10,722	61.8	54,268	78.5	47,785	66.6	32,734	65.7
Medicare	44,074	25.6	3269	18.8	7073	10.2	9009	12.6	8016	16.1
Medicaid	2911	1.7	737	4.2	793	1.1	2780	3.9	1103	2.2
Other	16,699	9.7	1490	8.6	4094	5.9	7201	10.0	4379	8.8
Unknown/not reported	9202	5.3	1130	6.5	2892	4.2	4990	7.0	3579	7.2
Smoking status										
Yes	13,740	8.0	1677	9.7	2671	3.9	4835	6.7	3765	7.6
Never	93,139	54.1	10,470	60.4	53,250	77.0	46,518	64.8	31,229	62.7
Quit	50,353	29.3	3984	23.0	8962	13.0	14,793	20.6	11,009	22.1
Passive ^c	1342	0.8	87	0.5	318	0.5	448	0.6	361	0.7
Missing/not asked	13,441	7.8	1130	6.5	3919	5.7	5171	7.2	3447	6.9
CCI score ^d										
0	105,877	61.5	9852	56.8	51,665	74.7	46,473	64.8	34,098	68.5
1-2	21,431	12.5	2024	11.7	8524	12.3	8702	12.1	5896	11.8
3-4	33,054	19.2	3855	22.2	7684	11.1	13,104	18.3	7726	15.5

5-6	8925	5.2	1232	7.1	967	1.4	2747	3.8	1638	3.3
> 6	2782	1.6	385	2.2	280	0.4	739	1.0	453	0.9

BMI, body mass index; CCI, Charlson Comorbidity Index.

^aObesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent.

^bObesity classes for the patients of Asian-Pacific descent were defined as class 1: BMI 25 kg/m² to < 30 kg/m²; class 2: BMI 30 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m². For all other patients, obesity classes were defined as class 1: BMI 30 kg/m² to < 35 kg/m²; class 2: BMI 35 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m².

^bPassive smoking refers to second-hand smoking exposure.

^dCCI score is a categorization of patient comorbidities that are associated with a weight from 1 to 6 based on the adjusted risk of mortality or resource use; the sum of all the weights results in a single comorbidity score for a patient. A score of 0 indicates that no comorbidities were found. The higher the score, the more likely the predicted outcome will result in mortality or higher resource use.

eAppendix Table 6. Baseline Demographics and Clinical Characteristics Among Patients With Obesity, by Region

	South Bay/ Peninsula (Palo Alto)		San Francisco/ West Bay		East Bay		Central Valley		Sacramento Sierra	
	n	% / SD	n	% / SD	n	% / SD	n	% / SD	n	% / SD
All patients	515,614		95,734		75,122		123,354		284,966	
Patients with obesity ^a	162,359	31.5	28,488	29.8	23,151	30.8	55,554	45.0	110,561	38.9
Obesity class ^b										
Class 1	108,462	21.0	17,716	18.5	13,700	18.2	30,451	24.7	63,579	22.3
Class 2	38,879	7.5	7069	7.4	5988	7.97	15,418	12.5	29,363	10.3
Class 3	15,018	2.9	3703	3.9	3463	4.6	9685	7.9	17,619	6.2
Age, mean years	48.9	15.1	53.5	15.4	50.4	15.6	51.6	16.3	51.3	16.0
Sex										
Female	80,049	49.3	16,084	56.5	15,030	64.9	31,159	56.1	62,207	56.3
Male	82,310	50.7	12,404	43.5	8121	35.1	24,395	43.9	48,354	43.7
Race/ethnicity										
Non-Hispanic White	54,585	33.6	16,531	58.0	9325	40.3	28,179	50.7	63,449	57.4
Hispanic	25,390	15.6	5104	17.9	4482	19.4	16,933	30.5	19,856	18.0
Non-Hispanic Black	2991	1.8	1080	3.8	4534	19.6	2386	4.3	6357	5.8
Non-Hispanic Asian	51,857	31.9	2859	10.0	3044	13.2	2908	5.2	8416	7.6
Non-Hispanic American Indian/ Alaska Native	171	0.1	86	0.3	40	0.2	180	0.3	454	0.4
Non-Hispanic Native Hawaiian/Other Pacific Islander	697	0.4	93	0.3	125	0.5	297	0.5	601	0.5
Other/unknown	26,668	16.4	2699	9.5	1601	6.9	4671	8.4	11,428	10.3
Insurance										
Commercial	114,028	70.2	17,277	60.7	162,48	70.2	31,235	56.2	65,904	59.6
Medicare	25,684	15.8	6117	21.5	4107	17.7	13,127	23.6	22,406	20.3
Medicaid	2853	1.8	1044	3.7	468	2.0	2022	3.6	1937	1.8
Other	11,240	6.9	2534	8.9	1011	4.4	5526	10.0	13,552	12.3
Unknown/not reported	8554	5.3	1516	5.3	1317	5.7	3644	6.6	6762	6.1
Smoking status										
Yes	8097	5.0	2003	7.0	1685	7.3	4884	8.8	10,019	9.1
Never	111,098	68.4	15,349	53.9	14,443	62.4	31,911	57.4	61,859	56.0
Quit	33,539	20.7	7185	25.2	5616	24.3	13,140	23.7	29,621	26.8
Passive ^c	816	0.5	146	0.5	117	0.5	305	0.6	1172	1.1
Not asked	32	0.0	7	0.0	3	0.0	12	0.0	28	0.0
Missing	8777	5.4	3798	13.3	1287	5.6	5302	9.5	7862	7.1
CCI score ^d										
0	113,962	70.2	18,342	64.4	15,330	66.2	33,442	60.2	66,889	60.5

	South Bay/ Peninsula (Palo Alto)		San Francisco/ West Bay		East Bay		Central Valley		Sacramento Sierra	
	n	% / SD	n	% / SD	n	% / SD	n	% / SD	n	% / SD
1-2	19,686	12.1	3508	12.3	2693	11.6	6662	12.0	14,028	12.7
3-4	23,179	14.3	5051	17.7	3965	17.1	11,188	20.1	22,040	19.9
5-6	4354	2.7	1055	3.7	935	4.0	3262	5.9	5903	5.3
>6	1178	0.7	532	1.9	228	10.0	1000	1.8	1701	1.5

BMI, body mass index; CCI, Charlson Comorbidity Index

^aObesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent.

^bObesity classes for the patients of Asian-Pacific descent were defined as class 1: BMI 25 kg/m² to < 30 kg/m²; class 2: BMI 30 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m². For all other patients, obesity classes were defined as class 1: BMI 30 kg/m² to < 35 kg/m²; class 2: BMI 35 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m².

^bPassive smoking refers to second-hand smoking exposure.

^dCCI score is a categorization of patient comorbidities that are associated with a weight from 1 to 6 based on the adjusted risk of mortality or resource use; the sum of all the weights results in a single comorbidity score for a patient. A score of 0 indicates that no comorbidities were found. The higher the score, the more likely the predicted outcome will result in mortality or higher resource use.

eAppendix Table 7. Number of Healthcare Utilization Encounters by Obesity Status for Patients With at Least One Encounter in the Follow-Up Window

	Patients without obesity		Patients with Obesity ^a					
<i>Obesity class^b</i>	Not applicable		Obesity Class 1		Obesity Class 2		Obesity Class 3	
Encounter type	mean (SD)	median	Mean (SD)	median	Mean (SD)	median	Mean (SD)	median
Office encounter	3.74 (3.82)	3	4.09 (4.04)	3	4.55 (4.36)	3	5.19 (4.80)	4
ED visits	1.54 (1.55)	1	1.52 (1.50)	1	1.58 (1.52)	1	1.72 (1.78)	1
Inpatient admissions	1.41 (0.93)	1	1.36 (0.88)	1	1.38 (0.87)	1	1.37 (0.91)	1

^aObesity was defined as a body mass index (BMI) ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent.

^bObesity classes for the patients of Asian-Pacific descent were defined as class 1: BMI 25 kg/m² to < 30 kg/m²; class 2: BMI 30 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m². For all other patients, obesity classes were defined as class 1: BMI 30 kg/m² to < 35 kg/m²; class 2: BMI 35 kg/m² to < 40 kg/m²; and class 3: BMI ≥ 40 kg/m².

eAppendix Table 8. Healthcare Utilization Regression Model, Unadjusted and Adjusted for Demographic and Clinical Variables

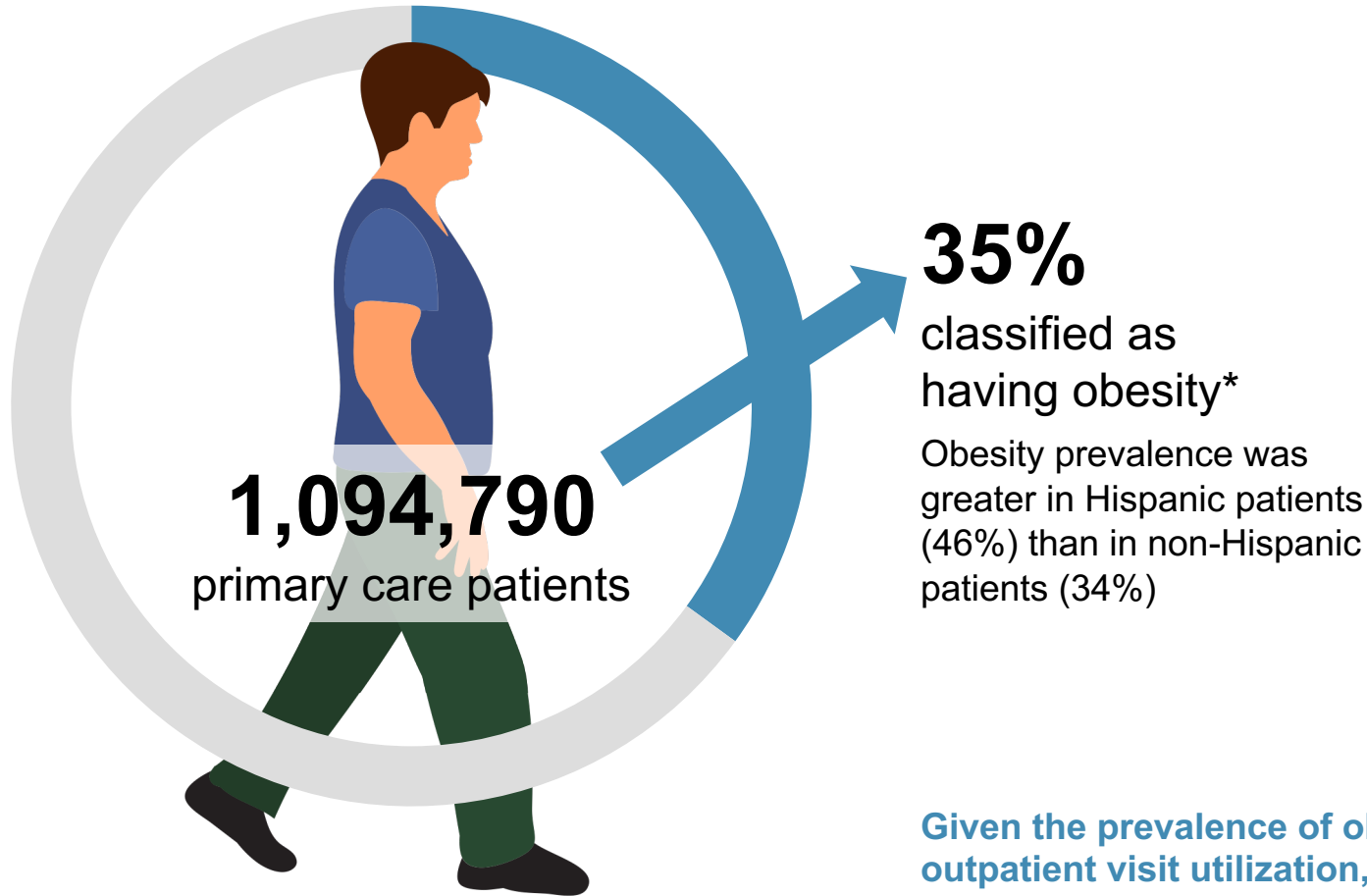
Characteristics	Utilization & Obesity Class			Utilization & Obesity Class, Age, Sex			Utilization & Obesity Class, Age, Sex, Race/Ethnicity			Utilization & Obesity Class, Age, Sex, Race/Ethnicity, Smoking Status, Insurance			Utilization & Obesity Class, Age, Sex, Race/Ethnicity, Smoking Status, Insurance, Comorbidities			
	OR	95% CI	P Value	OR	95% CI	P Value	OR	95% CI	P Value	OR	95% CI	P Value	OR	95% CI	P Value	
Obesity Class																
	0	1.00	Referent		1.00	Referent		1.00	Referent		1.00	Referent		1.00	Referent	
	1	1.21	(1.19, 1.22)	<0.001	1.23	(1.21, 1.24)	<0.001	1.25	(1.23, 1.26)	<0.001	1.25	(1.23, 1.26)	<0.001	1.11	(1.10, 1.126)	<0.001
	2	1.50	(1.47, 1.52)	<0.001	1.56	(1.54, 1.59)	<0.001	1.54	(1.52, 1.57)	<0.001	1.53	(1.50, 1.55)	<0.001	1.22	(1.19, 1.24)	<0.001
	3	1.94	(1.90, 1.99)	<0.001	2.07	(2.03, 2.12)	<0.001	1.91	(1.87, 1.96)	<0.001	1.86	(1.82, 1.90)	<0.001	1.32	(1.29, 1.35)	<0.001
Age																
				1.03	(1.03, 1.03)	<0.001	1.03	(1.03, 1.03)	<0.001	1.02	(1.01, 1.02)	<0.001	1.01	(1.005, 1.006)	<0.001	
Sex																
	Male			1.00	Referent		1.00	Referent		1.00	Referent		1.00	Referent		
	Female			1.27	(1.25, 1.28)	<0.001	1.26	(1.24, 1.27)	<0.001	1.27	(1.26, 1.29)	<0.001	1.30	(1.28, 1.31)	<0.001	
Race/Ethnicity																
	Non-Hispanic White						1.00	Referent		1.00	Referent		1.00	Referent		
	Hispanic						1.18	(1.16, 1.19)	<0.001	1.19	(1.171, 1.20)	<0.001	1.18	(1.16, 1.19)	<0.001	
	NH African American						1.28	(1.24, 1.31)	<0.001	1.23	(1.20, 1.27)	<0.001	1.17	(1.14, 1.20)	<0.001	
	NH Asian						0.65	(0.65, 0.66)	<0.001	0.70	(0.69, 0.71)	<0.001	0.76	(0.75, 0.77)	<0.001	
	NH Native						1.61	(1.45, 1.81)	<0.001	1.53	(1.37, 1.71)	<0.001	1.40	(1.24, 1.57)	<0.001	
	NH Pacific						1.15	(1.07, 1.24)	<0.001	1.15	(1.07, 1.25)	<0.001	1.10	(1.02, 1.19)	0.02	
	Other/Unknown						0.76	(0.75, 0.77)	<0.001	0.78	(0.77, 0.79)	<0.001	0.81	(0.797, 0.82)	<0.001	
Smoking Status																
	Never									1.00	Referent		1.00	Referent		
	Current									1.37	(1.35, 1.40)	<0.001	1.22	(1.199, 1.25)	<0.001	
	Quit/Past									1.27	(1.25, 1.28)	<0.001	1.15	(1.14, 1.17)	<0.001	
	Passive									1.13	(1.06, 1.195)	<0.001	1.07	(1.004, 1.14)	0.04	
	Unkown									1.12	(1.10, 1.14)	<0.001	1.07	(1.05, 1.09)	<0.001	
Insurance Type																
	Commercial									1.00	Referent		1.00	Referent		
	Medicaid									1.80	(1.75, 1.85)	<0.001	1.51	(1.47, 1.55)	<0.001	
	Medicare									1.79	(1.76, 1.81)	<0.001	1.46	(1.44, 1.48)	<0.001	
	Other									1.39	(1.28, 1.52)	<0.001	1.38	(1.26, 1.51)	<0.001	
	Self-pay/Unknown									0.75	(0.72, 0.79)	<0.001	0.78	(0.74, 0.82)	<0.001	
Clinical Comorbidities																
	Charlson Comorbidity Index															
	0												1.00	Referent		
	1-2												1.35	(1.33, 1.38)	<0.001	
	3-4												1.47	(1.43, 1.52)	<0.001	
	5-6												1.71	(1.63, 1.80)	<0.001	
	>6												2.03	(1.88, 2.19)	<0.001	
	ASCVD												1.56	(1.53, 1.59)	<0.001	
	Adenocarcinoma of the Esophagus												1.75	(1.15, 2.756)	0.01	
	Anxiety Disorder												1.41	(1.39, 1.44)	<0.001	
	Any Malignancy												1.31	(1.27, 1.35)	<0.001	
	Asthma												0.87	(0.84, 0.89)	<0.001	
	Breat Cancer												1.27	(1.197, 1.35)	<0.001	
	Chronic Kidney Disease/ESLD												1.25	(1.21, 1.29)	<0.001	
	Chronic Lung Disease												1.18	(1.14, 1.21)	<0.001	
	Colon/Rectal Cancer												1.17	(1.06, 1.30)	0.003	
	Depression												1.31	(1.29, 1.33)	<0.001	
	Dyslipidemia												1.04	(1.03, 1.06)	<0.001	
	Gallbladder/Extraheptatic Bile Duct Cander												1.97	(1.008, 4.33)	0.06	
	Gastro-Esophageal Reflux Disease												1.54	(1.51, 1.56)	<0.001	
	Hypertension (essential/primary)												1.21	(1.199, 1.23)	<0.001	
	Kidney and Other Urinary Organ Cancer												1.21	(1.04, 1.42)	0.02	
	Liver and Intrahepatic Bile Duct Cancer												1.17	(0.87, 1.60)	0.32	
	Meningioma												1.77	(0.55, 7.95)	0.38	
	Metabolic Syndrome												0.98	(0.899, 1.06)	0.58	
	Musculoskeletal Pain												1.67	(1.65, 1.69)	<0.001	
	Non-alcoholic fatty liver disease/NASH												0.99	(0.945, 1.04)	0.76	
	Obstrucive sleep apnea												1.47	(1.43, 1.52)	<0.001	
	Osteoarthritis, Hip/Knee												1.33	(1.289, 1.37)	<0.001	
	Ovarian Cancer												1.26	(1.03, 1.54)	0.02	
	Pancreatic Cancer												2.09	(1.39, 3.298)	<0.001	
	Polycystic Ovary Syndrome												1.30	(1.22, 1.39)	<0.001	
	Pre-diabetes												1.02	(1.001, 1.03)	0.04	
	Psoriasis												1.21	(1.16, 1.26)	<0.001	
	Stomach Cancer												1.41	(0.95, 2.16)	0.10	
	Thyroid Cancer												1.28	(1.16, 1.42)	<0.001	
	Type2Diabetes												1.19	(1.17, 1.22)	<0.001	
	Urinary Incontinence												1.36	(1.31, 1.42)	<0.001	
	Uterine Cancer												0.96	(0.73, 1.27)	0.77	

BMI, body mass index; CCI, Charlson Comorbidity Index

Notes: Obesity was defined as a BMI ≥ 30 kg/m² for non-Asian patients and a BMI ≥ 25 kg/m² for patients of Asian-Pacific descent (obesity class 1: BMI 30 kg/m² to < 35 kg/m² / BMI 25.0 to <30kg/m²; obesity class 2: BMI 35 kg/m² to < 40 kg/m² / BMI 30.0 to <40kg/m²; obesity class 3: BMI ≥ 40 kg/m² / BMI ≥ 40 kg/m², respectively). Passive smoking refers to second-hand smoking exposure. CCI score is a categorization of patient comorbidities which are associated with a weight from 1 to 6 based on the adjusted risk of mortality or resource use; the sum of all the weights results in a single comorbidity score for a patient. A score of 0 indicates that no comorbidities were found. The higher the score, the more likely the predicted outcome will result in mortality or higher resource use.

Characterizing Obesity in a Large Healthcare Delivery System

To better understand the prevalence of obesity and associated health care use within an integrated healthcare system in California, a retrospective cross-sectional study using electronic health records was conducted. Primary care patients 18 years or older receiving care at Sutter Health between 2015 and 2020 were included in the study.



Number of Outpatient Visits – Patients:

Without obesity	(3.7)	
Class 1	(4.1)	
Class 2	(4.6)	
Class 3	(5.2)	

Odds of Being High Utilizers (3+ visits) Compared to those Without Obesity

Class 1
1.1x

Class 2
1.2x

Class 3
1.3x

Given the prevalence of obesity in the Sutter Health system and associated outpatient visit utilization, there is a need for greater awareness of the impact of obesity and tools or resources to help healthcare professionals better support their patients with obesity.

*Obesity = body mass index (BMI) of ≥ 30 kg/m² or ≥ 25 kg/m² for Asian individuals