MILLIMAN REPORT

Obesity in A Claims-Based Analysis of the Commercially Insured Population: Prevalence, Cost, and the Influence of Obesity Services and Anti-Obesity Medication Coverage on Health Expenditures

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Intended for presentation to a payer, formulary committee, or other similar entity carrying out its responsibilities for the selection of drugs for coverage or reimbursement on behalf of a healthcare organization.

The results of this study are not intended to provide efficacy or safety data about the anti-obesity medications use in it nor does it guarantee financial or clinical performance of those AOMs.


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Executive Summary

Obesity is associated with more than $200 billion (in 2008 dollars) in annual medical costs[1] and with 12.9% of total annual private payer spend.[2] In this study, we summarize the existing literature on the cost impacts of obesity and perform independent analysis of survey and claims administrative data with two goals: 1) quantify the prevalence of obesity in the commercially insured population, and 2) examine the influence of commercial insurance coverage of obesity services on health expenditures. To better understand the interaction of benefit design and obesity outcomes, we constructed an index to measure the extent of engagement of healthcare purchasers (including employers, payers, PBMs, and others) in obesity management. Our analysis of claims data finds that health plans that provide better coverage of obesity services tend to have lower costs for obesity-associated comorbidities.

THE CLINICAL OUTCOMES AND COST IMPACT OF OBESITY

Facts about obesity convey why it is such an important health issue.

- The clinical and economic burden of obesity is high, and severe obesity is increasing year-over-year
  - Our analysis of the National Health and Nutrition Examination Survey (NHANES) results for 2017-2018 shows that 40.9% of commercially insured adults age 18-64 have obesity (defined as a body mass index (BMI) of 30 kg/m^2 or higher [3])
  - 9.5% of commercially insured adults with obesity have severe obesity (defined as a BMI of 40 kg/m^2 or higher[3]), which is 7.7% higher than 10 years ago
- Obesity is associated with increased risk of numerous comorbidities, which can negatively impact patients' quality of life, mortality, and medical costs[1,4,5]
  - Obesity is most strongly associated with an increased risk of type II diabetes for females (relative risk (RR) = 12.4)[4]
  - Regardless of smoking status and history of disease, overall risk of death increases with increasing BMI for both men and women in all age groups, with a high BMI being most predictive of death from cardiovascular disease, especially in men (RR = 2.9) when compared to those with a BMI of 23.5 to 24.9 kg/m^2 [6]
  - Common comorbidities of obesity can add anywhere from $486 (for dyslipidemia) to $1,065 (for osteoarthritis) in incremental health care costs per year[7]
- Clinical opinion has shifted to classify obesity as a chronic, progressive, relapsing disease, rather than a lifestyle choice, but societal perception has been slow to change [8,9] and providers still significantly under-code obesity in administrative claims data [10]
- Weight loss is associated with improved clinical outcomes and reduced health care costs [1,11]
- Weight loss treatments vary in efficacy and durability:
  - While bariatric surgery is associated with the greatest average excess weight loss (46-81%), it is also the most costly treatment option and may have high reoperation rates.[12,13] Bariatric surgery is also subject to numerous coverage hurdles that can limit patient access to this treatment [14,15]
  - Weight loss management programs can drive clinically meaningful weight loss, but results are tied to patient engagement, and patients often regain weight upon program completion [16]
  - When used as an adjunct to lifestyle modification, anti-obesity medications increase the likelihood of achieving clinically meaningful weight loss in adherent patients[11,17]; despite this, utilization has been limited, likely due to barriers in provider prescribing and benefits coverage[18,19]
- Insurance coverage of obesity treatment services has been increasing over time, but coverage restrictions for bariatric surgery include clinical certification and weight loss requirements[14,15]

- Multiple economic models support increased use of anti-obesity medications and bariatric surgery. [20–22] Improving insurance coverage for bariatric surgery alone has been estimated to generate $1.50 to $4.80 per member per month (PMPM) in cost savings in the long-term, depending on plan design[21]

IMPLICATIONS FOR HEALTH CARE PURCHASERS

Our claims-based analysis supports that there is significant under-coding of obesity in administrative claims data: only about 14% of members in our dataset were diagnosed with obesity, compared to an estimated 40.9% based on our analysis of NHANES data. This suggests that commercial plans may not be able to discern the true clinical and economic burden of obesity on their populations using claims-based assessments alone.

Still, claims data can be a powerful tool for health care purchasers to manage benefits programs. In this study, we used adjudicated claims data to identify important information about obesity. A product of this study is the development of an obesity engagement measure which, along with the findings and methodology details presented in this paper, can help health care purchasers/payers to analyze their own data. Benefit design decisions are among the most important reasons for health care purchasers to analyze their data, and we present an engagement scale so that they can determine whether their approach to obesity is comprehensive, siloed, or in-between.

In considering their own data and findings, we suggest purchasers keep in mind the following dynamics for how obesity and benefit design interact:

- The cost burden of obesity is high [1,2]
- Obesity is a progressive disease that increases the risk of developing other conditions [9,23,24]
- Bariatric surgery is highly effective, but it is only recommended for a subset of patients with BMI ≥40 kg/m^2 or BMI ≥35 kg/m^2 with one or more severe obesity-related comorbidities, leaving people with lower BMIs that are not responding to lifestyle therapy with limited options. Bariatric surgery is also associated with high reoperation rates and potential complications, as well as high costs, so coverage for other treatments is necessary [11–13]
- The addition of AOMs to lifestyle modification may lead to greater weight loss in adherent patients compared to lifestyle modification alone [11,17]
- Our analysis of a large medical claims database, described in the body of this report, found that patients with obesity enrolled in non-high deductible health plans that are more engaged in obesity management are likely to have lower costs for several comorbidities than those enrolled in less engaged plans

Claims data analysis has its limitations, and any analysis must be pursued cautiously. Please refer to the methodology section for details on our study approach and limitations.

This paper was commissioned by Novo Nordisk, a pharmaceutical manufacturer. The findings reflect the work of the authors, who are employees of Milliman. Milliman does not intend to endorse any product or service. Dieguez, Pyenson, and Steffens are Members of the American Academy of Actuaries and meet its qualifications for this work. The authors note that other methods or sources of data may produce results that differ from those presented here.

Background

OBESITY HIGHLIGHTS FROM LITERATURE

Obesity and Severe Obesity Prevalence

Obesity rates are on the rise in the United States, driving significant comorbidity burden, mortality, and social costs. Obesity prevalence among adults 20-74 years old has more than tripled over the past 60 years, increasing by almost 25% over the past decade alone.[3] Severe obesity has become increasingly widespread in recent years, with prevalence climbing 20% between the 2015-2016 and 2017-2018 National Health and Nutrition Examination Survey (NHANES) reports, compared to only a 7% increase for obesity prevalence overall among adults 20-74 years old.[3]

Body mass index (BMI, calculated as weight in kilograms divided by height in meters squared, kg/m^2) is generally used to segment patients into overweight (BMI 25.0-29.9 kg/m^2), class I obesity (BMI 30.0-34.9 kg/m^2), class II obesity (35.0-39.9 kg/m^2), and class III/severe obesity (BMI ≥ 40.0 kg/m^2) groups.[3,11] According to the 2017-2018 NHANES, greater than two-thirds of United States adults aged 20-74 have overweight (BMI >25 kg/m^2) or obesity (>30kg/m^2) [3]; of these, 42.8% of US adults have obesity (BMI 30 kg/m^2 or more), with 9.6% of adults having severe obesity (BMI 40 kg/m^2 or more)[3]. Men and women have similar obesity prevalence (42.1% of adult females vs. 43.5% of adult males), but women have a higher prevalence of severe obesity (12% of adult females vs. 7.3% of adult males).[3]

Obesity-Related Comorbidity Burden

Obesity is associated with an increased risk of numerous related illnesses. It is strongly associated with an increased risk of type II diabetes for females (relative risk (RR) = 12.4). Obesity is also associated with many cancers (including but not limited to postmenopausal breast, ovarian, colorectal, and kidney cancer), all cardiovascular diseases (including hypertension, coronary artery disease, congestive heart failure, pulmonary embolism, and stroke), asthma, gallbladder disease, osteoarthritis, and chronic back pain.[4] Recent research has also linked obesity to increased risk of rheumatoid arthritis, major depressive disorder [5], obstructive sleep apnea[25] , receipt of prescription opioids [26], and, most recently, higher morbidity and mortality from COVID-19.[27] These comorbidities can negatively affect not only patient quality of life but also mortality.[4,28] Health-related quality of life (QoL) scores have been found to worsen as BMI increases [29], and, among people with severe obesity awaiting weight loss surgery, QoL scores have been shown to be comparable to QoL scores for people with diabetes or laryngeal cancer. [1]Researchers have also reported a 2.57-fold increased risk of death in people with a BMI of 40.0 to 59.9 kg/m^2 compared to people with a BMI in the normal range (18.5-24.9 kg/m^2); people with a BMI greater than 40.0 kg/m^2 are reported to live 6.5 to 13.7 years less than people in the normal range.[5]

Direct and Indirect Costs of Obesity

Obesity-related illnesses are costly. In a 2013 report, obesity-related illnesses were estimated to account for $209.7 billion in medical costs (2008 dollars) annually in the US[1], and one later meta-analysis estimated the incremental medical costs attributable to obesity to be $1,901 per person with obesity per year (2014 dollars).[30] Obesity has been estimated to cause around 8.5% of total Medicare spend, 11.8% of total Medicaid spend, and 12.9% of total private payer spend.[2] There is a clear association between severity of obesity and direct healthcare costs. In a recent study evaluating obesity-related costs among privately insured employees, obesity class I patients were $1,775 per patient per year (PPPY) more costly than the reference cohort (patients without overweight, obesity, or underweight BMI codes and without overweight or obesity diagnosis codes); obesity class II patients were $3,468 PPPY more costly, and obesity class III patients were $11,481 PPPY more costly (in 2018 dollars).[31] According to a separate modeling study, each excess kilogram of weight was estimated to contribute $140 per year to annual healthcare costs. [32]

People with obesity utilize healthcare resources significantly more than those without obesity. Compared to individuals without obesity, individuals with obesity are reported to have higher rates of prescriptions (55%), primary care provider contacts (32%), and hospitalizations (16%).[33] Inpatient, emergency department, and outpatient utilization have also been shown to be higher for people with obesity.[34] This additional healthcare utilization is likely due to the increased comorbidity burden for patients with excess weight. [2] In one study of the Geisinger Health System, researchers predicted consistently high annual incremental costs for some of the conditions associated with

obesity: osteoarthritis ($1,065), heart failure ($1,005), depression ($951), sleep apnea ($850), hypertension ($745), diabetes ($559), and dyslipidemia ($486). [7]

Obesity also has a measurable effect on indirect costs, in the form of productivity losses and absenteeism. One longitudinal study estimated lifetime productivity losses of $18,064 for overweight employees and $19,390 for employees with obesity.[35] Compared to normal weight employees, employees with obesity missed 1.2 to 1.9 more workdays per year, and obesity is reported to account for 6.5% - 12.6% of total absenteeism costs in the workplace.[36] Another study found that the combined annual costs of absenteeism and presenteeism due to increased weight were estimated at $5,515 for overweight employees and between $6,402 and $9,104 for employees with class I to class III obesity.[35]

Workers' compensation claims are negatively affected by workers who are overweight or who have obesity. A study of the Duke Health and Safety Surveillance System found that employees with class III obesity (BMI ≥40 kg/m^2) filed workers compensation claims at a rate of 11.65 per 100 full-time employees (FTEs) compared to 5.8 per 100 FTEs for employees in the normal BMI range.[37] Workers compensation claims for overweight or obese employees are also more likely to be high cost. One multi-year study found that after adjusting for other factors, employees who were overweight or who had obesity were 2.81 and 3.19 times, respectively, more likely to incur a claim expense of at least $100,000 after a severe injury than employees of normal weight. [38]

Clinical and Economic Impact of Weight Loss and Maintenance of Weight

Encouragingly, weight loss has been shown to abate both the negative clinical and economic consequences of obesity. Weight loss that shifts people from having obesity to being overweight by midlife has been associated with a 54% reduction in all-cause mortality risk as compared to adults with stable obesity.[39] Another study found a sustained 10% reduction in body weight would decrease patients' expected years of life burdened with hypertension, hypercholesterolemia, and type 2 diabetes and the expected lifetime incidence of CHD and stroke, as well as decrease the expected lifetime medical care costs of these five diseases by $2,200 to $5,300.[40] Even weight maintenance can result in lower costs when compared to weight gain. In a four-year study of the economic impact of weight gain vs. weight maintenance among patients with type 2 diabetes, patients who maintained weight within 5% of baseline experienced a reduction in costs of about $400 regardless of their level of glycemic control.[41] Similarly, another study found that employees who moved from BMI < 30 kg/m^2 to BMI ≥ 30 kg/m^2 increased their average annual medical costs by about 9.9% more than employees who remained at a BMI < 30 kg/m^2.[42] Conversely, employees who actively lost weight experienced 2.3% lower annual cost increases than those who remained at a higher weight.[42]

In this study, we sought to build on this knowledge in several ways, including examining the effects of varying levels of benefits coverage for obesity-management services.

Findings

PREVALENCE OF OBESITY IN THE COMMERCIALLY INSURED POPULATION

Since obesity is often under-coded in administrative claims data[10], we performed an analysis of national survey data from the National Health and Nutrition Examination Surveys (NHANES) to estimate changes in obesity prevalence among commercially insured plans. To do this, we demographically adjusted data from the 1999-2018 NHANES surveys to reflect the demographics of the commercially insured population. NHANES is a major program of the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC), and has the responsibility for producing vital and health statistics for the United States. The survey examines a nationally representative sample of about 5,000 persons each year, to which it applies demographic weighting to create national prevalence and trends.

Using age-gender distributions derived from Milliman's Commercial Health Cost Guidelines (HCGs), we adjusted the NHANES sample weights for each survey respondent to be consistent with the age-gender distributions of the commercially insured population (instead of the national population) for each year included in the study. This allowed

us to recalculate the prevalence of obesity and distribution of BMI for the commercially insured population specifically. (See Appendix D for additional information on this process.)

Our analysis found that, in 2018, 71% of the commercially insured population had a BMI greater than 25 kg/m^2, indicating some level of overweight or obesity; 40.9% of this population were specifically affected by obesity (BMI 30+ kg/m^2). This prevalence is slightly lower than the prevalence reported by NHANES for the overall US adult population, where 42.8% of US adults aged 20-74 have a BMI 30+ kg/m^2.[3] However, NHANES-based reports for the overall US adult population include data for Medicare and Medicaid beneficiaries as well as for uninsured people, while our figures are for the commercially insured population. Obesity prevalence among commercially insured males in our analysis was 43.4% compared to 38.4% for commercially insured females.

About 9.5% of the commercially insured population were found to have very severe obesity. Importantly, our analysis found that the share of patients with obesity in the commercial population who have very severe obesity has increased from 15.6% to 23.3% over the past 10 years (2008-2018).

EXHIBIT 1. DEMOGRAPHICALLY ADJUSTED NHANES OBESITY PREVALENCE AMONG THE COMMERCIALLY INSURED POPULATION (2017-2018)

BMI Class	*% of Total Commercially Insured Population**
Normal or Underweight (BMI <25 kg/m^2)	29.0%
Overweight (BMI 25-29.9 kg/m^2)	30.1%
Obesity class I (BMI 30-34.9 kg/m^2)	21.6%
Obesity class II (BMI 35-39.9 kg/m^2)	9.7%
Obesity class III (Severe, BMI 40+ kg/m^2)	9.5%
Total with Obesity (BMI 30+ kg/m^2)	***40.9%***

Note: These results are derived from a descriptive analysis and cannot be generalized beyond the commercial plan population.

Our analysis of NHANES data indicates that:

- 40.9% of the US commercially insured population (adults aged 18-64) have obesity (BMI 30+ kg/m^2). This is about three times higher than the portion of commercially insured members with a diagnosis of obesity in administrative claims data.
- 9.5% of the commercially insured population have very severe obesity. As a share of the total commercial patients with obesity, this represents 23.3%, which is a significant increase from 10 years ago, when very severe obesity accounted for only 15.6% of the obesity seen in this population (2008-2018).
- 43.4% of commercially insured males and 38.4% of commercially insured females have obesity.
- 71% of the commercially insured population have a BMI >25 kg/m^2, indicating some level of overweight or obesity.

IMPACT OF COVERAGE OF OBESITY TREATMENT

A key component of this work is the development of a novel approach to measure the purchaser's level of engagement in the management of obesity through the coverage of several obesity-related services. Comprehensive benefits for chronic conditions typically involve a broad scope of services, including hospital care, medical care, behavioral health services, and pharmaceutical treatment. For the treatment of obesity as a chronic condition, comprehensive benefits would include services such as bariatric surgery, behavioral counselling, nutritional education, and pharmaceuticals.

We identified 10,866,997 commercially insured patients eligible for inclusion in this study. **APPENDIX A** provides more detail on the development of the study population. From the study population, we identified 2,859 distinct plans, representing groups of members with similar healthcare benefits.

We developed an obesity engagement index that captures the comprehensiveness (or not) of a purchaser's coverage and access to obesity-related services. Our index is based on the purchaser's performance as measured in their healthcare claims data. We evaluated obesity-related primary care and specialist visits, anti-obesity medication (AOM) use, bariatric surgeries, and obesity-related counseling. For each purchaser associated with our study population, we determined the benefit richness for these four obesity-related services as shown in Exhibit 2. To measure benefit richness for each service, we used the portion of the total claim amount paid by the plan, which is also known as actuarial value (AV). A higher AV indicates that the purchaser is willing to pay for a greater share of these services, resulting in lower member out of pocket expenses. This is expected to encourage members to use obesity-related services. AVs for each relevant service were aggregated by insured group and used as markers to determine a purchaser's level of engagement in the management of obesity. To avoid statistical fluctuations due to small sample sizes, we excluded plans that did not meet minimum values for utilization per 1000 members for bariatric surgeries and AOMs (see Exhibit 2 for the AV thresholds).

AV thresholds were selected to divide the study population into three groups of approximately equal size: "Engaged", "Not Engaged", and "Indeterminate".

- To be considered Engaged, a plan had to meet a minimum AV threshold for bariatric surgeries or AOMs and at least one other of the four key services.
- To be considered "Not Engaged", a plan had to fall below the minimum AV threshold for at least three services. This requirement along with the requirement above produced two mutually exclusive groups of plans for our analysis.
- All other plans were considered "Indeterminate".

EXHIBIT 2: PARAMETERS USED TO DEFINE OBESITY MANAGEMENT ENGAGEMENT

Obesity Service	Minimum AV Threshold	Minimum Utilization, if applicable
Obesity Primary Care/Specialist	0.80	N/A
Bariatric Surgery	0.95	0.1 surgeries per 1,000
Obesity-related Counseling	0.80	N/A
Anti-Obesity Medication	0.85	2.0 scripts per 1,000

Engaged and Not Engaged plans had similar average member risk scores (considering all members enrolled in these plans, not just members diagnosed with obesity). Risk scores take into consideration age, sex, health status, and income level, and are widely used in the health insurance industry to predict relative levels of healthcare spending for an insured population. Average monthly medical and drug costs per member in Engaged plans were about 6% higher than in Not Engaged plans. This is likely because Engaged plans tend to provide more generous benefits overall, and lower member cost sharing is associated with higher utilization of healthcare services: the average member cost sharing in Engaged plans was 10% across all services, compared to 17% in Not Engaged plans (see Exhibit A2: in **APPENDIX A**). The median member cost sharing was 9% in Engaged plans and 14% in Not Engaged plans.

Despite higher overall spending, members in Engaged plans utilized obesity-related services at higher rates than those in Not Engaged plans (see Exhibit 3: **UTILIZATION OF OBESITY-RELATED SERVICES PER 1000 MEMBERS BY PLAN ENGAGEMENT LEVEL**). However, Engaged groups saw 10% more bariatric surgeries and 10% more AOM scripts. Across all patients in the study with an obesity diagnosis, 88% had at least one claim for an obesity-related primary care or specialist visit in the measurement period, 12.1% had at least one claim for obesity-related counseling, and

1.2% had a claim related to bariatric surgery. Only 2.1% of patients with obesity had AOM use. These figures were higher for Engaged plans than Not Engaged, in particular for utilization rates of bariatric surgery and AOMs, as shown in **EXHIBIT A4** in **APPENDIX A**.

EXHIBIT 3: UTILIZATION OF OBESITY-RELATED SERVICES PER 1000 MEMBERS BY PLAN ENGAGEMENT LEVEL

Utilization of Obesity-Related Services per 1000 members by Engagement Level*						
	Engaged		**Not Engaged**		**Difference from Engaged to Not Engaged (% Difference)**	
Obesity Prevalence						
Total Population	4,150,707		4,255,144			
1+ claim with Obesity Dx in any position	13.7%		13.5%		0.14% (1.0%)	
N	566,644		574,909			
Severe Obesity (using 1+ Dx in any position)	5.3%		5.4%		-0.04% (0.7%)	
N	221,446		228,711			
Obesity-Related Services Utilization (per 1,000)						
Obesity-related Primary Care and Specialist Visits	211.4	visits	212.8	visits	-1.3 (-1%)	visits
Bariatric Surgeries	1.6	surgeries	1.5	surgeries	0.1 (10%)	surgeries
Inpatient Facility Surgery	1.3	surgeries	1.2	surgeries	0.1 (11%)	surgeries
Outpatient Facility Surgery	0.3	surgeries	0.3	surgeries	0.0 (3%)	surgeries
Obesity-related Counseling	36.0	visits	29.7	visits	6.3 (21%)	visits
Anti-Obesity Medication (AOM)	19.3	scripts	17.5	scripts	1.8 (10%)	scripts

**Non-HDHP plans, nationwide*

We observed that obesity is under-coded at all engagement levels. Patients were classified as having obesity if they had at least one claim with an obesity diagnosis in any position observed during the measurement period. Engaged, Not Engaged, and Indeterminate plans showed comparable rates of obesity, as well as rates of severe obesity.

To test the significance of the relationship between plan engagement and the comorbidity costs of members with obesity, we performed multiple regression analyses, adjusting for plan size, region, risk score (to control for age, sex, and health status), severe obesity rate, utilization of obesity-related services, and overall plan actuarial value (to adjust for the relative richness of benefits for all covered services, not just those obesity-related). We did not adjust for continuous enrollment, as all members were required to be continuously enrolled throughout the study period. Since medical cost data does not typically follow a bell curve, we used a log transformation to reduce the skewness of the data. Statistical significance was calculated using a t-test.

The results of the multiple regression analyses are presented in Exhibit 4. Cost associated with the obesity comorbidities heart failure and knee osteoarthritis were statistically significantly lower for patients enrolled in Engaged plans than for those enrolled in Not Engaged plans. Several other obesity-related comorbidities, including Hypertension, Dyslipidemia, and Type 2 Diabetes, also had lower adjusted costs in Engaged plans, though these were not statistically significant. Note that costs modeled in the regression are condition specific (i.e., they require a diagnosis for the comorbidity on the claim). Including the Indeterminate plans in the regression did not materially

affect the resulting coefficients or statistical significance. Therefore, Indeterminate plans were excluded from this regression analysis.

EXHIBIT 4: DIFFERENCES IN THE LOG-TRANSFORMED ANNUAL ALLOWED COMORBIDITY-RELATED MEDICAL COST PER MEMBER WITH OBESITY BY COMORBIDITY AND INSURED GROUP ENGAGEMENT (NOT ENGAGED POPULATION = REFERENCE)

Outcome	N (Members with comorbidities)	Percent Change in Cost for Engaged * (95% CI) [*P*]
Hypertension	487,575	**-2.9%** (-8.6%, 3.1%) [*P*>0.05]
Dyslipidemia	323,877	**-5.1%** (-12.5%, 2.9%) [*P*>0.05]
Type 2 Diabetes	242,416	**-3.8%** (-10.6%, 3.5%) [*P*>0.05]
Sleep Apnea	175,793	**-0.7%** (-8.1%, 7.3%) [*P*>0.05]
Prediabetes	21,526	**-5.5%** (-19.2%, 10.6%) [*P*>0.05]
Asthma	77,446	**-0.9%** (-11.1%, 10.4%) [*P*>0.05]
Heart Failure	7,546	**-22.2%** (-38.5%, -1.7%) [*P*<0.05]
Knee Osteoarthritis	46,103	**-13.7%** (-25.1%, -0.6%) [*P*<0.05]
PCOS	666	**13.3%** (-18.2%, 56.9%) [*P*>0.05]
Psoriasis	13,176	**-6.8%** (-21.7%, 11.0%) [*P*>0.05]
Urinary Incontinence	3,305	**1.2%** (-21.6%, 30.8%) [*P*>0.05]
GERD	119,449	**-4.1%** (-12.4%, 5.1%) [*P*>0.05]

**Adjusted for region, risk score, total group count, morbid obesity rate (denominator=obese), AV, obesity rate (denominator=total group count), AOM utilization, Counseling utilization, Bariatric utilization, Obesity utilization (denominator for all utilization measures=total group count). Note: All members continuously enrolled throughout the study period. P-value calculated using t-test.*

In addition to comorbidity-related medical spending, we performed regression analysis to study total prescription drug spending for all obese members with at least one comorbidity, adjusting for region, risk score (to control for age, sex, and health status), plan AV (to adjust for the relative richness of benefits for all covered services, not just those obesity-related), and each member's number of comorbidities. We did not adjust for continuous enrollment, as all members were required to be continuously enrolled throughout the study period. We included all Rx costs because of the difficulty of assigning drugs to a specific condition. Annual per-patient prescription drug costs were about 4.0% lower in Engaged plans than in Not Engaged plans, as shown in Exhibit 5. See **EXHIBIT A6** in **APPENDIX A** for more details.

EXHIBIT 5: DIFFERENCES IN THE LOG-TRANSFORMED ANNUAL PRESCRIPTION DRUG ALLOWED COST PER MEMBER WITH OBESITY AND AT LEAST ONE COMORBIDITY BY INSURED GROUP ENGAGEMENT LEVEL

Outcome	N (Members with comorbidities)	Percent Change in Cost for Engaged* (95% CI) [*P*]
Rx Total Cost	769,270	**-4.0%** (-5.0%, -3.1%) [*P*<0.01]

**Adjusted for region, risk score, plan AV, and number of comorbidities (out of 12 comorbidities specified in this analysis; stratified into groups of 1,2,3,4+ comorbidities). P-value calculated using t-test.*

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

In summary, our analysis of claims data for non-HDHP plans engaged and not engaged in the coverage of obesity-related services suggests the following:

- The coding rate for obesity in administrative claims data is much lower than actual rates of obesity.
- Engaged and Not Engaged insured groups saw generally comparable utilization rates for obesity-related services, but Engaged groups had higher utilization of obesity-related counseling and bariatric surgery.
- Multiple regression analysis showed that, adjusting for other factors which may influence costs, patients with obesity in Engaged plans had statistically significant lower medical costs related to the following conditions:
    - Heart Failure with Preserved Ejection Fraction
    - Knee Osteoarthritis
- After adjusting for other factors which may influence costs, per member prescription drug spending for members with obesity and at least one comorbidity is lower in Engaged plans than those in Not Engaged plans.

Discussion

This study confirms findings in the published literature that obesity is under-coded in administrative claims data. Our demographic adjustment of the NHANES data indicates that 40.9% of members in the commercial population may be classified as having obesity; however, only about 14% of members in the claims data we analyzed were coded with an obesity diagnosis. As has been noted in other publications on this topic, under-coding of obesity can have a negative effect on researchers' ability to truly account for the impact of obesity as a risk or prognostic factor when assessing clinical outcomes from administrative claims data.[10] We would add that this under-coding may also affect insured plans' bottom-lines. This is because obesity is not currently included as a condition in the HHS-HCC risk score, which is used as part of risk adjustment calculations that ultimately determine revenue for many insurance plans. We suspect that the exclusion of obesity as a risk factor in this calculation is in part due to unreliable coding of this disease. We believe that including obesity in this risk score model could not only assist plans in better quantifying the true risk burden of their population, but also could encourage plans to incentivize better coding of obesity among their provider networks.

Our analysis also confirmed findings in the published literature of low AOM utilization. Across all examined plans, 2.1% of patients with obesity were linked to claims for AOMs. We observed higher rates of AOM utilization among patients in Engaged plans compared to those in Not Engaged plans and Engaged plans had higher costs per AOM script than Not Engaged plans. This result is a likely an artifact of inherent differences in the mix of brand and generic drugs covered by Engaged vs. Not Engaged groups. Plans with less generous benefit coverage for AOMs may implement narrower formularies that could result in lower costs per script, limiting patients' and providers' treatment options.

Our results indicate that Engaged plans, which have more generous coverage of obesity-related services such as AOMs and bariatric surgery, have lower associated comorbidity costs than their Not Engaged counterparts. After adjustment for other factors, patients with obesity enrolled in Engaged plans were associated with lower costs for heart failure and knee osteoarthritis. A similar association with lower costs was found when analyzing overall prescription drug spending for patients with obesity enrolled in Engaged plans relative to Not Engaged plans. These associations suggest that patients with obesity enrolled in Engaged plans either have less severe comorbidity burden or receive better management for their conditions.

These results suggest the need for more research and analysis. The authors hope that purchasers will use the methodologies we present here to guide analysis of their own insurance programs. While our results are intriguing, they could be driven by several factors that we did not analyze or are not available in the data. For example, patients enrolled in Engaged plans had richer benefits coverage for obesity-related services. These patients may be more likely to seek and receive care, as Engaged health plans had a higher overall AV, which means they can expect low

out-of-pocket costs. This could lead to greater adherence of chronic care regimens and ultimately improved management of comorbid conditions. Similarly, patients who benefit from more generous insurance coverage for obesity-related services may be less likely to delay care or become noncompliant due to financial hardships or other administrative obstacles. This could lead to earlier intervention for comorbid conditions or perhaps even greater success from weight loss treatments. In addition, socio-economic drives could be responsible for the less severe comorbidity burden observed among Engaged plans' populations with obesity. Due partially to the issue of obesity under-coding, these hypotheses are challenging to validate using administrative claims data alone and would necessitate additional research and clinical resources to investigate.

Data Sources & Methodology

DATA SOURCES

- 1999-2018 National Health and Nutrition Examination Survey (NHANES)[43]

  The National Health and Nutrition Examination Survey (NHANES) is a major program of the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). NCHS has the responsibility for producing vital and health statistics for the United States. The NHANES is designed to assess the health and nutritional status of adults and children in the US and is unique in that it employs both interviews and physical examinations. The survey examines a nationally representative sample of about 5,000 persons each year. It includes demographic, socioeconomic, dietary, and health-related data as well as medical, dental, and physiological measurements and laboratory test results. NHANES findings are used to determine the prevalence of major diseases and their risk factors and to assess nutritional status and its association with health promotion and disease prevention. NHANES findings are also the basis for national standards for measurements such as height, weight, and blood pressure.

- 2018 IBM MarketScan® Commercial Claims Database (MarketScan) [44]

  The 2018 IBM MarketScan® Commercial Claims Database (MarketScan) contains all paid claims generated by several million commercially insured lives. The MarketScan database represents the inpatient and outpatient healthcare service use of individuals nationwide who are covered by the benefit plans of large employers, health plans, government, and public organizations. The data includes diagnosis codes, procedure codes, and DRG codes, as well as NDC codes and the amounts paid by commercial insurers. The MarketScan database links paid claims and encounter data to detailed patient information across sites and types of providers (and over time).

- 2018 Milliman Consolidated Health Cost Guidelines Source Administrative Claims Database (CHSD)

  The 2018 Milliman Consolidated Health Cost Guidelines Source Database contains proprietary historical claims experience from several of Milliman's Health Cost Guideline (HCG) data contributors. The database contains annual enrollment and paid medical and pharmacy claims for over 10 million commercially insured individuals covered by the benefit plans of large employers nationwide.

We scrubbed the data to eliminate duplicate members in the two commercial datasets (MarketScan and CHSD). Please see **EXHIBIT A1** in **APPENDIX A** for more details on the steps to identify these individuals.

ESTIMATION OF OBESITY PREVALENCE AMONG THE COMMERCIALLY INSURED POPULATION

We leveraged data from the National Health and Nutrition Examination Surveys (NHANES) to assess the prevalence of obesity in the commercially insured population. Ten NHANES surveys were used: 1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, 2009-2010, 2011-2012, 2013-2014, 2015-2016, and 2017-2018. We included data only

from NHANES participants who received an examination, had commercial insurance, and were between the ages of 18 and 64. Any participants who were pregnant at the time of their examination were excluded.

When developing estimates of prevalence and trend, NHANES standardly weights their survey samples to match total population counts from the Census Bureau. When a sample is weighted in NHANES, it is representative of the US civilian noninstitutionalized resident population. A sample weight (also called a MEC Exam weight) is assigned to each participant in the survey. That weight is reflective of the number of people in the population represented by that sample participant.[45] These weights are provided alongside the actual survey data.

For participants meeting the data inclusion requirements for our analysis, we adjusted their NHANES MEC Exam weights, such that the NHANES age-gender distribution would be consistent with the age-gender distribution we identified in the Milliman Commercial Health Cost Guidelines (HCGs) from that respective year. For additional information about the adjustment factors and weighting process, please see **APPENDIX D**.

We then identified respondents as overweight or obese as follows:

- Overweight: BMI of at least 25 kg/m^2, but less than 30 kg/m^2 (we segmented this further into 25-26.9 kg/m^2 and 27-29.9 kg/m^2)
- Obesity class I: BMI of at least 30 kg/m^2, but less than 35 kg/m^2
- Obesity class II: BMI of at least 35 kg/m^2, but less than 40 kg/m^2
- Obesity class III: BMI of 40 kg/m^2 and over

Using our demographically adjusted weights, we calculated trends in obesity prevalence in the US commercially insured population by obesity class and gender for each survey year.

IDENTIFICATION OF PATIENT STUDY POPULATION FOR COMMERCIAL PLAN ENGAGEMENT ANALYSIS

We used the 2018 IBM MarketScan® Commercial Claims Database (MarketScan) and 2018 Milliman Consolidated Health Cost Guidelines Source Administrative Claims Database (CHSD) for our analysis of commercial plan engagement and obesity-related services. Members were required to be 18 years of age or older as of January 1, 2018 to be included in the study. We also required:

- Continuous enrollment with both medical and pharmacy coverage as an active employee (or dependent) in a non-capitated plan for all 12 months of 2018
- Enrollment in a qualified insured group defined as non-capitated groups who cover 500 or more qualified members

Members 65 years of age and older as of December 31, 2018 were excluded.

Insured groups were empirically determined to be either high-deductible (HDHP) or non-HDHP. Because high deductibles in HDHPs typically apply to all service categories, AVs for specific services can be volatile (as they are affected by other services provided earlier in the year, before satisfying the deductible). This makes AVs less reliable to measure engagement for HDHPs. Therefore, plans identified as HDHPs were excluded from the study. In addition, we removed groups with extremely low utilization (less than 5% of members have a Medical or Rx claim), unusual paid and/or allowed cost values, no Rx utilization, or unspecified region. Groups with potential overlap between CHSD and MarketScan datasets were also excluded. (See **EXHIBIT A1** in **APPENDIX A** for more details).

OBESITY IDENTIFICATION IN STUDY POPULATION

After determining our study population, we calculated the coded obesity rate by insured group. Due to concerns regarding under-coding of obesity diagnoses and BMI in administrative claims data, we first performed sensitivity testing on three obesity identification algorithms. In each algorithm, patients were determined to have obesity if:

1. Patients reported one or more claims of any type with an obesity International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10 CM) diagnosis code in the primary position
2. Patients reported one or more claim of any type with an obesity ICD-10 CM diagnosis code in any position
3. Patients reported two or more claims on different dates of service with an obesity ICD-10 CM diagnosis code in any position

We selected the most inclusive coding definition of obesity to maximize the number of patients identified in this study (algorithm 2 above). We then used BMI codes to identify members who had severe obesity, based on the presence of an ICD-10 CM diagnosis code indicating morbid obesity (E6601, E662), an ICD-10 CM diagnosis code indicating a BMI of 40 kg/m^2 or greater, or an ICD-10 CM diagnosis code indicating a BMI of 35 kg/m^2 or greater who was also identified as having one of the 12 comorbid conditions of interest. Approximately 65% of patients with obesity had at least one diagnosis code to indicate BMI.

COMPARISON OF SELECTED OUTCOMES AMONG "ENGAGED" VS. "NOT ENGAGED" INSURED PLANS

Each plan in our database was assigned an engagement level based on the richness of obesity-related services. The thresholds used to measure benefit richness were chosen so that plans representing about one third of the subject population fell into each of the Engaged, Not Engaged, and Indeterminate categories.

To determine engagement, we examined the utilization and actuarial value of obesity related services for each plan. Threshold values were selected such that benefits for obesity-related services were meaningfully different, while maintaining adequate sample size to produce comparable populations. To avoid statistical fluctuations due to small sample sizes, we excluded plans that did not meet minimum values for utilization per 1000 members for bariatric surgeries and AOMs (see Exhibit 2 for the AV thresholds). AV thresholds were selected to divide the study population in three groups of approximately equal size: "Engaged", "Not Engaged", and "Indeterminate":

- To be considered Engaged, a plan had to meet a minimum AV threshold for bariatric surgeries or AOMs and at least one other of the four key services.
- To be considered "Not Engaged", a plan had to fall below the minimum AV threshold for at least three services. This requirement along with the requirement above produced two mutually exclusive groups of plans for our analysis.
- All other plans were considered "Indeterminate".

We summarized the following information across plans at each level of engagement:

1. Cost and utilization of obesity-related services,
2. Prevalence of 12 obesity-related comorbidities[46]:
    - Asthma
    - Gastroesophageal reflux disease (GERD)
    - Type 2 Diabetes
    - Dyslipidemia
    - Hypertension
    - Polycystic Ovarian Syndrome (PCOS)
    - Prediabetes
    - Knee Osteoarthritis
    - Psoriasis

- Sleep Apnea
- Heart Failure with preserved ejection fraction (HFpEF)
- Urinary Incontinence

Note: we were unable to identify claims associated with musculoskeletal pain, so it was not included in our study comorbidities of interest.

3. Obesity and comorbid-related medical spending,
4. All cause prescription drug spending,
5. Risk Scores (2018 HHS's Hierarchical Condition Category "Gold" Model)[47]

We compared the following outcomes of interest across our Engaged and Not Engaged cohorts of insured groups:

- AOM utilization
- Obesity-related service utilization
- All-cause health expenditures
- Regional differences
- Comorbidity prevalence and cost of comorbid conditions

To examine comorbidity prevalence and the cost of comorbid conditions, we performed multiple regression analysis and calculated statistical significance using a t-test. We applied a log transformation and adjusted for plan size, region, risk score (to control for age, sex, and health status), severe obesity rate, obesity-related service utilization levels, and overall plan AV (to adjust for the relative richness of benefits for all covered services, not just those obesity-related). We did not adjust for continuous enrollment, as all members were required to be continuously enrolled throughout the study period. We note that the inclusion of Indeterminate plans did not materially affect the regression analysis.

Limitations

Obesity is coded in claims data with far less frequency than NHANES and other sources suggest. This is a significant limitation of utilizing administrative claims data alone to assess the clinical and economic effects of obesity – plan disease burden is likely to be highly understated. This under-coding has the potential to result in the misclassification of plans as low engagement and in the loss of relevant utilization data as a result of patients being missed by our algorithm. To guard against this, we chose a broad definition of obesity in our claims data analysis: at least one claim indicating an obesity diagnosis in any position. Even with this broadest definition, claims data indicates a prevalence of obesity of about 14%, compared to approximately 41% in NHANES. To the extent that our algorithm captures members who do not have obesity, which seems unlikely given the under-coding of obesity, the average healthcare costs for members with obesity and comorbid conditions in this study may be overstated. Obesity was defined using ICD-10 codes, which may potentially select for members with higher BMI classes, since those tend to be coded more frequently than those with overweight or lower BMI classes.

We recognize that costs may be impacted by the severity of obesity. Diagnosis codes that indicate BMI are often missing in administrative claims data. Our analysis therefore attempts to adjust average costs in plans with different engagement levels by using the average prevalence rate of severe obesity within each plan in the dataset. This adjustment does not account for the BMI of individual members with obesity within each plan; however, given that BMI is often absent from claims data, the average rate of severe obesity across all members in a plan may be a more reliable measure of disease severity.

The AV and utilization thresholds used in our engagement algorithm were selected so that members in our study were split into three groups of roughly the same size: Engaged, Not Engaged, and Indeterminate. This approach

required actuarial judgement to select thresholds such that benefits for obesity-related services were meaningfully different, while maintaining adequate sample size to produce comparable populations.

Our analysis of administrative claims data was restricted to commercial plan enrollees in plans that we identified as non-HDHP. The conclusions from this analysis may not be applicable to other populations.

The costs associated with each of the comorbidities in our study represent all comorbidity-related medical costs for a member with obesity. Comorbidity-related claims were determined based on diagnosis codes (see Appendix B) on each claim for a member identified with obesity and the comorbidity. A claim must have a diagnosis code for the condition (in any position) for the claim to count toward comorbidity-related claim cost. Since we identify comorbidity-related costs using a diagnosis code in any position on the claim, the claim costs included in our regression analysis are likely to include some care not directly related to the comorbidity. While the claims included in our analysis required a diagnosis code indicating the presence of the comorbid condition, they were not required to also include a diagnosis of obesity. Therefore, the claim costs included in our regression analysis are likely to include some care not directly related to obesity. We modeled prescription drug costs separately from medical costs because of the difficulty of assigning drugs to a specific condition. For the same reason, prescription drug costs were modeled in total, and not assigned to any specific comorbid condition.

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Appendices

APPENDIX A: SUPPLEMENTARY EXHIBITS

EXHIBIT A1: DEVELOPMENT OF THE STUDY POPULATION

Development of the Study Population	
Analysis Step	**Unique Members**
All 2018 Data (CHSD + MarketScan)	79,216,510
Commercial Members in Non-Capitated Plans	52,156,731
Ages 18 - 64	30,362,664
Continuously Enrolled in 2018	20,447,477
Enrolled in Groups of 500+ Qualified Members	16,059,906
Remove Outlier Groups[1]	14,947,667
HDHP Members	**4,080,670**
Non-HDHP Members	**10,866,997**

[1]Groups with extremely low utilization (less than 5% of members have a Medical or Rx claim), unusual paid and/or allowed cost values, no Rx utilization, or unspecified region. Groups with potential overlap between CHSD and MarketScan datasets also excluded.

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

Methodology to Remove Groups with Potentially Overlapping Members in CHSD and MarketScan Data

We compared member birth year, Metropolitan Statistical Area (MSA), and service dates for obesity-related services across groups. Members with the same birth year, gender, MSA, and obesity-related services (based on Healthcare Common Procedural Coding System (HCPCS) code and ICD Diagnosis Codes) on 3+ distinct dates were flagged as a potentially overlapping member. Groups with 10 or more with potentially overlapping members were excluded from the analysis. This step resulted 14 groups excluded, accounting for 70,633 members (0.5% of groups and 0.1% of members, respectively).

EXHIBIT A2: SUMMARY OF MEMBERSHIP AND COSTS BY PAYER ENGAGEMENT LEVEL

Summary Information by Payer Obesity-Related Service Engagement Level			
	Engaged	**Not Engaged**	**Indeterminate**
Members	4,150,707	4,255,144	2,461,146
Groups	1,010	575	1,274
Total Allowed PMPM	$582.19	$550.71	$497.05
Total Medical Allowed PMPM	$442.14	$420.68	$377.72
Total Rx Allowed PMPM	$140.05	$130.03	$119.33
Average Risk Score	1.395	1.399	1.309
Average Plan AV	0.895	0.829	0.862

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

EXHIBIT A3: GEOGRAPHIC DISTRIBUTION OF MEMBERSHIP BY PAYER ENGAGEMENT LEVEL

Geographic Distribution of Members							
	Distribution of Regions by Engagement Level				**Distribution of Engagement Level by Region**		
	Engaged	Not Engaged	Indeterminate		Engaged	Not Engaged	Indeterminate
A: CT, ME, MA, NH, RI, VT, NY	13%	2%	9%		65%	9%	26%
B: DE, DC, MD, PA, VA, WV, NJ	28%	19%	8%		54%	38%	9%
C: NC, SC,GA, FL	11%	14%	20%		30%	39%	31%
D: KY, TN, AL, MS	7%	8%	4%		40%	47%	13%
E: IL, IN, MI, MN, OH, WI	16%	19%	11%		38%	46%	16%
F: AR, LA, NM, OK, TX	7%	24%	13%		18%	62%	20%
G: IA, KS, MO, NE	4%	1%	10%		36%	12%	52%
H: CO, MT, ND, SD, UT, WY	1%	2%	6%		15%	29%	56%
I: AZ, CA, HI, NV	11%	9%	12%		42%	32%	26%
J: AK, ID, OR, WA	2%	3%	8%		20%	33%	47%

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

EXHIBIT A4: SHARE OF MEMBERS WITH OBESITY WITH EVIDENCE OF OBESITY-RELATED SERVICE UTILIZATION BY PAYER ENGAGEMENT LEVEL

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

	% of members with obesity with at least one claim for obesity-related service			
	PCP/Specialist	**Bariatric Surgery**	**Counseling**	**AOM**
Engaged	87.5%	1.4%	13.5%	2.7%
Indeterminate	89.8%	0.5%	10.3%	0.2%
Not Engaged	87.6%	1.3%	11.8%	2.6%
Total	**88.0%**	**1.2%**	**12.1%**	**2.1%**

EXHIBIT A5: ALLOWED COST PPPM AND PREVALENCE RATES OF COMORBIDITIES AMONG PATIENTS WITH OBESITY BY PLAN ENGAGEMENT LEVEL, BEFORE ADJUSTING FOR RISK AND OTHER FACTORS

	Engaged		**Not Engaged**	
	Prevalence	Allowed PPPM	Prevalence	Allowed PPPM
Asthma	5.5%	$641.63	5.0%	$640.14
GERD	8.2%	$832.92	7.8%	$828.77
Dyslipidemia	21.1%	$495.38	21.9%	$480.51
Hypertension	31.7%	$575.56	33.8%	$582.76
PCOS	0.1%	$306.07	0.0%	$284.21
Knee osteoarthritis	3.2%	$823.01	3.1%	$832.11
Psoriasis	0.9%	$449.84	0.9%	$451.36
Sleep Apnea	12.8%	$584.67	11.4%	$598.35
Heart Failure	0.5%	$1,103.18	0.5%	$1,168.47
Urinary Incontinence	0.2%	$481.28	0.2%	$560.57
Prediabetes	1.4%	$349.84	1.4%	$317.21
Type 2 Diabetes	15.8%	$718.18	16.7%	$725.72
Total*	**53.3%**	**$1,164.54**	**54.2%**	**$1,162.87**

** Total prevalence represents unique patients with obesity and at least one comorbidity above, divided by patients with obesity. Total allowed PPPM represents allowed cost for each comorbidity in a population with obesity and the comorbidity, divided by member months for unique obesity patients with any comorbidity above.*

Note: The values above are not adjusted for differences in plan size, region, risk score, severe obesity rate, obesity-related service utilization levels, and overall plan actuarial value.

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

EXHIBIT A6: DIFFERENCES IN THE PREVALENCE OF COMORBIDITIES PER MEMBER WITH OBESITY BY COMORBIDITY AND INSURED GROUP ENGAGEMENT LEVEL (REFERENCE = NOT ENGAGED)

Outcome	N (Members with comorbidities)	Estimate (95% CI) p*
Hypertension	487,575	
Not Engaged		Reference
Engaged		-0.005 (-0.012, 0.003) p=0.221
Indeterminate		0.008 (0.000, 0.016) p=0.043
Dyslipidemia	323,877	
Not Engaged		Reference
Engaged		0.004 (-0.002, 0.011) p=0.200
Indeterminate		0.009 (0.002, 0.016) p=0.010
Type 2 Diabetes	242,416	
Not Engaged		Reference
Engaged		-0.001 (-0.006, 0.004) p=0.662
Indeterminate		0.000 (-0.005, 0.005) p=0.919
Sleep Apnea	175,793	
Not Engaged		Reference
Engaged		0.008 (0.003, 0.012) p=0.002
Indeterminate		-0.001 (-0.006, 0.004) p=0.660
Prediabetes	21,526	
Not Engaged		Reference
Engaged		0.000 (-0.001, 0.002) p=0.570
Indeterminate		0.004 (0.002, 0.005) p=<.0001
Asthma	77,446	
Not Engaged		Reference
Engaged		0.002 (-0.001, 0.004) p=0.207
Indeterminate		0.004 (0.001, 0.007) p=0.005
Heart Failure	7,546	
Not Engaged		Reference
Engaged		0.000 (-0.001, 0.001) p=0.739
Indeterminate		0.002 (0.001, 0.003) p=0.000
Knee Osteoarthritis	46,103	

Not Engaged		Reference
Engaged		0.001 (-0.001, 0.003) p=0.158
Indeterminate		0.002 (0.000, 0.004) p=0.018
PCOS	666	
Not Engaged		Reference
Engaged		0.000 (-0.001, 0.001) p=0.919
Indeterminate		0.003 (0.002, 0.005) p=<.0001
Psoriasis	13,176	
Not Engaged		Reference
Engaged		0.001 (0.000, 0.002) p=0.153
Indeterminate		0.004 (0.003, 0.005) p=<.0001
Urinary Incontinence	3,305	
Not Engaged		Reference
Engaged		0.000 (-0.001, 0.001) p=0.827
Indeterminate		0.002 (0.001, 0.003) p=0.003
GERD	119,449	
Not Engaged		Reference
Engaged		0.000 (-0.003, 0.004) p=0.912
Indeterminate		0.006 (0.002, 0.009) p=0.001

**Adjusted for region, risk score, total group count, morbid obesity rate (denominator=obese), AV, obesity rate (denominator=total group count), AOM utilization, Counseling utilization, Bariatric utilization, Obesity utilization (denominator for all utilization measures=total group count). Note: all members were continuously enrolled throughout the study period. P-value calculated using t-test.*

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

EXHIBIT A7: DIFFERENCES IN THE LOG ANNUAL ALLOWED MEDICAL COST OF COMORBIDITIES PER MEMBER WITH OBESITY BY COMORBIDITY AND INSURED GROUP ENGAGEMENT LEVEL (REFERENCE = NOT ENGAGED)

Outcome	N (Members with comorbidities)	Logged Annual Allowed Medical Cost Impact of Engagement* (95% CI) [*P*]	Percent Change in Cost for Members in Engaged Plans* (95% CI) [*P*]
Hypertension	487,575	**-0.03** (-0.09, 0.03) [*P*>0.05]	**-2.9%** (-8.6%, 3.1%) [*P*>0.05]
Dyslipidemia	323,877	**-0.05** (-0.13, 0.03) [*P*>0.05]	**-5.1%** (-12.5%, 2.9%) [*P*>0.05]
Type 2 Diabetes	242,416	**-0.04** (-0.11, 0.03) [*P*>0.05]	**-3.8%** (-10.6%, 3.5%) [*P*>0.05]
Sleep Apnea	175,793	**-0.01** (-0.08, 0.07) [*P*>0.05]	**-0.7%** (-8.1%, 7.3%) [*P*>0.05]
Prediabetes	21,526	**-0.06** (-0.21, 0.10) [*P*>0.05]	**-5.5%** (-19.2%, 10.6%) [*P*>0.05]
Asthma	77,446	**-0.01** (-0.12, 0.10) [*P*>0.05]	**-0.9%** (-11.1%, 10.4%) [*P*>0.05]
Heart Failure	7,546	**-0.25** (-0.49, -0.02) [*P*<0.05]	**-22.2%** (-38.5%, -1.7%) [*P*<0.05]
Knee Osteoarthritis	46,103	**-0.15** (-0.29, -0.01) [*P*<0.05]	**-13.7%** (-25.1%, -0.6%) [*P*<0.05]
PCOS	666	**0.12** (-0.20, 0.45) [*P*>0.05]	**13.3%** (-18.2%, 56.9%) [*P*>0.05]
Psoriasis	13,176	**-0.07** (-0.24, 0.10) [*P*>0.05]	**-6.8%** (-21.7%, 11.0%) [*P*>0.05]
Urinary Incontinence	3,305	**0.01** (-0.24, 0.27) [*P*>0.05]	**1.2%** (-21.6%, 30.8%) [*P*>0.05]
GERD	119,449	**-0.04** (-0.13, 0.05) [*P*>0.05]	**-4.1%** (-12.4%, 5.1%) [*P*>0.05]

**Adjusted for region, risk score, total group count, morbid obesity rate (denominator=obese), AV, obesity rate (denominator=total group count), AOM utilization, Counseling utilization, Bariatric utilization, Obesity utilization (denominator for all utilization measures=total group count). Note: all members were continuously enrolled throughout the study period. P-value calculated using t-test.*

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

EXHIBIT A8: DIFFERENCES IN THE LOG ANNUAL PRESCRIPTION DRUG ALLOWED COST PER MEMBER WITH OBESITY AND AT LEAST ONE COMORBIDITY BY INSURED GROUP ENGAGEMENT LEVEL (REFERENCE = NOT ENGAGED)

Outcome	N (Members with comorbidities)	Engagement Impact to Annual Allowed Rx Cost (log-scale) Estimate* (95% CI) [*P*]	Percent Increase/Decrease in Cost in Engaged vs Not Engaged* (95% CI) [*P*]
Rx Total Cost	769,270	**-0.04** (-0.05, -0.03) [*P*<0.01]	**-4.0%** (-5.0%, -3.1%) [*P*<0.01]

**Adjusted for region, risk score, plan AV, and number of comorbidities (out of 12 comorbidities specified in this analysis; stratified into groups of 1,2,3,4+ comorbidities). Note: all members were continuously enrolled throughout the study period. P-value calculated using t-test.*

Sources: 2018 IBM MarketScan and 2018 Milliman CHSD databases

APPENDIX B: CODE SETS

TABLE B1: CODES TO IDENTIFY OBESITY MANAGEMENT SERVICES AND OBESITY RELATED CONDITIONS

Condition	Code Type	Code List
AOM	NDC	See Table B3
Bariatric Surgery	HCPCS	43631-43635, 43644, 43645, 43770-43775, 43842, 43843, 43845-43848, 43850, 43855, 43860, 43865, 43886-43888, S2083
Bariatric Surgery	MS-DRG	619, 620
Obesity Primary Care/Specialist	ICD-10-CM	E6601, E6609, E661, E662, E668, E669, Z6830, Z6831, Z6832, Z6833, Z6834, Z6835, Z6836, Z6837, Z6838, Z6839, Z6841, Z6842, Z6843, Z6844, Z6845
Counseling (Obesity dx in primary position required)	HCPCS	98966-98972, 99201-99205, 99211-99215, 99241-99245, 99304-99310, 99318, 99324-99328, 99334-99337, 99341-99345, 99347-99350, 99421-99423, 99441-99444, 99446- 99449, 99451, 99452, S0315, S0316
Counseling (Obesity dx in any position required)	HCPCS	96150-96156, 96158-96160, 96164, 96165, 96167, 96168, 96170, 96171, 97802-97804, 98960-98962, 99078, 99401-99404, 99411, 99412, 99420, G0270, G0271, G0446, S9445, S9446, S9451, S9452, S9470
Counseling (Obesity dx not required)	HCPCS	G0447, G0473, S9449
Asthma	ICD-10-CM	J4520-J4522, J4530-J4532, J4540-J4542, J4550-J4552, J45901, J45902, J45909, J45990, J45991, J45998
Dyslipidemia	ICD-10-CM	E780, E7800, E7801, E781-E784, E7841, E7849, E785, E7881, E7889, E789
GERD	ICD-10-CM	K210, K219, K2270, K22710, K22711, K22719
Heart Failure - Diastolic	ICD-10-CM	I5030-I5033
Hypertension	ICD-10-CM	I10, I130, I1310, I1311, I132, I160, I161, I169, I674
PCOS	ICD-10-CM	E282
Knee Osteoarthritis	ICD-10-CM	71516, 71526, 71536, 71596, M170, M1710-M1712, M172, M1730-M1732, M174, M175, M179
Prediabetes	ICD-10-CM	R7303
Psoriasis	ICD-10-CM	L400, L401, L404, L4050-L4054, L4059, L408, L409, L413-L415, L418, L419
Sleep Apnea	ICD-10-CM	G4730, G4731, G4733, G4737, G4739
	HCPCS	A4604, A7027, A7030, A7034-A7039, A7044-A7046, E0470-E0472, E0561, E0562, E0601
Type 2 Diabetes	ICD-10-CM	E1100, E1101, E1110, E1111, E1121, E1122, E1129, E11311, E11319, E11321, E113211-E113213, E113219, E11329, E113291- E113293, E113299, E11331, E113311-E113313, E113319, E11339, E113391-E113393, E113399, E11341, E113411-E113413, E113419, E11349, E113491, E113492, E113493, E113499, E11351, E113511, E113512, E113513, E113519, E113521-E113523, E113529, E113531- E113533, E113539, E113541-E113543, E113549, E113551-E113553, E113559, E11359, E113591-E113593, E113599, E1136, E1137X1, E1137X2, E1137X3, E1137X9, E1139, E1140-E1144, E1149, E1151, E1152, E1159, E11610, E11618, E11620, E11621, E11622, E11628, E11630, E11638, E11641, E11649, E1165, E1169, E118, E119, O24111-O24113, O24119, O2412, O2413
Urinary Incontinence	ICD-10-CM	N3942, N3946, N39498, R32, R3981
	HCPCS	T4521-T4528, T4535-T4537, T4539-T4544

TABLE B2: OBESITY DIAGNOSIS CODES DETAIL

Code Type	Code	Description
ICD-10-CM	Z6830	Body mass index (BMI) 30.0-30.9, adult
ICD-10-CM	Z6831	Body mass index (BMI) 31.0-31.9, adult
ICD-10-CM	Z6832	Body mass index (BMI) 32.0-32.9, adult
ICD-10-CM	Z6833	Body mass index (BMI) 33.0-33.9, adult
ICD-10-CM	Z6834	Body mass index (BMI) 34.0-34.9, adult
ICD-10-CM	Z6835	Body mass index (BMI) 35.0-35.9, adult
ICD-10-CM	Z6836	Body mass index (BMI) 36.0-36.9, adult
ICD-10-CM	Z6837	Body mass index (BMI) 37.0-37.9, adult
ICD-10-CM	Z6838	Body mass index (BMI) 38.0-38.9, adult
ICD-10-CM	Z6839	Body mass index (BMI) 39.0-39.9, adult
ICD-10-CM	Z6841	Body mass index (BMI) 40.0-44.9, adult
ICD-10-CM	Z6842	Body mass index (BMI) 45.0-49.9, adult
ICD-10-CM	Z6843	Body mass index (BMI) 50-59.9, adult
ICD-10-CM	Z6844	Body mass index (BMI) 60.0-69.9, adult
ICD-10-CM	Z6845	Body mass index (BMI) 70 or greater, adult
ICD-10-CM	E6601	Morbid (severe) obesity due to excess calories
ICD-10-CM	E6609	Other obesity due to excess calories
ICD-10-CM	E661	Drug-induced obesity
ICD-10-CM	E662	Morbid (severe) obesity with alveolar hypoventilation
ICD-10-CM	E668	Other obesity
ICD-10-CM	E669	Obesity, unspecified

TABLE B3: LIST OF NDC CODES TO DEFINE ANTI-OBESITY MEDICATION

List of NDC Codes to Define AOMs
00004025752, 00009002401, 00009002402, 00093210901, 00093211001, 00093211256, 00115120501, 00115120502, 00115120510, 00169280015, 00185064401, 00185064410, 00185064701, 00185064710, 00185405701, 00185405710, 00185500001, 00185500010, 00185525401, 00185525410, 00187049701, 00440807630, 00527059701, 00527059710, 00527130801, 00527130810, 00527131001, 00527131010, 00527131701, 00527143801, 00527143810, 00527144501, 00527144510, 00527147501, 00527147701, 00527174201, 00527174210, 00527174301, 00527174310, 00527174330, 00591078201, 00591078301, 00603519216, 00603519221, 00603519232, 10544004130, 10544011621, 10544011630, 10544011645, 10544059228, 10544059230, 10544059328, 10544059828, 10544059830, 10544060230, 10544060245, 10544060260, 10544062021, 10544062028, 10702000109, 10702002501, 10702002503, 10702002510, 10702002601, 10702002610, 10702002701, 10702002710, 10702002801, 10702002810, 10702002901, 10702002910, 10702004001, 10702004003, 10702004050, 10702004401, 10702004406, 10702007701, 10702007710, 10702007801, 10702007810, 11534015701, 11534015703, 11534015901, 11534015903, 11534015930, 11534016001, 11534016003, 11534016030, 11534017601, 11534017603, 13107006101, 13107006199, 13107010501, 13107010601, 16590018515, 16590018530, 16590018560, 16590018615, 16590018630, 16590018660, 16590064230, 16590064260, 21695050900, 21695050930, 21695051015, 21695051030, 21695051300, 21695051307, 21695051330, 21695059707, 21695059721, 21695059742, 21695059760, 21695087630, 23155017401, 23155017403, 24090072085, 24090072185, 24090072285, 31722035901, 33261034107, 33261034114, 33261034121, 33261034128, 33261034130, 33261034142, 33261034156, 33261034160, 33261034184, 33261034190, 33261034192, 33261035314, 33261035328, 33261035330, 33261035360, 33261035390, 33261035407, 33261035414, 33261035428, 33261035430, 33261036107, 33261036114, 33261036121, 33261036128, 33261036130, 33261036607, 33261036614, 33261036621, 33261036628, 33261036630, 33261039007, 33261039014, 33261039015, 33261039028, 33261039030, 33261040530, 33261040807, 33261040814, 33261040828, 33261040830, 33261045807, 33261045814, 33261045821, 33261045842, 33261045890, 33261047115, 33261047123, 33261047128, 33261047145, 33261078321, 33261078328, 33261078342, 33261078356, 33261078360, 33261078390, 33358028715, 33358028730, 33358028760, 35356000328, 35356000330, 35356000360, 35356000390, 42254023607, 42254023630, 42254043830, 42806008101, 42806008130, 42806052401, 42806052410, 43063018230, 43063018260, 43063033207, 43063033214, 43063033215, 43063033221, 43063033228, 43063033230, 43063033242, 43063033245, 43063033260, 43063033290, 43063033293, 43063034801, 43063034807, 43063034814, 43063034821, 43063034828, 43063034830, 43063034856, 43063034860, 43063034890, 43063034893, 43063038415, 43063038430, 43063042514, 43063042528, 43063042530, 43063042556, 43063042560, 43063042590, 43063043707, 43063043714, 43063043715, 43063043721, 43063043728, 43063043730, 43063043745, 43063043760, 43063043790, 43063051007, 43063051014, 43063051028, 43063051030, 43063051056, 43063051060, 43063051081, 43063051088, 43063051090, 43063053207, 43063053214, 43063053221, 43063053228, 43063053230, 43063054114, 43063054130, 43063054145, 43063054190, 43063059607, 43063059614, 43063059615, 43063059621, 43063059628, 43063059630, 43063059642, 43063059645, 43063059660, 43063059690, 43063059693, 43063064614, 43063064621, 43063064628, 43063064630, 43063064660, 43063065430, 43063065460, 43063077270, 43063089214, 43063089230, 43547026310, 43547026410, 43547026411, 43547040410, 43547040411, 45963032711, 45963032796, 47463004400, 47463004410, 47463004430, 47463004460, 47463004490, 47463020630, 47463020660, 47463020690, 47463020730, 47463057821, 47463057830, 47463057842, 47463057860, 47463057872, 47463057874, 47463057890, 47463057930, 47463058030, 47463058107, 47463058114, 47463058130, 47463058145, 47463058160, 47463058207, 47463058230, 47463058260, 47463058272, 47463058274, 47463058290, 49999036028, 49999036030, 49999036115, 49999036130, 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APPENDIX C: COVERAGE AND TREATMENT ISSUES

Bariatric surgery

Bariatric surgery has long been the gold standard in weight loss treatment, largely due to its ability to enable significant and meaningful weight loss for patients with obesity. Bariatric surgery is only indicated for patients with BMI ≥40 kg/m^2 or BMI ≥35 kg/m^2 with one or more severe obesity-related comorbidities, however, which restricts its usefulness for patients with less severe obesity.[11] Depending on the procedure and the study, bariatric surgery has been reported to produce lasting excess weight loss from 46%-81% of baseline weight, though revision rates are likewise high (as much as 78% in some studies).[12] In fact, Lap-Band has recently fallen out of favor as a direct result of this issue.[48] Other less invasive procedures, such as sleeve gastrectomies, demonstrate revision rates in the 32%-36% range.[12] Despite the risk of revisions, sleeve gastrectomy procedures are not declining in popularity; on the contrary, they appear to be increasing in use as surgeons abandon Lap-Band in favor of other minimally invasive techniques.[49]

Although effective, bariatric surgery is costly and does not guarantee short-term savings. A systematic literature review of published cost analyses found that mean total procedural costs for bariatric surgery ranged from $13,307 to $15,237 (in 2016 dollars).[13] A separate study determined that while bariatric patients demonstrated lower pharmacy and office visit costs postsurgery, their inpatient costs were higher in years 2 and 3 postsurgery than their counterparts with severe obesity who did not have the operation.[50] Studies conflict regarding the breakeven point for bariatric surgery overall. A study published in 2008 concluded that downstream savings associated with bariatric surgery begin to offset the initial costs of the procedure around 2 to 4 years postsurgery.[51] More recent longitudinal studies are less optimistic. One 2013 study did not identify any reductions in overall health care costs associated with bariatric surgery among privately insured patients at 6 years postsurgery[50], and a 10-year cohort study of veterans with severe obesity found that health care expenditures converged after 10 years for the bariatric surgery and no bariatric surgery cohorts.[52] In these studies, researchers pointed out that patients' outpatient pharmacy utilization declined postsurgery, but complications were common, leading to increased levels of inpatient utilization, which resulted in minimal change in overall costs.[50,52] These studies indicate that procedure safety and revision rates have a significant impact on the cost effectiveness of bariatric surgery as an OM tool.

Weight Management Programs

Another popular treatment is weight management programs, which rely heavily on patient engagement in order to drive clinically meaningful weight loss (5% or more of baseline weight[11]). Currently, the most successful programs in randomized clinical trials are Jenny Craig (average 7.3% of baseline weight lost over 14-26 weeks in their Platinum Program)[53] and Weight Watchers (average 5.5% of baseline weight lost over 12 weeks).[54] Both trials found that weight loss success correlated directly with program engagement. The longer patients remained engaged in the program the greater their likelihood of increased weight loss.[53,54] However, in the Jenny Craig study, 50% of participants had dropped out of the program by week 10[53], while in the Weight Watchers study, 30% attended fewer than 50% of sessions.[54] Comparable results have been observed across other studies and similar programs.[55–57] Corporate-sponsored weight loss programs demonstrate more mixed results: in one study of two large employers that implemented the Naturally Slim program, employees lost an average of 4.93% weight off their baseline, but regained significant weight in the immediate 15 months post program.[16] Upon reengaging in the program, participants did not achieve the same level of weight loss as they did during their initial engagement.[16] Finally, a survey study published in 2018 found that just 17% of patients with obesity perceived employer-sponsored wellness offerings as helpful in supporting weight loss.[58] These studies suggest that corporate-sponsored programs may not be as effective as payers may hope.

Anti-Obesity Medication (AOM)

Obesity treatment guidelines state that pharmacotherapy is an optional addition to lifestyle change efforts for overweight patients with weight-related comorbidities or patients with obesity.[11] This is because in nearly all studies of AOMs, the addition of weight-loss medication consistently results in a greater weight loss than lifestyle changes alone.[11] In clinical trials, AOMs combined with lifestyle modification (e.g., diet and exercise) produced greater than 5% weight loss off baseline on average.[59–61] Importantly, for all AOMs, patient success is tied to adherence and

duration of therapy, and outcomes are better the earlier patients initiate.[62] Moreover, AOMs do not work once stopped, and so gradual weight gain is likely after discontinuation.[63] Uptake of AOMs has been relatively low over the past decade, despite the gradual introduction of additional AOMs into the market.[19] In one large study of electronic health record-derived data, only 2.9% of adults with obesity were prescribed AOMs in 2019, up from 1.1% in 2010.[18] This is perhaps due to providers' perceptions regarding AOMs' safety and limited experience utilizing these agents.[64,65] Still, with these issues in mind, clinical guidelines recommend "clinicians and their patients with obesity should have access to all approved medications to allow for the safe and effective individualization of appropriate pharmacotherapy for weight loss."[11]

Current State of Health Care Coverage for Obesity Treatment Options

There is significant variability in coverage and reimbursement for obesity management (OM) services across payers and plans.[15,66,67] The Affordable Care Act mandates coverage for US Preventive Services Task Force (USPSTF) - recommended preventive services[68], but these are limited in scope for obesity to screenings and lifestyle interventions, and provide no guidance on other services, such as pharmacotherapy and bariatric surgery. As a result, payers have taken different approaches to defining the scope of covered obesity-related services for adult beneficiaries.[15] Coverage appears to be increasing over time, but some payers still do not cover many effective treatments.[15] Among payers that cover bariatric surgery, utilization is often strictly controlled using clinical certification processes, as well as caps on plan reimbursement for claims related to bariatric surgery.[14,66] One study showed that access to bariatric surgical care was impeded by insurance certification processes in 22% of medically acceptable candidates.[14] AOMs are also not broadly or generously covered by payers, despite evidence that with adequate pharmacy coverage, patients stay on anti-obesity drugs longer, see their doctors more often, and lose more weight.[20,69] This suggests that lack of coverage may actually be curbing the potential efficacy of these drugs as OM tools.

This gap in coverage for OM services is a plausible outcome of payers' and healthcare systems' historical perception of obesity as a lifestyle choice, making it difficult to justify covering these services more generously.[22,69] Yet numerous studies suggest that improving coverage for obesity treatments could have a significant positive effect on obesity-related healthcare expenditures.[20,21,70] For example, one analysis suggests that expanding coverage of obesity treatments for eligible individuals could generate $20-$23 billion budgetary savings to Medicare over 10 years, corresponding to savings of $6,842-$7,155 for each Medicare beneficiary receiving such treatment.[70] Another 10-year economic modeling study projected that shifting to unrestricted coverage for bariatric surgery could lead to net savings of $1.20 to $31.80 PMPM in patients with type 2 diabetes mellitus.[21] Finally, coverage improvement for AOMs could also drive significant financial results for plans: for US adults aged 25 and older, next-generation AOMs have been projected to generate $1.9 to $2.5 trillion in lifetime societal value defined as monetized quality of life, productivity gains, and savings in medical spending, depending on uptake.[20] In the face of significant rising costs for obesity and increasing trends in obesity prevalence, these models all point to substantial economic value for plans that invest in improved access to and coverage of obesity-management services, especially as obesity is now considered a chronic disease.[8,11]

Obesity as a Chronic and Relapsing Progressive Disease

Obesity has historically been viewed as a lifestyle choice or a risk factor rather than as a standalone disease state.[9] In the past decade, however, the clinical community has definitively stated that obesity bears the characteristics of a chronic, relapsing disease process and should be viewed as one.[9,11,23] Data have shown that lifestyle and behavioral factors alone are not to blame for obesity.[9] Genetic factors can play a significant role in the onset and progression of excess adiposity; in fact, nearly 100 genes have been identified that are tied to obesity and fat distribution.[9] Epigenetic factors have also been found to play a role in predisposing some people to weight gain, insulin resistance, and beta-cell failure, which are also key physiological changes in the development of type II diabetes.[9] The relapsing nature of obesity has been connected to causes outside of mere environmental factors: pathological changes, such as alterations in the hormonal state of patients who attempt weight loss, as well as functional impairments, often contribute significantly to patients' difficulty losing weight or sustaining weight loss.[9]

Despite these clinical realities, obesity is still significantly under-coded in administrative claims data.[10] This under-coding likely reflects suboptimal obesity management in primary care due to lack of provider education about obesity

and the efficacy and safety of its available treatments.[71] Providers are also still susceptible to deep-rooted stigma surrounding obesity, as well as fear and frustration about perceived patient noncompliance regarding weight loss and behavioral recommendations.[71] Still, current clinical recommendations are clear: all stakeholders must take obesity seriously as a serious, chronic disease in order to improve access to and financial coverage for appropriate evidence-based weight-management treatments.[23]

APPENDIX D: NHANES WEIGHT ADJUSTMENT METHODOLOGY

The National Health and Nutrition Examination Surveys (NHANES) weight their survey samples to match total population counts from the United States Census Bureau. A sample weight is assigned to each survey participant. When a sample is weighted in NHANES, it is representative of the US civilian noninstitutionalized resident population. A sample weight (also called a MEC Exam weight) is assigned to each participant in the survey. That weight is reflective of the number of people in the population represented by that survey participant.

We included data only from NHANES participants who received an examination, had commercial insurance, and were between the ages of 18 and 64. Any participants who were pregnant at the time of their examination were excluded. For participants meeting the data inclusion requirements for our analysis, we adjusted their NHANES MEC Exam weights, such that the NHANES age-gender distribution would be consistent with the age-gender distribution we identified in the Milliman Commercial Health Cost Guidelines (HCGs) from that respective year. The Milliman HCGs provide standard commercial demographics that are intended to represent a typical 10,000 employee commercial group population.

As an example, we will illustrate the demographic adjustment process for the 2017-2018 NHANES MEC survey weights. Note that the same process was performed for each NHANES survey year, using the Milliman Commercial HCGs from that survey's most recent respective year (i.e., HCGs from 2018 were used to adjust the 2017-2018 NHANES survey). TABLE D1 summarizes the 2018 commercial Milliman HCGs by age bucket and gender. TABLE D2 summarizes the 2017-2018 NHANES MEC weights of participants meeting our inclusion criteria in the same age-gender buckets as the Milliman commercial HCGs. An adjustment factor was then calculated such that the MEC Weights in TABLE D2 reflected the same distribution as the commercial HCGs in TABLE D1.

TABLE D1: 2018 COMMERCIAL MILLIMAN HEALTH COST GUIDELINES (HCG) AGE / GENDER DISTRIBUTION

Age Group	Male	Female
18-19	2.4%	2.4%
20-24	5.4%	5.4%
25-29	4.7%	5.2%
30-34	4.9%	5.2%
35-39	4.8%	5.1%
40-44	5.3%	5.6%
45-49	5.3%	5.7%
50-54	5.7%	6.2%
55-59	5.4%	5.9%
60-64	4.4%	4.7%

TABLE D2: 2017-2018 NHANES MEC WEIGHT OF INCLUDED PARTICIPANTS

Age Group	Male	Female
18-19	2,283,337	2,324,003
20-24	5,301,451	5,243,461
25-29	4,528,500	5,012,851
30-34	6,613,961	5,871,919
35-39	5,168,613	6,714,306
40-44	6,932,547	5,476,180
45-49	6,295,454	7,171,963
50-54	5,211,604	6,403,235
55-59	7,853,341	8,233,338
60-64	6,487,972	7,189,468
Total	116,317,500	

TABLE D3 summarizes the calculated demographic adjustment factors. For example, the male age 18-19 adjustment factor was calculated as the total MEC weight of all included NHANES participants (116,317,500) times the HCG commercial age-gender distribution for that age-gender bucket (2.4%) divided by the MEC weight of the included NHANES participants who were in that age-gender bucket (2,283,337). This results in a demographic-adjustment factor of 1.23. The MEC weight of each included NHANES male participant between the ages of 18-19 was then multiplied by 1.23. This results in new NHANES weights demographically adjusted to Milliman's commercial HCG age-gender distribution summarized in **TABLE D4**. This process was performed for each NHANES survey contained in our analysis. The new weights were then used to calculate obesity prevalence within the commercially insured market.

TABLE D3: COMMERCIAL HCG AGE/GENDER DISTRIBUTION ADJUSTMENT FACTORS

Age Group	Male	Female
18-19	1.23	1.21
20-24	1.19	1.20
25-29	1.21	1.21
30-34	0.86	1.04
35-39	1.09	0.89
40-44	0.89	1.19
45-49	0.98	0.93
50-54	1.27	1.13
55-59	0.80	0.84
60-64	0.79	0.76

TABLE D4: 2017-2018 NHANES WEIGHTS DEMOGRAPHICALLY ADJUSTED TO THE 2018 MILLIMAN COMMERCIAL HCGS

Age Group	Male	Female
18-19	2,817,903	2,802,669
20-24	6,307,795	6,269,709
25-29	5,466,596	6,053,118
30-34	5,682,416	6,093,743
35-39	5,636,713	5,987,103
40-44	6,147,064	6,543,157
45-49	6,185,150	6,665,032
50-54	6,626,946	7,243,937
55-59	6,299,407	6,878,313
60-64	5,149,213	5,461,517

APPENDIX E: ALGORITHMS TO IDENTIFY MEMBERS WITH OBESITY-RELATED COMORBIDITIES

- The following comorbidities were identified using the below algorithm: **Asthma, Dyslipidemia, Gastroesophageal Reflux Disease (GERD), Hypertension, Knee Osteoarthritis, Prediabetes, and Psoriasis**

  - At least one acute inpatient, non-acute inpatient, or observation qualified claim with a comorbidity-specific diagnosis code in any position.

    OR

  - At least two outpatient qualified claims with a comorbidity-specific diagnosis code in any position on different dates of service. Claims need not be of the same type.

- **Heart Failure with Preserved Ejection Fraction (Diastolic Heart Failure)** was defined by the following process:

  - **Step H1 – Define the study population for patients with heart failure (HF)**
  - HF patients are identified as individuals with one or more qualifying claim type coded with a HF diagnosis code in any position on the claim.
    - Exclude patients who receive heart transplants. Patients receiving heart transplants incur an inpatient admission that results in discharge from a heart transplant MS-DRG with a heart transplant ICD-10-PCS procedure code reported on any claim billed for the same admission.
  - **Step H2 – Categorize each HF patient as systolic, diastolic, or unspecified**
  - For each claim meeting the following criteria, identify and count the number of diastolic, systolic, and unspecified heart failure diagnosis codes appearing in any position.
    - Qualified claims
    - Radiology professional services
    - Cardiology-related professional services
  - For each HF patient, sum the number of systolic, diastolic, and unspecified diagnosis codes appearing on claims reviewed in the year. Attribute patients to only one of systolic, diastolic, or unspecified if the following conditions are met:
    - Systolic
      - Patient only reports systolic diagnosis codes in the year.
      - Patient reports systolic and unspecified, but not diastolic, diagnosis codes in the year.
      - Patient reports both systolic and diastolic diagnosis codes (regardless of presence of unspecified) and count of systolic > diastolic.
    - Diastolic
      - Patient only reports diastolic diagnosis codes in the year.
      - Patient reports diastolic and unspecified, but not systolic, diagnosis codes in the year.
      - Patient reports both systolic and diastolic diagnosis codes (regardless of presence of unspecified) and count of systolic < diastolic.
    - Unspecified: all remaining patients

- Includes patients reporting systolic and diastolic diagnosis codes where the count of systolic equals the count of diastolic.

- **Infertility in Polycystic Ovary Syndrome** was identified as
  - At least one acute inpatient, non-acute inpatient, ED, or observation qualified claim with a Polycystic Ovarian Syndrome diagnosis code reported in any position

    OR

  - at least two outpatient qualified claims with a Polycystic Ovarian Syndrome diagnosis code in any position on different dates of service. Claims need not be of the same type.

    AND

  - At least one acute inpatient, non-acute inpatient, ED, or observation qualified claim with an Infertility diagnosis code reported in any position.

    OR

  - at least two outpatient qualified claims with an Infertility diagnosis code in any position on different dates of service. Claims need not be of the same type.
  - *Note: patients with this condition at one point in time could have a pregnancy at another point in time (achieved naturally or through reproductive technology)*

- **Sleep Apnea** was identified as:
  - At least one acute inpatient, non-acute inpatient, ED, or observation qualified claim with a Sleep Apnea diagnosis code reported in any position.

    OR

  - at least two outpatient qualified claims with a Sleep Apnea diagnosis code in any position on different dates of service. Claims need not be of the same type.

    OR

  - At least two HCPCS code charges for Sleep Apnea on different dates of service.

- **Type 2 Diabetes** was defined using the following process:
- **Step D1: Identify Diabetes Total population**
  - Requires at least two outpatient, observation, emergency department (ED), or non-acute inpatient encounters on different dates of service with a diagnosis of diabetes. The visit type need not be the same for the two visits, nor must the diabetes diagnosis codes be from the same diagnosis code list.

    OR

  - At least one acute inpatient encounter with a diagnosis of diabetes.

    OR

  - Members who were dispensed hypoglycemic/antihyperglycemics/insulin AND have at least one outpatient, observation, ED, or non-acute inpatient encounter with a diagnosis of diabetes.

- The diabetes index date is the date of the earliest claim that qualifies the patient into the diabetes population.

- **Step D2: Identify members with Type 1 diabetes from the total diabetes population (T1DM population)**
  - Start with the total diabetes population (**Step D1** above).
  - Have at least one claim with a code on the T1DM list and no codes from the T2DM list (can have claims coded with codes from the Other Diabetes code list).

    OR

  - Have claims coded with codes from both the T1DM and T2DM list and the majority of diabetes codes are from the T1DM list (claims coded with codes from the Other Diabetes code list are not considered in this determination).
  - If there is no majority between the T1DM and T2DM codes (50/50 split), patient is designated as T2DM.
  - Exclude from the Type 1 population and assign to the Type 2 population members identified in the previous steps (**Step D2, bullets 1-4**) who were dispensed hypoglycemics/antihyperglycemics.
  - Exclude from the Type 1 population and assign to the Type 2 population members identified in the previous steps (**Step D2, bullets 1-4**) who were not dispensed insulin.
- **Step D3: Identify members with Type 2 diabetes from the total diabetes population (T2DM population)**
  - Start with the total diabetes population (**Step D1,** above).
  - Members of the total diabetes population who do not meet the criteria for the Type 1 population (**Step D2,** above) constitute the Type 2 population.
  - Note that in steps above, members who were dispensed hypoglycemics/antihyperglycemics and members who were not dispensed insulin were reassigned to the Type 2 population.

- **Urinary Incontinence in Females** patients was identified as:
  - Female on their eligibility record

    AND

  - At least one acute inpatient, non-acute inpatient, ED, or observation qualified claim with an Incontinence diagnosis code in any position.

    OR

  - at least two outpatient qualified claims with an Incontinence diagnosis code in any position on different dates of service. Claims need not be of the same type.

    OR

  - At least three Incontinence HCPCS codes charges on different dates of service.

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