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Eight-year trends in obesity-related complications and health care cost progression in a US population with obesity: A retrospective cohort study

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Abstract

Aims: Obesity-related complications (ORCs) impose a substantial health burden on affected individuals, and economic costs to health care systems. We examined ORCs and the progression of direct health care costs over 8 years, stratified by obesity class.

Materials and Methods: Adults with obesity were identified in linked US medical records and administrative claims databases. The index date was the first body mass index measurement of 30 to <70 kg/m^2 between 1 January 2007 and 31 March 2012; a ≥8-year continuous enrolment post-index was required for inclusion. Diagnosis codes for five specific ORCs and total health care costs were recorded in each year of follow-up. Costs adjusted for clinical and demographic factors were also estimated.

Results: Of 28 583 eligible individuals, 17 892 had class I obesity, 6550 had class II obesity and 4141 had class III obesity. From baseline to year 8, the presence of type 2 diabetes and knee osteoarthritis doubled in all obesity classes, with even larger increases for chronic kidney disease and heart failure. Observed and adjusted total health care costs generally increased from the baseline year to year 8. The difference in costs between obesity classes increased over time: at year 1, individuals with class III obesity had 26.8% higher costs than those in class I, but at year 8, this difference was 40.7%. Outpatient costs constituted half of the total observed costs across obesity classes.

Conclusions: ORC rates and health care costs increase over time, and are greater in higher obesity classes. This could be mitigated by approaches that limit obesity progression.

KEYWORDS
cardiovascular disease, population study, real-world evidence, weight control

1 | INTRODUCTION

In the United States, an estimated 42.4% of adults were living with obesity [body mass index (BMI) ≥30 kg/m^2] in 2017-2018,[1] a condition associated with morbidity, mortality and compromised quality of life.[2] It is estimated that, by 2030, this will increase to one in two adults in the United States living with obesity, and one in four adults in the United States will have a BMI of ≥35 kg/m^2 (i.e. class II obesity).[3] Obesity is associated with increased risks for multiple related diseases and conditions, termed obesity-related complications (ORCs), including cardiovascular disease (CVD), type 2 diabetes (T2D) and chronic kidney disease (CKD).[4] The risks for developing many of these ORCs will probably increase in line with increasing BMI.[5] Obesity and ORCs have a significant economic impact worldwide, resulting from both health care expenditure[4] and loss of productivity.[6] A recent human development perspectives report by the World Bank Group[6] highlighted that health care costs linked to obesity and its complications are increasing worldwide, and suggested that these costs are expected to continue rising as medical treatment for chronic diseases becomes more advanced. Facilitating weight loss and preventing obesity are therefore key goals from both a public health and an economic perspective.

Although various behavioural, pharmacological and surgical interventions for weight loss are available, they vary in terms of cost, accessibility, consistency of individual response rate and long-term effectiveness. Therefore, it is important that health care systems can identify the individuals with the greatest unmet need for support with weight management, to ensure that appropriate treatments can be offered. Prevention of obesity progression via weight management will probably reduce the risk of ORCs developing, and there is evidence that weight loss can alleviate or treat existing ORCs.[7-9] Loss of 5%-10% of body weight can limit the symptoms of osteoarthritis (OA), and weight loss in the range of 3%- 10% of body weight is associated with a reduced risk of developing T2D.[8] A study quantifying the real-world effects of weight loss in more than 500 000 adults in the UK found substantial reductions in the risks of developing T2D, hypertension and other ORCs in people who lost, on average, 13% of their body weight, compared with those who maintained a stable weight.[10] Therefore, data on the development of ORCs and associated health care costs over time in individuals with obesity is a vital step towards assessing the long-term cost-effectiveness of weight management interventions.

Despite the recognized impact of obesity and its complications worldwide, information is still needed on the natural disease progression of ORCs and the corresponding impact on health care systems, particularly stratified by obesity severity. In this real-world study, we describe the longitudinal development of ORCs and direct health care costs in individuals with obesity in the United States, according to obesity class.

2 | MATERIALS AND METHODS

2.1 | Data source

This study used linked data from two linked databases: the IQVIA Ambulatory Electronic Medical Records (AEMR) database, and the IQVIA PharMetrics® Plus database.

IQVIA's AEMR database comprises records for approximately 75 million US patients,[11] collected from >40 000 physicians from large practices and physician networks. Information captured includes clinical details, and lab tests and results.

PharMetrics Plus comprises US-wide administrative claims data from approximately 150 million members at the time of the study,[12] including inpatient and outpatient diagnoses and procedures, prescription records, pharmacy and medical benefit information, demographic variables, health plan enrolment dates, and payments. Diagnoses are based on ICD-9-CM and ICD-10-CM (International Classification of Diseases, Ninth Revision or Tenth Revision, Clinical Modification) codes (Table S1). All data from both databases are compliant with the Health Insurance Portability and Accountability Act to protect patients' privacy.

This study was a retrospective analysis of secondary deidentified data, and therefore was not considered human subject research; consequently, ethical approval was not required. The Office for Human Research Protections under the US Department of Health and Human Services does not consider research of fully deidentified information to involve human subjects.

2.2 | Study design and population

This was a retrospective, observational study of individuals with obesity over an 8-year period. The index date was the date of the first BMI measurement in the range of 30 to <70 kg/m^2 during the index period (1 January 2007 to 31 March 2012). BMI values were either determined from available BMI records, or calculated from available height and weight data in the AEMR.

For inclusion, individuals were required to be ≥18 years of age at the index date, to have continuous enrolment in PharMetrics Plus for ≥1 year pre-index (the 1-year baseline period) and ≥8 years post-index (the 8-year follow-up period), and to have linkage to the PharMetrics Plus database. Owing to the enrolment requirements, the full study period ran from 1 January 2006 to 31 March 2020.

To identify individuals new to the specific obesity class, individuals were excluded from the study if, in the baseline year, which was defined as the year immediately preceding index date, they had ≥1 BMI value in the AEMR or an obesity diagnosis code in PharMetrics that was the same as or higher than their obesity classification in this study. Individuals with invalid/missing age, sex, region or health plan enrolment dates were excluded. Individuals who were pregnant in the baseline year, or had a diagnosis of cancer (other than non-melanoma skin cancer) in all available records pre-index with continuous enrolment were also excluded.

Individuals were divided into three cohorts by obesity class at index (class I obesity: BMI ≥30.0 to <35.0 kg/m^2; class II obesity: BMI ≥35.0 to <40.0 kg/m^2; class III obesity: BMI ≥40.0 to <70.0 kg/m^2).

Demographic characteristics at baseline were available in PharMetrics Plus, and the presence of different ORCs and health care costs by obesity class were derived from PharMetrics Plus at baseline and for each year over the 8-year follow-up.

2.3 | Outcomes

The primary outcomes were the presence of recorded ORCs and total health care costs at baseline (encompassing costs for any medical care

TABLE 1 Baseline demographics in the year preceding the index date by obesity class[a] at index

Baseline characteristics	Obesity class I n = 17 892	Obesity class II n = 6550	Obesity class III n = 4141
Age (years), mean ± SD	45.7 ± 10.6	45.8 ± 10.3	45.3 ± 10.2
Women, n (%)	7397 (41.3)	3290 (50.2)	2468 (59.6)
Region, n (%)			
Northeast	6268 (35.0)	2241 (34.2)	1422 (34.3)
Midwest	5210 (29.1)	1968 (30.0)	1299 (31.4)
South	5277 (29.5)	1990 (30.4)	1250 (30.2)
West	1137 (6.4)	351 (5.4)	170 (4.1)
Race/ethnicity, n (%)			
White	12 005 (67.1)	4473 (68.3)	2767 (66.8)
African American	645 (3.6)	265 (4.0)	231 (5.6)
Asian	127 (0.7)	28 (0.4)	7 (0.2)
Hispanic	124 (0.7)	36 (0.5)	18 (0.4)
Unknown	4991 (27.9)	1748 (26.7)	1118 (27.0)
Payer type, n (%)			
Commercial	9765 (54.6)	3452 (52.7)	2120 (51.2)
Medicaid	45 (0.3)	26 (0.4)	15 (0.4)
Medicare risk	176 (1.0)	47 (0.7)	43 (1.0)
Self-insured	7901 (44.2)	3023 (46.2)	1963 (47.4)
Unknown	5 (<0.1)	2 (<0.1)	0 (0.0)
CCI score, mean ± SD	0.2 ± 0.6	0.3 ± 0.7	0.4 ± 0.7
CCI score, n (%)			
0	14 919 (83.4)	5144 (78.5)	3027 (73.1)
1	2168 (12.1)	1075 (16.4)	801 (19.3)
2	579 (3.2)	236 (3.6)	225 (5.4)
3	125 (0.7)	57 (0.9)	58 (1.4)
4	59 (0.3)	24 (0.4)	18 (0.4)
>5	42 (0.2)	14 (0.2)	12 (0.3)

Abbreviations: BMI, body mass index; CCI, Charlson comorbidity index.
[a]Class I obesity: BMI ≥30.0 to <35.0 kg/m^2; class II obesity: BMI ≥35.0 to <40.0 kg/m^2; class III obesity: BMI ≥40.0 to <70.0 kg/m^2.

or prescription costs), in each year of follow-up, and averaged over the 8 years of follow-up. The ORCs investigated were CKD, CVD, heart failure, OA of the knee and T2D.

Secondary outcomes were costs reported for mutually exclusive health care categories: outpatient pharmacy (termed 'drug costs'), inpatient hospitalizations (termed 'inpatient costs'), emergency room (ER) visits (termed 'ER costs') and outpatient medical care (termed 'outpatient costs'). Details of outpatient health care resource utilization (HCRU) were also captured. Total and constituent direct health care costs were evaluated in the baseline year and annually during follow-up. Direct health care costs included the reimbursed amount paid by payers combined with the patient out-of-pocket cost (e.g. co-pay, co-insurance).

Outpatient costs comprised the following mutually exclusive HCRU categories: outpatient physician office visits, outpatient surgical visits, laboratory and pathology, radiology, and other ancillary services. Other ancillary services included all outpatient medical care that does not fall into the other defined categories such as drugs administered in the office or clinic (i.e. Health Care Common Procedure Coding System drugs), durable medical equipment (sterile supplies, external ambulatory insulin infusion pumps, medical implants), routine venepuncture, electrocardiogram, or use of a recovery room.

2.4 | Statistical analyses

The percentage of individuals with an ORC for any given year was estimated from the proportion of individuals with the diagnosis code for the ORC for that year. The presence of the diagnosis code in any given year does not necessarily indicate newly diagnosed disease, but rather that the relevant condition is being managed and recorded in that year.

Both observed and adjusted costs are presented. Mean observed annual total health care costs were calculated for each BMI class in

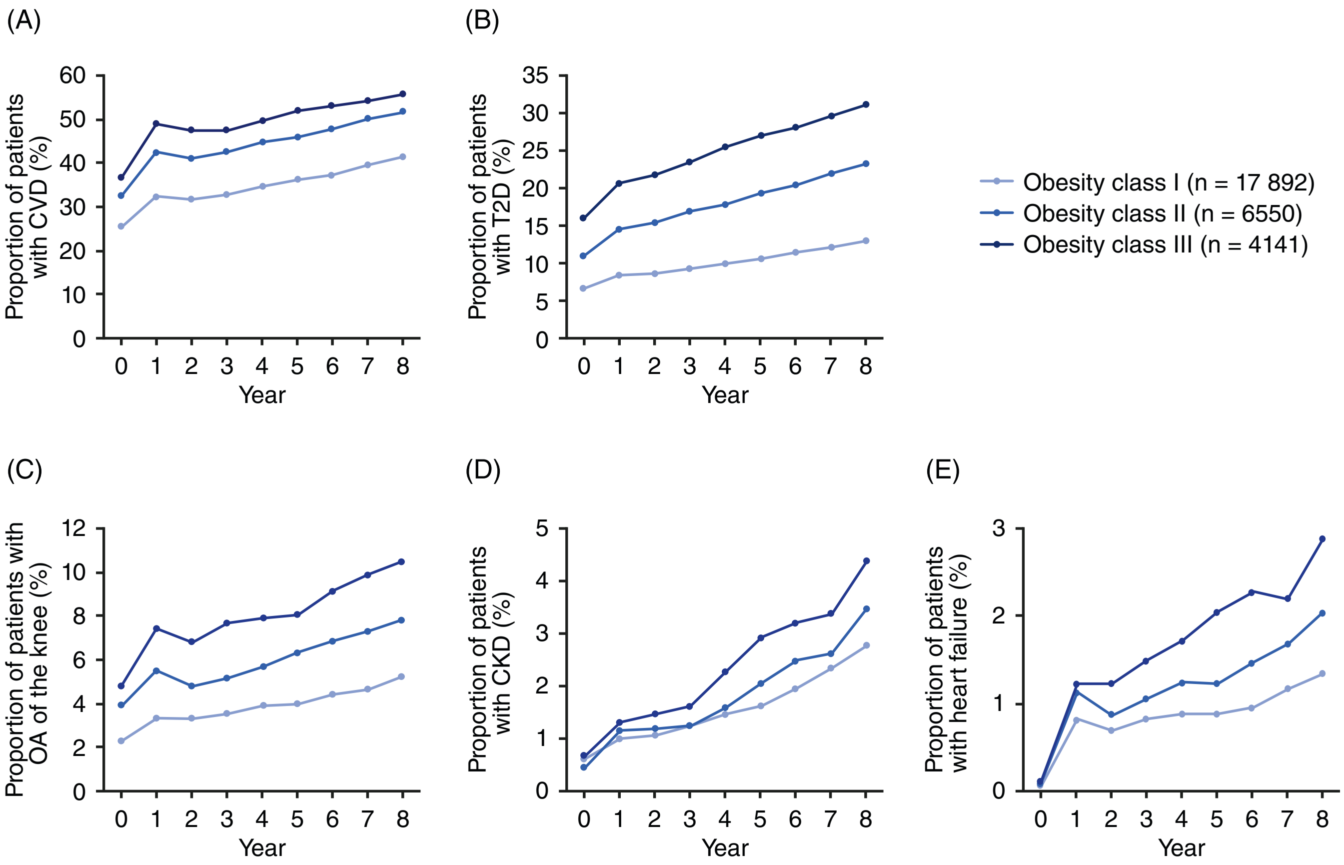

FIGURE 1 Presence of cardiovascular disease (CVD), type 2 diabetes (T2D), osteoarthritis (OA) of the knee, chronic kidney disease (CKD) and heart failure during each year of follow-up by obesity class† at index. Note the differing scales on the y-axes. 'Year 0' refers to the baseline year.†Class I obesity: BMI ≥30.0 to <35.0 kg/m^2; class II obesity: BMI ≥35.0 to <40.0 kg/m^2; class III obesity: BMI ≥40.0 to <70.0 kg/m^2. BMI, body mass index

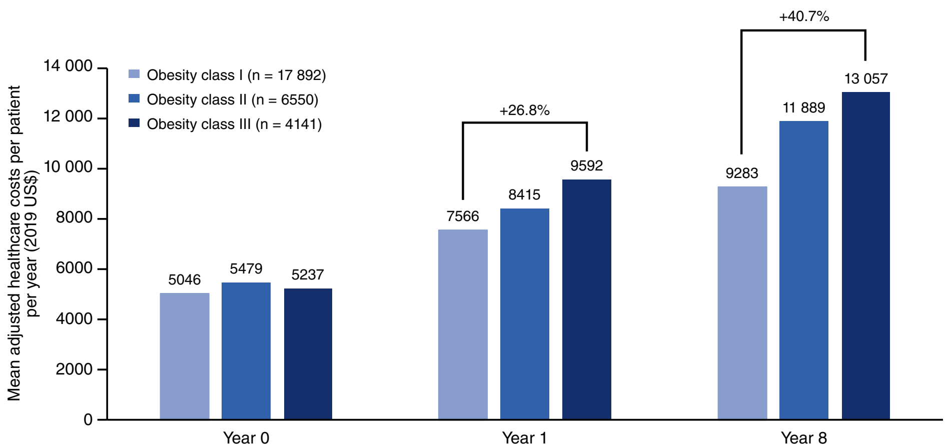

FIGURE 2 Adjusted yearly total health care costs at year 1 and year 8 by obesity class at index.†,‡ 'Year 0' refers to the baseline year. †Class I obesity: BMI ≥30.0 to <35.0 kg/m^2; class II obesity: BMI ≥35.0 to <40.0 kg/m^2; class III obesity: BMI ≥40.0 to <70.0 kg/m^2. ‡Costs were estimated using generalized estimating equation models with a gamma distribution, adjusting for obesity class, age group, sex, region, health plan type, year of cost, Charlson Comorbidity Index (CCI) score category, and for the following interactions: age group × sex, age group × region, and obesity class × year of cost. BMI, body mass index

the baseline year and each year of follow-up. Costs were calculated on a per-patient per-year basis, and averaged across all individuals in the cohort.

Adjusted costs for years 0 (baseline year), 1 and 8 were predicted from generalized estimating equation models with a gamma distribution, adjusting for obesity class, age group, sex, region, health plan

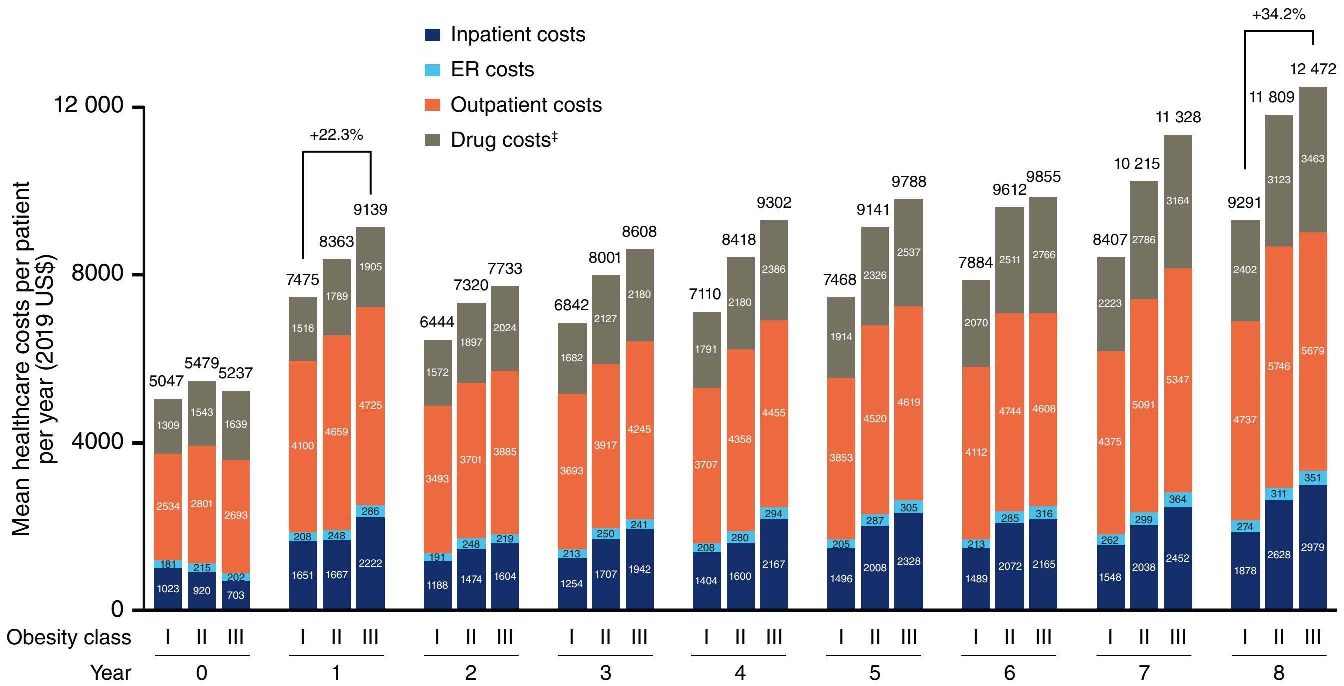

FIGURE 3 Observed health care costs and cost components in the baseline year and over 8 years of follow-up by obesity class† at index. Costs were converted to 2019 US$ using the medical component of the Consumer Price Index. 'Year 0' refers to the baseline year. †Class I obesity: BMI ≥30 to <35 kg/m^2 (n = 17 892); class II obesity: BMI ≥35 to <40 kg/m^2 (n = 6550); class III obesity: BMI ≥40 to <70 kg/m^2 (n = 4141). Total costs were calculated using raw data (more than one decimal place). ‡Excluding Health care Common Procedure Coding System (HCPCS) drug costs. BMI, body mass index; ER, emergency room; HCPCS, Health Care Common Procedure Coding System

type, year of cost, Charlson Comorbidity Index score and for the following interactions: age group × sex, age group × region, and obesity class × year of cost, allowing for comparisons between the BMI cohorts. Age groups were defined as follows: 18-34, 35-44, 45-54, 55-64 and ≥65 years. Costs were converted to 2019 US$ using the medical component of the Consumer Price Index.

Analyses were conducted using SAS® Release 9.4 (SAS, Cary, NC, USA).

3 | RESULTS

3.1 | Study population and baseline characteristics

In total, 28 583 individuals fulfilled all inclusion criteria. At index, 17 892 individuals (62.6%) had class I obesity, 6550 individuals (22.9%) had class II obesity and 4141 individuals (14.5%) had class III obesity.

Table 1 summarizes the characteristics of individuals at baseline. Mean age did not differ by obesity class, but the proportion of women was greater in higher obesity classes (41.3% of those with class I obesity; 59.6% of those with class III obesity). Approximately two-thirds of the study population was white, and ethnicity was unknown in one-quarter of individuals, with the prevalence of Asian, African American and Hispanic ethnicities within the different obesity classes ranging 0.2%-5.6%. Most individuals had either commercial insurance or self-insurance. Generally, Charlson Comorbidity Index scores increased with increasing obesity class.

3.2 | Trends in obesity-related complications during the follow-up period

Of the ORCs included in the analyses, CVD and T2D were the most frequently recorded complications at all time points, whereas the presence of OA of the knee, CKD and heart failure was generally recorded in ≤10% of individuals at all time points (Figure 1). The frequency of all individual ORCs generally increased from the baseline year (year 0) to year 8 (Figure 1), but there was an increase in ORC presence at year 1 and a decrease at year 2.

The relative increase in the presence of diagnosed ORCs from the baseline year to year 8 was greater for individuals in higher obesity classes for some ORCs (CKD and heart failure), but not others (T2D, CVD and OA of the knee). The relative increase in ORCs was also generally highest for the ORCs that were least frequent at pre-index. For example, CKD was four to eight times more frequent in year 8 (class I: 2.8%; class II: 3.5%; class III: 4.4%) than in the baseline year (class I: 0.6%; class II: 0.5%; class III: 0.7%), whereas the presence of T2D approximately doubled from the baseline year (class I: 6.8%; class II: 11.1%; class III: 16.2%) to year 8 (class I: 13.1%; class II: 23.2%; class III: 31.1%) in all obesity classes (Figure 1).

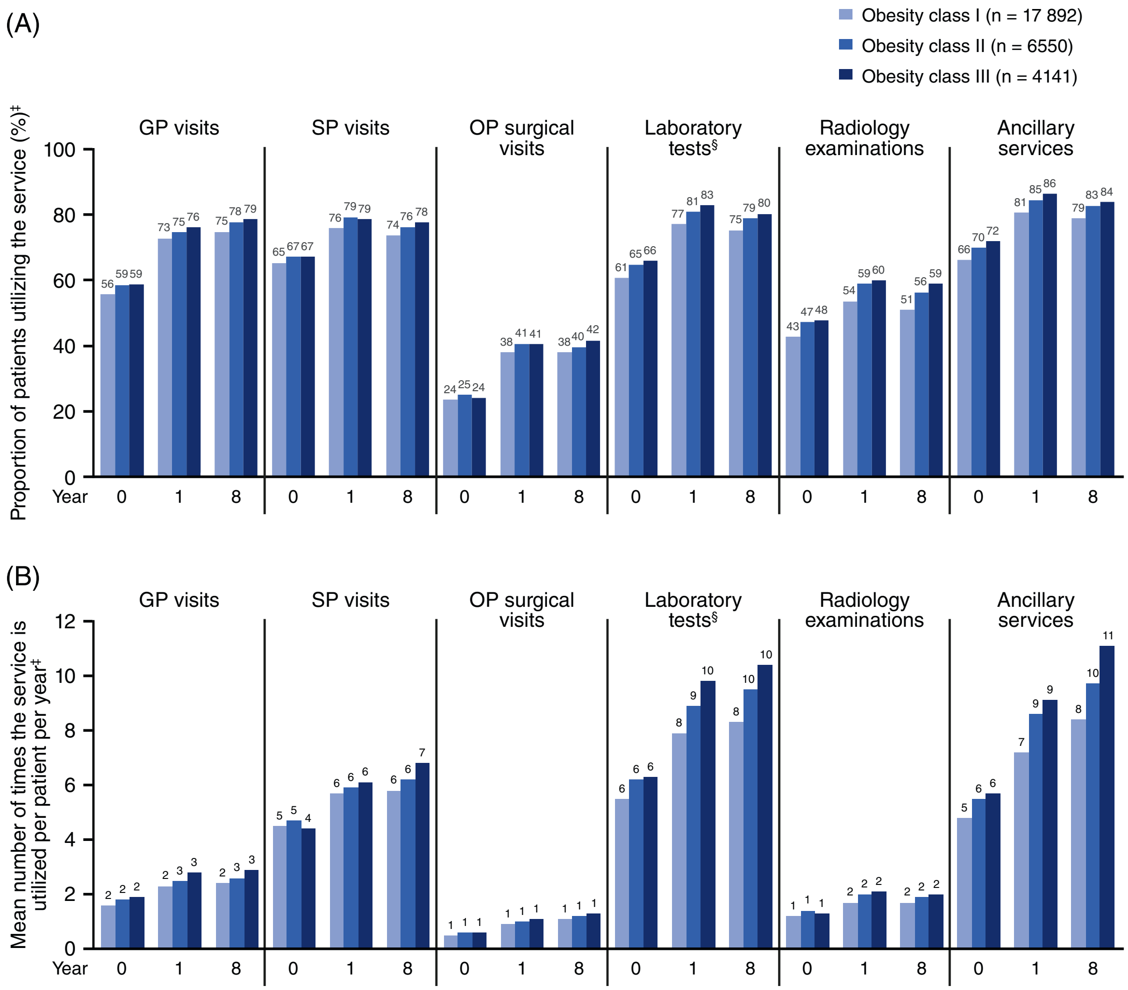

FIGURE 4 Progression and breakdown of outpatient health care resource utilization by obesity class† at index. 'Year 0' refers to the baseline year. Note that data were plotted using raw data (more than one decimal place), but numbers shown above bars have been rounded to the nearest integer. †Class I obesity: BMI ≥30.0 to <35.0 kg/m^2; class II obesity: BMI ≥35.0 to <40.0 kg/m^2; class III obesity: BMI ≥40.0 to <70.0 kg/m^2. ‡Defined as individuals with ≥1 instance of utilizing the specified service in the specified year. §Includes pathology examinations. GP, general practitioner; OP, outpatient; SP, specialty physician

3.3 | Progression of health care costs

In the baseline year, adjusted total health care costs were similar across obesity classes. Mean annual adjusted total health care costs generally increased from the baseline year to year 8 for all obesity classes (Figure 2). When observed costs paid by the insurer and those paid by the individual were examined separately, the same trend was seen in both types of costs (Table S2). The difference in costs between obesity classes also increased over time. At year 1, adjusted costs for class II obesity ($8415) were 11.2% higher than for class I obesity ($7566), and costs for class III obesity ($9592) were 26.8% higher than for class I obesity. At year 8, individuals with class II obesity had 28.1% higher health care costs compared with those with class I obesity ($11 889 vs. $9283), and those with class III obesity had 40.7% higher health care costs than those with class I obesity ($13 057 vs. $9283; Figure 2).

Mean annual observed total health care costs generally followed the pattern of the adjusted costs, increasing from baseline to year 8, with a progressive increase in the difference between obesity classes over time (Figure 3). For example, costs for individuals with class III obesity were 22.3% higher than for those with class I obesity in year 1, but 34.2% higher in year 8. The largest contributor to total observed health care costs in all years was outpatient costs, making up roughly half of the total costs; the other half comprised mainly drug costs and inpatient costs, whereas ER costs were minimal (Figure 3).

Although total observed costs were relatively higher for the higher obesity classes (Figure 3), the relative contribution of outpatient, drug, inpatient and ER costs to total costs was similar across obesity classes. However, the percentage contributed by inpatient costs for individuals with class III obesity increased from 13.4% in year 0 (baseline year) to 24.3% in year 1, whereas the equivalent increase was lower in the lower obesity classes. Over the 8 years of follow-up, the contribution of drug costs to total observed health care costs within each obesity class increased modestly, from 20% to 21% in year 1 (depending on obesity class) to 26% to 28% in year 8, whereas the contribution of outpatient costs decreased from 52% to 56% in year 1 to 46% to 51% in year 8 (Figure 3).

3.4 | Outpatient costs and health care resource use

Outpatient costs were the main drivers of the observed health care costs across all obesity classes, and therefore we explored the breakdown of these costs and the associated HCRU further. In the baseline year, the major contributors to outpatient costs were ancillary services, outpatient surgeries, and specialty physician visits, which together contributed ≥55% of total observed outpatient costs (Figure S1). Figure 4 shows the breakdown of outpatient HCRU in years 0 (baseline year), 1 and 8 by obesity class. The most frequently utilized services in all years of follow-up and across all obesity classes were GP visits, specialty physician visits, laboratory and/or pathology test procedures and ancillary services; these were utilized by >70% of individuals in years 1 and 8, independent of the obesity class.

4 | DISCUSSION

The association between obesity, other chronic diseases and higher health care costs is well-recognized, but the details of individual ORC progression over time and major cost contributors are less clear, particularly in relation to obesity class. Our study shows how the clinical and economic impacts of obesity progress over time, and indicates the benefits that can be achieved by preventing progression to severe obesity, and preventing ORCs.

The cohorts (groups of individuals with obesity class I, II or III) were well balanced for most baseline characteristics; however, there were clinically relevant differences between cohorts in the proportion of women and the proportion of individuals with comorbidities, both of which increased with increasing obesity class.

The present study examined both high-prevalence ORCs such as T2D and CVD, and low-prevalence ORCs associated with high morbidity and medical costs, such as CKD. Over the 8 years of follow-up, the recorded presence of ORCs was higher in the higher obesity classes. This finding appeared to be independent of age, because mean age was similar across obesity classes. In all three obesity classes, the presence of ORCs and health care costs increased over time. There was a clear increase in HCRU and associated costs in the year following the index obesity diagnosis, followed by a reduction in year 2, after which costs increased progressively until year 8 of follow-up. The incidence of chronic disease increases with age, and therefore it is probable that some of the increase in ORCs over time is explained by ageing of the study cohort over the follow-up; however, a substantial fraction of the increase will probably be explained by obesity. In a large UK study with up to 11 years of follow-up, there was a stepwise increase in the risk of developing ORCs for higher BMI classes, compared with normal weight, independent of age.[5] In line with the increases in ORC rates, the HCRU and total health care costs were higher in the higher obesity classes in our study. Collectively, these data are aligned with another US study, which showed that both direct and indirect costs increase with obesity severity.[13] Here, we also show that direct costs in all obesity classes increase over time, with a progressive widening of the gap between class I and class III obesity, highlighting the potential economic benefits of preventing obesity progression.

The relative increase in the presence of ORCs over time was generally highest for the least frequently recorded ORCs, such as CKD and heart failure, which are associated with particularly high medical costs, particularly as the disease progresses.[14,15] Therefore, increases in their prevalence will probably constitute a considerable proportion of the economic impact of obesity progression. Even at year 8, these ORCs remained substantially less frequent in lower than in higher obesity classes; therefore, it is probable that a considerable reduction in their prevalence, and associated costs, could be achieved via approaches that prevent progression to higher obesity classes. There is evidence that the risks of both frequently reported ORCs such as T2D and less common ORCs such as CKD can be reduced by weight loss.[10]

Outpatient costs were the main cost driver, contributing approximately 50% of total costs across all obesity classes. This pattern is distinct from previous analyses; in a study of 86 221 privately insured US individuals, hospitalization accounted for an increasing proportion of direct costs with increasing BMI, and was the main cost driver in individuals with class III obesity.[13] The cohort in the previous study was similar to the present cohort in terms of age, but may have included individuals with a longer duration of obesity, potentially contributing to an increased need for hospitalization. Increasing inpatient costs with obesity severity have also been reported in the UK,[16] and obesity has been identified as a risk factor for hospitalization.[17] Data from a study conducted in Germany also indicate that inpatient costs are higher than outpatient costs for individuals with obesity[18]; however, individuals included in this study had a mean age of 70 years, and were therefore older than individuals in our study were. The present study also used a comprehensive definition of outpatient costs, including laboratory and radiology investigations and drugs administered in outpatient settings. An additional factor, which was not assessed in the analyses, is the potential for outpatient costs contributed by consultations or preventive measures to offset inpatient costs by reducing the requirement for hospitalization. Overall, the disparities across studies indicate that cost estimates of obesity vary widely by country and population, but may also vary because of differences in costs included in the analyses and in health system approaches, such as disparities in the availability of universal health coverage and social health insurance. However, studies worldwide show that HCRU and health care costs increase with increasing obesity severity.[19,20]

Interestingly, outpatient surgical costs constituted approximately one-fifth of all outpatient costs over the follow-up period, even though such services were utilized by only 1% of individuals, whereas

GP visits were utilized by approximately 75% of individuals, but contributed only 7% of the costs. This suggests that outpatient costs are partly driven by high-cost procedures utilized by a relatively smaller proportion of people. Further characterization of these individuals is needed to determine the drivers of HCRU in this group.

This was a large, US-wide study describing a comprehensive range of outcomes by obesity class, showing the impact of obesity on both health and health care systems. The long follow-up highlights the costs and complications that could be avoided or limited by preventing obesity progression. However, there are several limitations to this study, including well-recognized limitations of using real-world evidence such as the potential for disease misclassification in medical databases, which can affect prevalence estimates. The underlying reasons for weight changes are also unknown. In addition, our results are based on a section of the US population that is largely commercially- or self-insured, and interaction with the health care system at the index date followed by continuous database enrolment for the 8-year study duration was an inclusion criterion. This may have led to selection bias, which is a common limitation of real-world evidence. The influence of race and ethnicity on the risk of developing obesity and ORCs, as well as on health care expenditure, is well-recognized,[21] and may have influenced our results. The effect of these variables was difficult to determine in our study owing to the small proportion of ethnic minority subgroups; however, the proportion of these groups did not vary appreciably across obesity classes. In addition, because of the nature of this study, ethnicity-specific BMI cut-offs to define obesity could not be used.[22] Nonetheless, because the majority of participants were white and only a small percentage of individuals were of Asian descent (≤0.7% across cohorts), this is not expected to influence the results of this study greatly. Similarly, it was not possible to evaluate the contribution of the socio-economic status to costs or comorbidities in our study. This factor probably has multiple different effects on obesity and HCRU: there is evidence that high social class is associated with higher obesity-related costs[23]; however, socio-economic deprivation has been linked to a higher risk of multimorbidity.[24] Our results may not be generalizable to uninsured or Medicare or Medicaid populations, and further research is required to show the impact of obesity in elderly people not in employment, as well as in those who are covered by traditional fee-for-service Medicare. This would help to quantify the unmet need and economic impact of individuals without insurance, who may live longer with undiagnosed ORCs and may not receive optimal treatment following a diagnosis, compared with insured individuals. It would also be valuable to compare our findings with data from a cohort of individuals without obesity, which may provide insights into the impact of obesity on individuals' likelihood of seeking or receiving health care. Further investigation of the impact of age of onset of obesity might also help to explain some of the trends observed in the occurrence of ORCs. Exploration of the impact of ORCs on indirect costs is also warranted. Published evidence indicates that indirect obesity-related costs resulting from lost productivity are similar to or higher than direct costs[19] and, therefore, the total economic burden of obesity is expected to be at least double the direct cost estimates in the present study. This is particularly relevant for younger individuals, who may live with obesity and ORCs for many years, with a potentially considerable impact on productivity.

5 | CONCLUSIONS

The presence of ORCs increases over time in people with obesity, and this increase is more pronounced in individuals in higher obesity classes. Health care costs are greater for individuals in higher compared with lower obesity classes, and over time, costs increase and the gap in costs widens between obesity classes. This underlines the unmet need for, and the potential benefit that can be gained from, weight management approaches that prevent the progression of obesity.

AUTHOR CONTRIBUTIONS

EdeL, MF, CLH and KSM were responsible for design and conceptualization of the study. VRA, MDeK and VD were involved in study design and conducted the analysis. All authors contributed to the interpretation of data and critical review of the manuscript, and approved the final version for submission.

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CONFLICT OF INTEREST

ME has received honoraria from AstraZeneca, Boehringer Ingelheim and Novo Nordisk. VRA, MDeK and VD are employees of IQVIA, which received consulting fees from Novo Nordisk A/S to perform this analysis. EdeL, MF, CLH and KSM are employees of Novo Nordisk. JP-S is Partner and Head of Health Analytics at Lane Clark & Peacock LLP, Chair-elect of the Royal Society for Public Health and reports personal fees from Novo Nordisk A/S and Pfizer Ltd outside of the submitted work.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/dom.14897.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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