Received: 24 April 2024 | Revised: 25 June 2024 | Accepted: 25 June 2024

DOI: 10.1111/dom.15785

ORIGINAL ARTICLE

WILEY

Variations in healthcare costs by body mass index and obesity-related complications in a UK population: A retrospective open cohort study

Jonathan Pearson-Stuttard FRSPH[1,2] | Sara Holloway DipHE[1] | Kasper Sommer Matthiessen MSc[3] | Andrew Thompson PhD[1,4] | Silvia Capucci MSc[3]

[1]Health Analytics, Lane Clark & Peacock LLP, London, UK

[2]Department of Epidemiology and Biostatistics, School of Public Health, Imperial College, London, UK

[3]Novo Nordisk A/S, Søborg, Denmark

[4]Wolfson Centre for Personalised Medicine, Institute of Systems, Molecular and Integrative Biology, University of Liverpool, Liverpool, UK

Correspondence
Jonathan Pearson-Stuttard, Health Analytics, Lane Clark & Peacock LLP, 95 Wigmore Street, London, W1U 1DQ, UK.
Email: jonathan.pearson-stuttard@lcp.uk.com

Funding information
Novo Nordisk A/S

Abstract

Aims: To estimate healthcare resource utilization (HCRU) and healthcare costs by body mass index (BMI) in a UK cohort and to explore how this varied by defined BMI strata.

Materials and Methods: This retrospective open cohort study used Discover, a linked primary and secondary electronic health records database covering 2.7 million individuals. Adults were stratified by BMI as: overweight (25–<30 kg/m^2); obesity class I (30–<35 kg/m^2); obesity class II (35–<40 kg/m^2); or obesity class III (≥40 kg/m^2). Cost data, comprising primary care, secondary care (inpatient admissions, outpatient appointments and emergency room visits) and prescriptions, were reported for 2015–2019.

Results: Overall, 1 008 101 individuals were overweight, 278 782 had obesity class I; 80 621 had obesity class II, and 42 642 had obesity class III. Healthcare costs and HCRU events per person per year increased over time (2015: £851–£1321 and 10.6–13.4 events; 2019: £1143–£1871 and 11.4–14.9 events), and were higher for each successive BMI group. Groups with chronic kidney disease or cardiovascular disease incurred particularly high costs. In 270 493 individuals with obesity in 2019, more than 72% of total healthcare costs were incurred by the highest cost quintile, which had a higher mean age and more obesity-related complications (ORCs) than lower cost quintiles.

Conclusions: The economic impact of obesity could be alleviated by weight management support based on unmet need, to limit the effects of BMI progression and ORC development.

KEYWORDS
cohort study, database research, observational study, population study, real-world evidence

1 | INTRODUCTION

The global prevalence of obesity (body mass index [BMI] ≥30 kg/m^2) has risen over recent decades, and this trend is set to continue. According to estimates in the 2023 World Obesity Atlas, 38% of the global population (aged >5 years) had either overweight (BMI 25–<30 kg/m^2) or obesity in 2020.[1] This figure is expected to rise to 51% by 2035, and 24% of individuals are projected to have obesity by that year.[1] Obesity is particularly prevalent in some regions, including North America and Western Europe.[2] In the United Kingdom, data

from the Health Survey for England indicate that 36% of the overall adult general population (aged ≥16 years) in 2019 had overweight and 31% had obesity, with 3% of the general population in the highest class of obesity (BMI ≥40 kg/m^2).[3]

An analysis using data from more than 2 million individuals in the UK Clinical Practice Research Datalink (CPRD) estimated the age-standardized risk of transitioning from overweight to obesity over 10 years to be 29%.[4] For people with obesity class I (BMI 30–<35 kg/m^2) or II (BMI 35–<40 kg/m^2), the absolute risk of transition to obesity class III over 10 years was 5%–22%, with higher risks in younger age groups. The importance of preventing this BMI progression is underlined by the close link between obesity and the development of chronic comorbidities, termed obesity-related complications (ORCs). These are conditions such as type 2 diabetes (T2D), cardiovascular disease and osteoarthritis of the knee (KOA), for which prevalence is positively associated with increasing BMI category.[5,6] In addition to their clinical impact, the presence of ORCs in people with obesity leads to additional healthcare resource utilization (HCRU) and healthcare costs.[7,8] The HCRU associated with different ORCs varies among types and number of conditions, and individuals with multimorbidity, defined as two or more chronic conditions, typically incur higher costs and HCRU than those with just one condition.[9]

The economic and clinical impacts of obesity on a population level can be addressed only by understanding the factors underlying HCRU and healthcare costs, and by identifying individuals at high risk of experiencing costly ORCs. To identify these areas of unmet need, we used data from a UK population to track costs and HCRU events between 2015 and 2019 in groups stratified by BMI (overweight or obesity class I, II or III) and by the presence of ORCs. We then extended this analysis to identify and characterize the subgroup of individuals with obesity who incurred the highest costs in 2019.

2 | MATERIALS AND METHODS

2.1 | Data source

This study used data from individuals identified in the real-world Discover database, which comprises linked electronic health records from primary care (from 1 January 2004) and secondary care (from 1 January 2015), covering 95% of the population residing in North West London, UK (2.7 million people),[10] with linkage to the Whole Systems Integrated Care database.[11] Pseudo-anonymized patient-level data are available for research through an application process via the North West London Information Governance Steering Group.

2.2 | Study design

This was a retrospective open cohort study. The study period began on 1 January 2004 and ended on 31 December 2019, to exclude healthcare data from the period during which healthcare systems were disrupted by the COVID-19 pandemic. The index date was the date during the study period on which an individual had an eligible BMI measurement and matched all other required criteria. Individuals were followed up from their index date until their study end date, which was either month of death, transfer-out date from the North West London region or end of study period, whichever was earliest. Here, we present cost data from eligible individuals in the database during the period 2015–2019.

2.3 | Study population

Eligible individuals aged 18 years or older with known sex were stratified into cohorts according to BMI measurements (either directly recorded or calculated based on height and weight) at study entry: overweight (25–<30 kg/m^2), obesity class I (30–<35 kg/m^2), obesity class II (35–<40 kg/m^2), obesity class III (≥40 kg/m^2), in line with National Institute for Health and Care Excellence guidance.[12]

Individuals were assessed on 1 January of each year using the most recent BMI measurement, and could remain in the same BMI group, transition to a different group, or enter an inactive group if their BMI was <25 kg/m^2 or there was no BMI measurement in the previous 3 years. Individuals in the inactive group were assessed with the rest of the study population on 1 January of each year, and could re-enter the analysis if the relevant criteria were met.

Individuals were excluded if they had no record of general practitioner (GP) or nurse practitioner visits for more than 5 years during follow-up.

Serial cross-sections consisting of all eligible individuals in the study database in each calendar year over the study period were assembled for mapping annual HCRU and costs. Individuals were followed up until their study end date, providing outcomes for a given calendar year regardless of time spent in the study population.

2.4 | Costs and HCRU events

The primary outcome of interest was all-cause total direct healthcare costs and cost components, comprising costs of primary care (GP consultations and practice nurse appointments, which were grouped together in component analyses), secondary care (inpatient admissions, outpatient care and emergency department visits) and prescriptions (see supplementary material in Data S1 for additional details). Overall and setting-specific HCRU was quantified as events per year for primary and secondary care interactions; prescriptions were not included in this assessment.

Primary care costs were derived from the Personal Social Services Research Unit (2020),[13] and secondary care costs were derived from the Secondary Uses Service, produced by National Health Service Digital. Prescription costs were calculated using net ingredient costs obtained from the national report on the net ingredient cost of all prescriptions dispensed in England in 2019.[14]

Healthcare costs were calculated for each year of the period 2015–2019, and as mean annual costs over that period. Costs were

adjusted to 2019 costs in pound sterling using UK Consumer Price Index inflation data from the Office for National Statistics.

2.5 | Obesity-related complications

The presence of ORCs was determined from primary or secondary care records using diagnosis codes (see supplementary material and Table S1 in Data S1). Diagnosis codes present at any time in each individual's healthcare record were considered relevant. Comorbidities considered when defining groups with ≥1, ≥2 or ≥3 ORCs in the analysis were asthma, atherosclerotic cardiovascular disease (ASCVD; including cerebrovascular disease, ischaemic heart disease or peripheral artery disease), back pain, chronic kidney disease (CKD) stages 3–5, dyslipidaemia, gastro-oesophageal reflux disease, heart failure, hypertension, KOA, obstructive sleep apnoea (OSA), polycystic ovary syndrome, prediabetes, psoriasis, T2D and urinary incontinence.

2.6 | Cost quintile analysis

To characterize the subgroup with obesity that incurred the highest costs, a cohort comprising individuals with obesity in 2019 (a composite of all obesity classes) was grouped into equally sized quintiles based on healthcare costs in that year. Demographic characteristics and ORCs were also assessed for each quintile.

2.7 | Statistical analysis

All outcomes were age-standardized to the European Standard Population in 2013.[15] Descriptive data are presented as mean (standard deviation [SD]) or median (interquartile range) for continuous variables and as number and percentage for categorical variables. In addition, 95% confidence intervals for cost data are included in supplementary tables in Data S1.

3 | RESULTS

3.1 | Study population and baseline characteristics

Of the 3 235 693 individuals in Discover during the 2004–2019 study period, a total of 1 410 146 individuals met the eligibility criteria for inclusion in the analysis: 1 008 101 with overweight, 278 782 with obesity class I, 80 621 with obesity class II, and 42 642 with obesity class III. Per calendar year reported for the analysis of costs, 624 224 individuals were included in 2015, 622 800 in 2016, 628 020 in 2017, 639 798 in 2018 and 651 196 in 2019. The numbers of included individuals per year in each BMI group for the full study period are shown in Table S2 in Data S1.

Baseline characteristics for included individuals at index date are shown in Table 1. The mean (SD) age ranged between 40.7 (15.6) and 43.1 (16.0) years across the groups. Overall, 45.9% of those with overweight were women, and there was a greater proportion of women in each successive obesity class (class I: 50.6%; class II: 60.5%; class III: 65.3%). In all groups, approximately 50% of individuals were White.

Age-standardized ORC prevalence estimates indicated that approximately half of individuals had at least one ORC at baseline (49.9%–59.2% across BMI groups; Table 1). The most common ORCs were hypertension (20.6%–31.2% across groups) and T2D (7.5%–13.8% across groups). The age-standardized prevalence of ≥1, ≥2 and ≥3 ORCs increased in each successive BMI group, and the same pattern was observed for heart failure, hypertension, KOA, OSA and T2D.

The prevalence of ORCs in the study cohort increased from 2015 to 2019. Table S3 in Data S1 shows the number of individuals in each BMI group with ≥3 ORCs in each calendar year of the analysis.

3.2 | Total healthcare costs and HCRU events for 2015–2019

The total healthcare costs incurred by each BMI group increased in each successive year (Figure 1A and Table S4 in Data S1). For example, the mean cost per person per year (PPPY) in the group with overweight was £851 in 2015 and £1143 in 2019. The equivalent mean costs for the group with obesity class III were £1321 in 2015 and £1871 in 2019. In each year, costs were higher with increasing BMI group, and this disparity grew over time. In 2015, costs were 55% higher for those with obesity class III versus overweight, whereas in 2019 they were 64% higher.

Similar patterns were observed for HCRU events (Figure 1B and Table S5 in Data S1): the mean number of events increased with BMI group and over time, with greater increases in the highest obesity classes (2015: overweight, 10.6 events; obesity class III, 13.4 events; 2019: overweight, 11.4 events; obesity class III, 14.9 events).

3.3 | Cost components

Inpatient admissions were the largest contributor to costs (Figure 1A and Table S6 in Data S1), and the overall proportion of total healthcare costs attributable to inpatient admissions was higher for successive BMI groups. There were also greater increases in inpatient admissions costs than in other types of cost over time: in 2015, 35%–37% of total costs were attributable to inpatient admissions, but by 2019 this had increased to 45%–49%. However, there was only a small increase in the mean number of inpatient admissions PPPY (2015: 0.2–0.3; 2019: 0.4–0.5; Figure 1B), indicating that individual admissions may have grown more costly over time.

Prescriptions and primary care were the next largest contributors to total healthcare costs. Primary care appointments were the most frequent type of HCRU event, with the mean number of appointments PPPY ranging between 8.7 and 11.6, increasing for successive

TABLE 1 Baseline characteristics of individuals included in the analyses.

Baseline characteristic	Overweight ($n = 1\,008\,101$)	Obesity class I ($n = 278\,782$)	Obesity class II ($n = 80\,621$)	Obesity class III ($n = 42\,642$)
Age, years, mean (SD)	41.2 (16.0)	43.1 (16.0)	42.8 (15.9)	40.7 (15.6)
Women, *n* (%)	462 678 (45.9)	141 035 (50.6)	48 805 (60.5)	27 836 (65.3)
BMI, kg/m^2, mean (SD)	26.9 (1.4)	31.9 (1.4)	37.0 (1.4)	46.4 (7.1)
Ethnicity, *n* (%)				
White	491 796 (48.8)	135 968 (48.8)	40 728 (50.5)	23 027 (54.0)
Asian or Asian British	281 849 (28.0)	69 206 (24.8)	16 715 (20.7)	7040 (16.5)
Black or Black British	87 480 (8.7)	31 693 (11.4)	10 812 (13.4)	5809 (13.6)
Mixed	28 744 (2.9)	8374 (3.0)	2625 (3.3)	1608 (3.8)
Other	88 074 (8.7)	24 149 (8.7)	6774 (8.4)	3573 (8.4)
Unknown	30 158 (3.0)	9392 (3.4)	2967 (3.7)	1585 (3.7)
ORCs, age-standardized prevalence, %				
AF	1.9	1.9	2.0	2.5
ASCVD	7.7	7.9	8.0	7.9
CKD	1.9	1.5	1.6	1.9
Depression	3.0	2.8	3.4	3.7
Heart failure	1.0	1.4	1.7	2.3
Hypertension	20.6	25.3	29.5	31.2
KOA	2.9	4.0	5.1	5.5
OSA	0.3	0.6	1.0	1.9
Prediabetes	2.3	1.7	1.9	2.0
T2D	7.5	9.5	12.3	13.8
≥1 ORC	49.9	52.6	57.5	59.2
≥2 ORCs	23.7	25.9	30.0	32.2
≥3 ORCs	10.5	11.7	14.2	15.9

Abbreviations: AF, atrial fibrillation; ASCVD, atherosclerotic cardiovascular disease; BMI, body mass index; CKD, chronic kidney disease; KOA, osteoarthritis of the knee; ORC, obesity-related complication; OSA, obstructive sleep apnoea; SD, standard deviation; T2D, type 2 diabetes.

BMI groups and remaining stable over time. Outpatient costs and mean number of outpatient appointments PPPY increased slightly over time: in 2015, average costs were £115–£178 and there were 1.0–1.5 appointments, whereas in 2019 average costs were £171–£246 and there were 1.5–2.1 appointments (all data PPPY). The mean number of outpatient appointments was also higher for successive BMI groups. Only 4%–5% of total healthcare costs were attributable to emergency department visits, and the number of visits did not increase substantively over time.

3.4 | Healthcare costs by obesity-related complication group

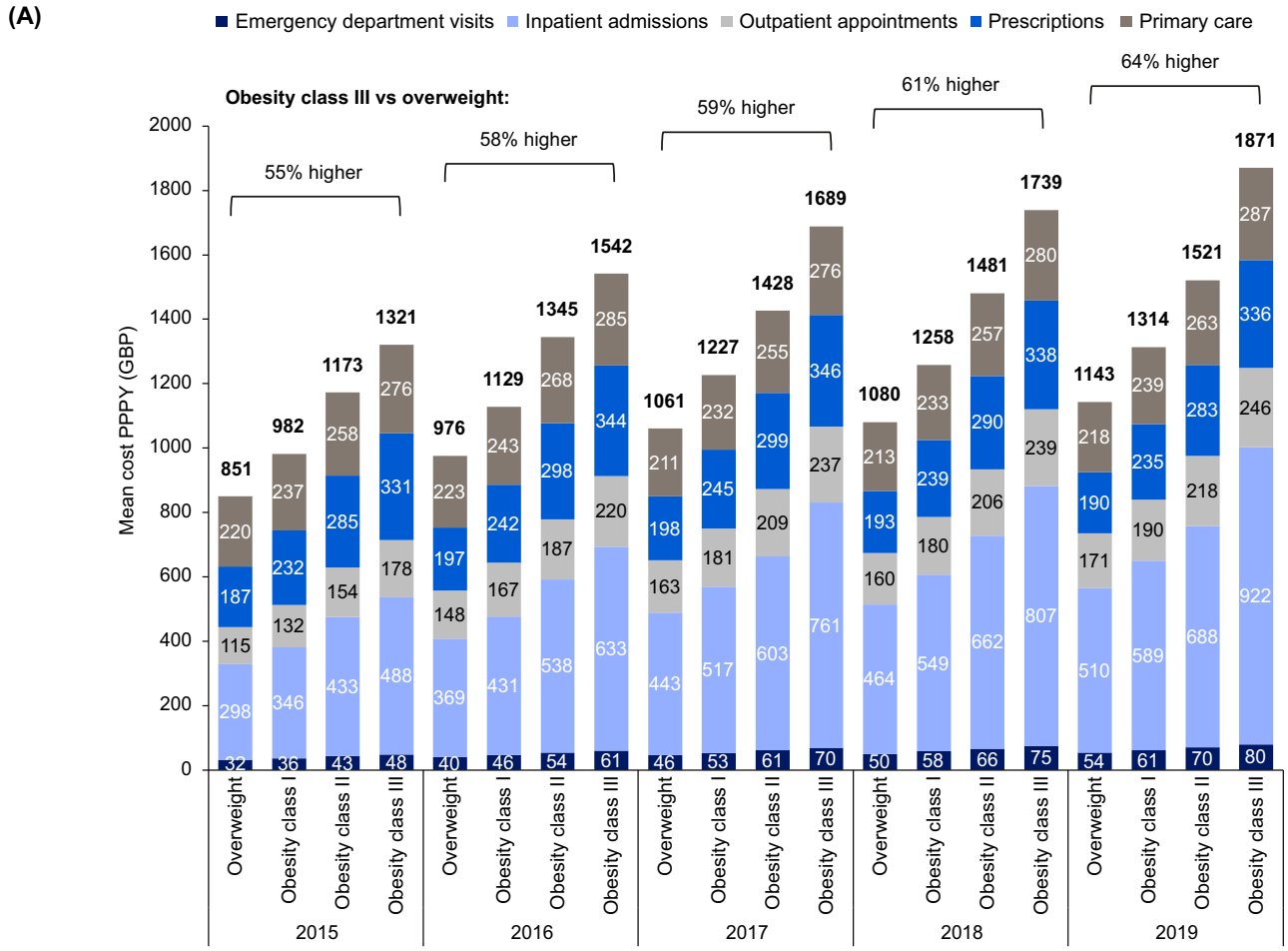
Average annual total healthcare costs for 2015–2019, grouped by the presence of specific ORCs and by number of ORCs, are shown in Figure 2. In general, costs were higher for each successive BMI group, the only exceptions being for individuals with CKD and heart failure. There was variation in healthcare costs between ORC groups: those incurring the highest annual costs were heart failure (£3651–£4320 PPPY across BMI groups), CKD (£2943–£4161), ASCVD (£2685–£3492) and atrial fibrillation (£2474–£3124). In addition, individuals with OSA and obesity class III incurred average annual costs of £2729 PPPY.

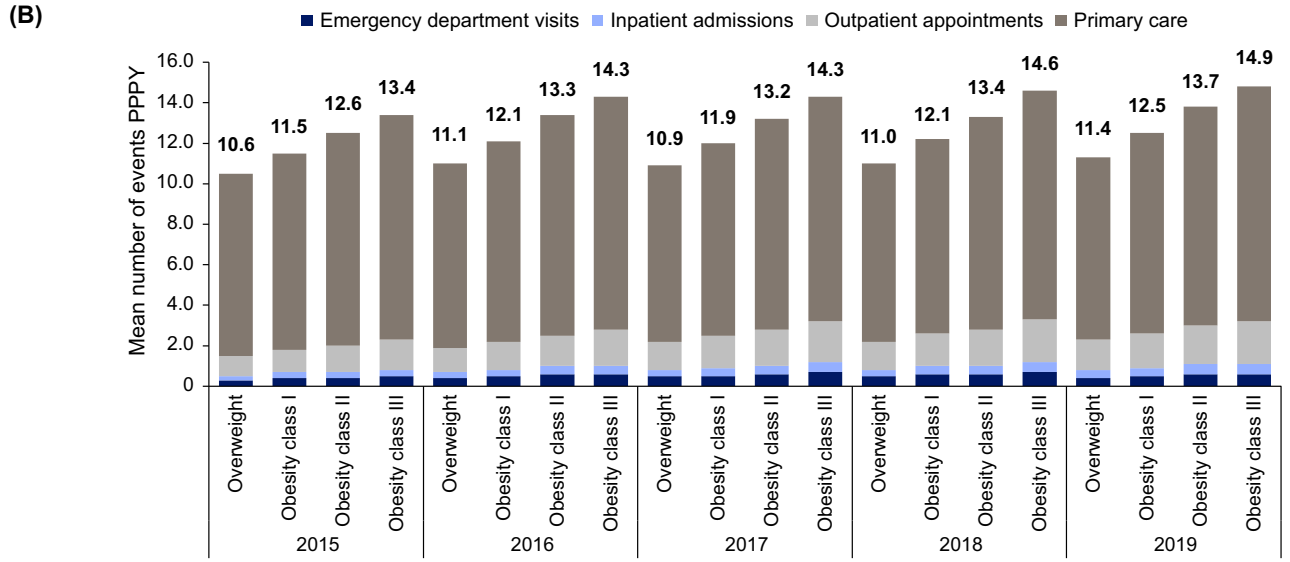
Healthcare costs increased with number of ORCs: costs PPPY were £1147–£1749 in the BMI groups with ≥1 ORC, £1353–£1957 in those with ≥2 ORCs and £1658–£2281 in those with ≥3 ORCs.

3.5 | Cost quintile analysis

In total, 270 493 individuals with obesity were included in the 2019 cost quintile analysis, resulting in approximately 54 100 individuals in each quintile (Table 2). The highest cost quintile (Q5) accounted for more than 72% of the total mean healthcare costs in 2019: £4670 PPPY (Figure 3A and Table S7 in Data S1). Costs for the next highest quintile (Q4) were much lower at £1034 PPPY, and were £45 PPPY in the lowest cost quintile.

As shown in Table 2, the mean (SD) age increased stepwise across the quintiles (Q1: 41.3 [13.3] years; Q5: 58.9 [16.5] years), as did the





Mean number of events PPPY																				
Primary care	9.0	9.7	10.5	11.1	9.1	9.9	10.9	11.5	8.7	9.5	10.4	11.1	8.8	9.6	10.5	11.3	9.0	9.9	10.8	11.6
Outpatient appointments	1.0	1.1	1.3	1.5	1.2	1.4	1.5	1.8	1.4	1.6	1.8	2.0	1.4	1.6	1.8	2.1	1.5	1.7	1.9	2.1
Inpatient admissions	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.4	0.5	0.3	0.4	0.4	0.5	0.4	0.4	0.5	0.5
Emergency department visits	0.3	0.4	0.4	0.5	0.4	0.5	0.6	0.6	0.5	0.5	0.6	0.7	0.5	0.6	0.6	0.7	0.4	0.5	0.6	0.6

FIGURE 1 (A) Cost components and (B) number of healthcare resource utilization events by calendar year and body mass index group. GBP, pound sterling; PPPY, per person per year.

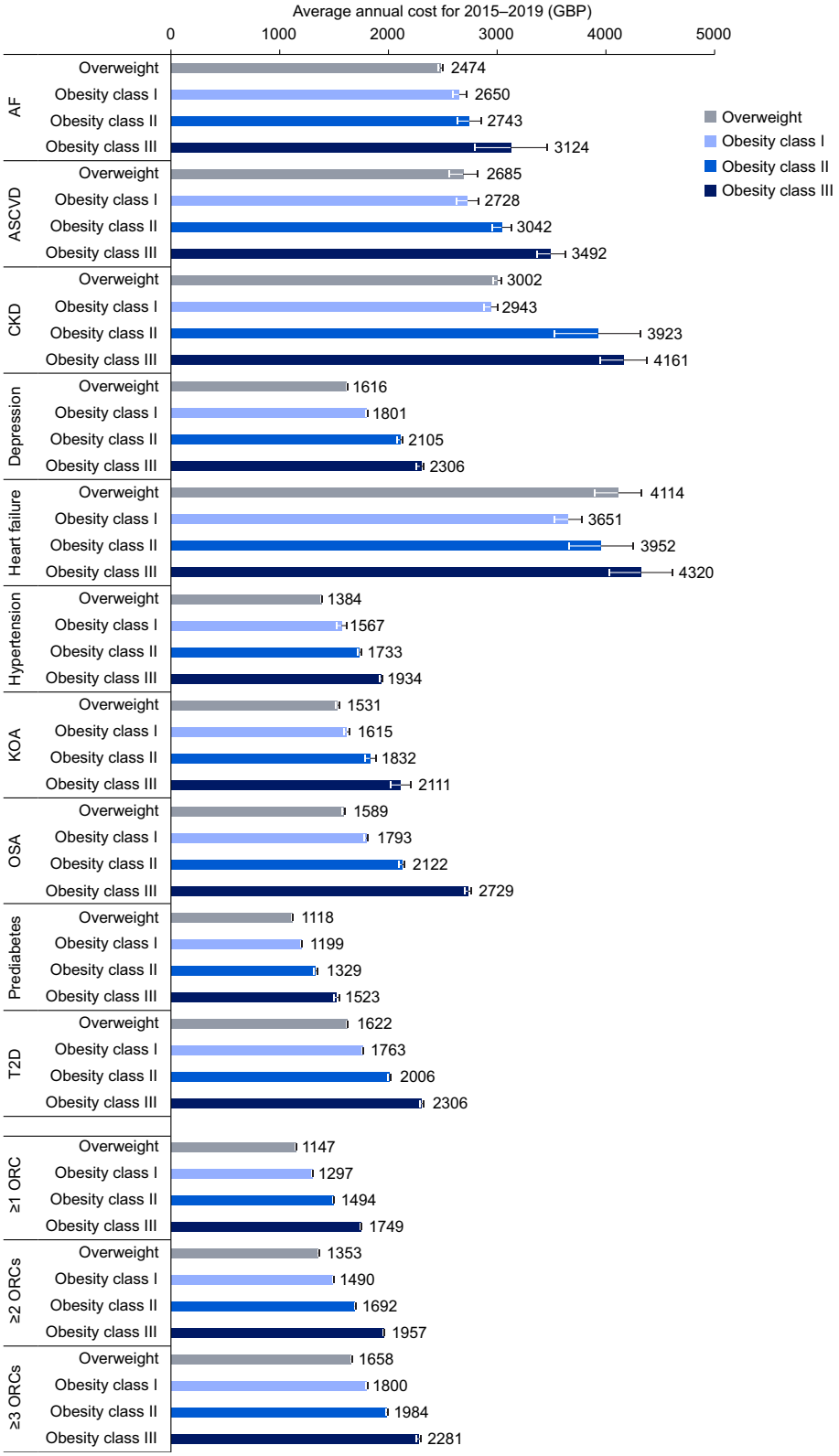


FIGURE 2 Average annual total costs during 2015–2019 by body mass index group and presence of obesity-related complications (ORCs). AF, atrial fibrillation; ASCVD, atherosclerotic cardiovascular disease; CKD, chronic kidney disease; GBP, pound sterling; KOA, osteoarthritis of the knee; OSA, obstructive sleep apnoea; T2D, type 2 diabetes.

proportion of women (Q1: 45.5%; Q5: 62.3%). There was also evidence of a small increase in mean (SD) BMI by cost quintile (Q1: 34.2 [4.9] kg/m^2; Q5: 35.1 [5.3] kg/m^2).

The prevalence of specific ORCs and multiple ORCs was considerably greater in Q5 than in Q1 (Figure 3B and Table S8 in Data S1). Relative to individuals in Q1, individuals in Q5 were approximately five times more likely to have ASCVD (Q1: 3.2%; Q5: 16.0%), depression (Q1: 2.4%; Q5: 11.6%) or T2D (Q1: 6.2%; Q5: 29.6%), and were also more than twice as likely to have hypertension or back pain. Just over half of individuals in Q1, but almost all individuals in Q5, had ≥1

TABLE 2 Baseline characteristics of individuals with obesity in 2019 by cost quintiles.

Characteristic	Obesity ($N = 270\,493$)	Q1 ($n = 54\,099$)	Q2 ($n = 54\,099$)	Q3 ($n = 54\,099$)	Q4 ($n = 54\,098$)	Q5 ($n = 54\,098$)
Age in 2019, years, mean (SD)	49.9 (16.3)	41.3 (13.3)	44.7 (14.3)	50.2 (15.2)	54.5 (15.4)	58.9 (16.5)
Women, *n* (%)	153 751 (56.8)	24 618 (45.5)	30 388 (56.2)	32 079 (59.3)	32 955 (60.9)	33 711 (62.3)
BMI in 2019, kg/m^2, mean (SD)	34.6 (4.9)	34.2 (4.9)	34.2 (4.7)	34.5 (4.8)	34.8 (5.0)	35.1 (5.3)

Abbreviations: BMI, body mass index; Q, quintile; SD, standard deviation.

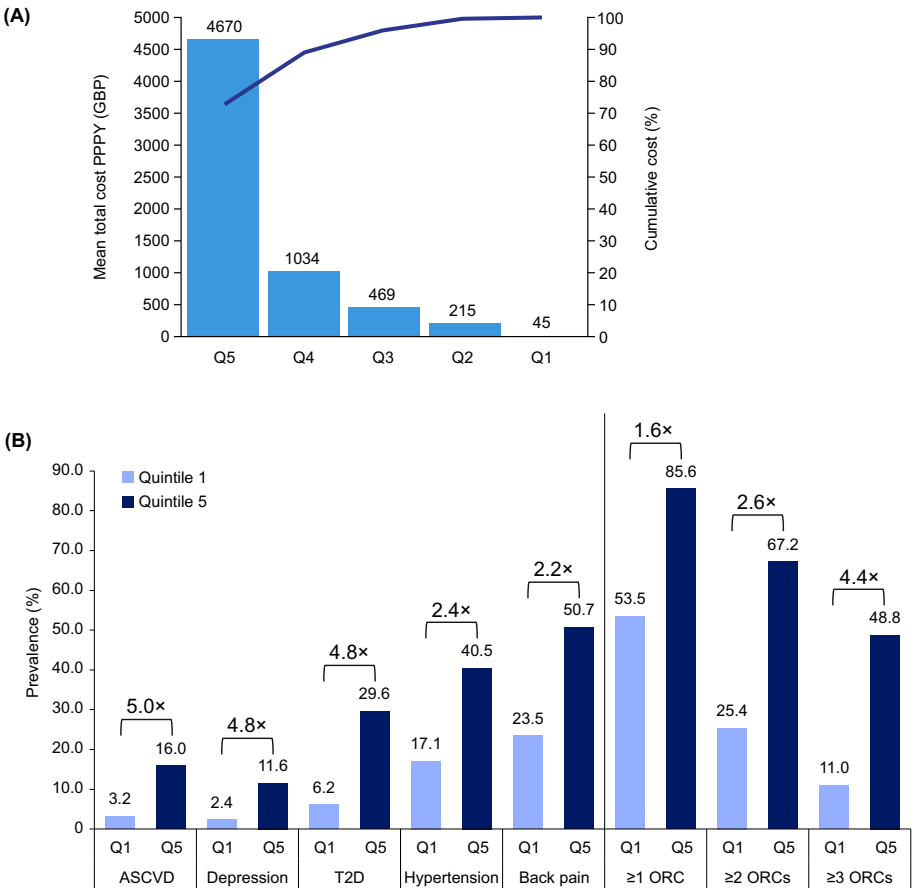


FIGURE 3 (A) Annual and cumulative costs in individuals with obesity in 2019, by cost quintile and (B) prevalence of obesity-related complications (ORCs) in the lowest (Q1) and highest cost (Q5) quintiles among individuals with obesity (2019 cross-section). In panel A, bars indicate the cost for each quintile, and the line indicates the cumulative cost as a percentage. ASCVD, atherosclerotic cardiovascular disease; GBP, pound sterling; PPPY, per person per year; Q, quintile; T2D, type 2 diabetes.

ORC (53.5% vs. 85.6%). Individuals in Q5 were more than twice as likely to have ≥2 ORCs than those in Q1 (Q1: 25.4%; Q5: 67.2%), and more than four times as likely to have ≥3 ORCs (Q1: 11.0%; Q5: 48.8%).

4 | DISCUSSION

The aim of this study was to use a large, representative electronic health records database to investigate how HCRU and costs were distributed across individuals living with overweight or obesity. We found that healthcare costs increased over time for people living with overweight or obesity, and both costs and cost increases were greater for successively higher BMI groups. This suggests that healthcare costs are increasing overall for this population, but costs for those in higher obesity classes are rising more sharply. We also found evidence that costs in obesity are strongly skewed, with 20% of those living with obesity in 2019 accounting for more than 72% of total healthcare costs, demonstrating large variation in unmet need.

A key finding of this study was that both total healthcare costs and HCRU increased between 2015 and 2019 for individuals with overweight or obesity. Importantly, the assessment of cost components and event types provides insights into the factors driving these findings. Although the number of inpatient admissions PPPY remained similar over time, the costs of these admissions increased, indicating that individual appointments became more costly. One possible interpretation of this is that patients who were hospitalized in each successive year of the follow-up period were more unwell than those hospitalized in previous years,

perhaps requiring longer lengths of stay once admitted. The increasing number of outpatient appointments over time in all groups also suggests that the study population experienced more health problems as follow-up progressed. Overall, the findings of our study indicate that costs and HCRU increase over time in individuals with overweight or obesity. Our results are aligned with previous analyses, which found that inpatient, outpatient, emergency room and drug costs increased over 8 years in a large US population with obesity.[16,17]

Previous studies, including a cross-sectional study[18] and a systematic literature review,[19] have shown that higher BMI is linked to greater healthcare costs. In our analysis, there was a stepwise increase in total healthcare costs, all cost components and mean numbers of HCRU events for each successive BMI group in every calendar year, and the disparity between the overweight and obesity class III groups increased over time. This was particularly apparent for the cost of inpatient admissions, for which the disparity between obesity class III and all other BMI groups increased markedly from 2015 to 2019. This suggests that individuals in the highest obesity class may be at particularly high risk of experiencing major health problems. The increase in healthcare costs for all groups over time is likely to be driven in part by increases in ORCs, as shown by the finding that the proportion of each BMI group with at least three ORCs increased between 2015 and 2019.

Assessment of average annual total healthcare costs for groups with specific ORCs showed that costs increased with BMI, but also appeared to vary depending on the type and number of ORCs present. The ORC groups with CKD or cardiovascular conditions incurred the highest costs. Costs were also higher in groups with successively higher numbers of ORCs, suggesting that multimorbidity may lead to higher HCRU. Notably, average annual costs for individuals with obesity class III and at least one ORC (£1749) were only slightly higher than those for the group with overweight and at least three ORCs (£1658). This indicates that the presence of ORCs may be associated with healthcare costs even in individuals with overweight rather than obesity. This is consistent with the findings of a previous analysis of US data, in which costs for individuals with specific ORCs, particularly CKD and CVD, were generally higher in higher obesity classes relative to lower classes.[17]

The cost quintile analysis found that 20% of the included individuals with obesity in 2019 incurred nearly three-quarters of the total healthcare costs. Relative to the lower cost quintiles, individuals in this group were older and more likely to be women, had slightly higher BMI, and had a higher comorbidity burden and greater rates of ORC multimorbidity. The high healthcare costs incurred by this particular group suggest that the overall economic impact of obesity could be greatly reduced by identifying high-risk individuals and offering prompt support and treatment to limit the progression of obesity and its complications. Importantly, previous real-world studies have indicated that weight loss can reduce both ORC risk[20,21] and healthcare costs,[22] highlighting the beneficial impacts of weight management.

Our study has several strengths. Discover contains a large, longitudinal set of detailed electronic healthcare records.[11,23] Therefore, our use of this database allowed us to identify large samples of individuals with eligible BMI measurements, permitting a robust cost quintile analysis to characterize a subgroup with high unmet need. This builds on the results of the present analysis and those of previous studies by indicating how existing knowledge about the impact of BMI and ORCs on healthcare costs can be translated into clinical practice. By prioritizing early intervention, the risk of progression to higher BMI classes, development of ORCs and requirement for HCRU can be limited or avoided.

The analysis was subject to the common limitations of observational studies. The study design required that an interaction with the healthcare system must have taken place in order for an eligible BMI measurement to be present, meaning that not all individuals in the population of interest were included. Electronic health records data and related research have the potential for misdiagnosis, miscoding and misclassification. This can affect studies of obesity; for example, an analysis of CPRD data found that the accuracy and completeness of BMI measurements in the database varied over time and according to demographic factors.[24] Owing to data availability, BMI was used as the only indicator of overweight or obesity in our analyses, and other measures, such as waist-to-hip ratio, were not considered. The data were externally age-standardized, but the analyses were not adjusted for other demographic factors such as age or ethnicity. As this was intended as a purely descriptive analysis, rather than an attempt to explore the individual effects of ORCs and other risk factors on healthcare costs, adjustment for multimorbidity or specific ORCs was outside the scope of the present study. Therefore, although costs were higher in groups with particular ORCs, and cost increases over time were accompanied by increases in multimorbidity, it is not possible to link our cost data definitively to the presence of ORCs. Future analyses incorporating regression analyses to quantify the impact of different ORCs on healthcare costs and HCRU events would be of great interest. Analyses that consider direct non-medical and indirect costs in addition to direct medical costs would also be of value.

In conclusion, healthcare costs varied across subgroups of individuals with overweight or obesity, tending to be greater in those with higher BMI and specific ORCs. This indicates the key importance of early intervention to limit the HCRU that results from BMI progression and treatment for ORCs. The people living with obesity that have the highest healthcare costs have a relatively high comorbidity burden and prevalence of ORC multimorbidity. Targeted prevention and obesity management efforts that reflect the variation in unmet need and support individuals in high-risk groups could both improve the health of people living with obesity and reduce healthcare demand and corresponding costs.

AUTHOR CONTRIBUTIONS

Sara Holloway and Andrew Thompson directly accessed and verified the underlying data reported in the manuscript. Jonathan Pearson-Stuttard, Sara Holloway and Andrew Thompson analysed the data.

Jonathan Pearson-Stuttard, Sara Holloway, Kasper Sommer Matthiessen, Andrew Thompson and Silvia Capucci had access to all data, and contributed to study concept and design. All authors contributed to drafting and critical revision of the manuscript text, and approved the manuscript for submission.

ACKNOWLEDGEMENTS

Medical writing support was provided by Caroline Freeman PhD of Oxford PharmaGenesis, Oxford, UK with funding from Novo Nordisk A/S.

FUNDING INFORMATION

This study was funded by Novo Nordisk A/S.

CONFLICT OF INTEREST STATEMENT

Jonathan Pearson-Stuttard is Partner and Head of Health Analytics at Lane Clark & Peacock LLP, Chair of the Royal Society for Public Health and reports personal fees from Novo Nordisk A/S and Pfizer Ltd outside of the submitted work. Sara Holloway and Andrew Thompson are employees of Lane Clark & Peacock LLP; Lane Clark & Peacock LLP received consulting fees from Novo Nordisk A/S to perform this analysis. Kasper Sommer Matthiessen and Silvia Capucci are employees of Novo Nordisk A/S.

DATA AVAILABILITY STATEMENT

The authors confirm that all data supporting the findings of this study are available within the article and its supplementary materials. Discover does not permit sharing or publication of individual patient data. Information on how to access Discover for research purposes can be found here: https://discover-now.co.uk/how-to-access-the-data/.

ORCID

Jonathan Pearson-Stuttard https://orcid.org/0000-0003-2175-9975

REFERENCES

1. World Obesity Federation. *World Obesity Atlas 2023*. Accessed January 16, 2024. https://s3-eu-west-1.amazonaws.com/wof-files/World_Obesity_Atlas_2023_Report.pdf
2. Ritchie H, Roser M. *Our World in Data. Obesity*. Last revised January 2024. Accessed January 12, 2024. https://ourworldindata.org/obesity
3. National Health Service Digital. *Health Survey for England, 2021: Data Tables*. December 15, 2022. Accessed October 25, 2023. https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2021/health-survey-for-england-2021-data-tables
4. Katsoulis M, Lai AG, Diaz-Ordaz K, et al. Identifying adults at high-risk for change in weight and BMI in England: a longitudinal, large-scale, population-based cohort study using electronic health records. *Lancet Diabetes Endocrinol*. 2021;9:681-694.
5. Divino V, Ramasamy A, Anupindi VR, et al. Complication-specific direct medical costs by body mass index for 13 obesity-related complications: a retrospective database study. *J Manag Care Spec Pharm*. 2021;27:210-222.
6. Haase CL, Eriksen KT, Lopes S, Satylganova A, Schnecke V, McEwan P. Body mass index and risk of obesity-related conditions in a cohort of 2.9 million people: evidence from a UK primary care database. *Obes Sci Pract*. 2021;7:137-147.
7. le Roux CW, Chubb B, Nortoft E, Borglykke A. Obesity and healthcare resource utilization: results from Clinical Practice Research Database (CPRD). *Obes Sci Pract*. 2018;4:409-416.
8. le Roux CW, Hartvig NV, Haase CL, Nordsborg RB, Olsen AH, Satylganova A. Obesity, cardiovascular risk and healthcare resource utilization in the UK. *Eur J Prev Cardiol*. 2021;28:1235-1241.
9. Soley-Bori M, Ashworth M, Bisquera A, et al. Impact of multimorbidity on healthcare costs and utilisation: a systematic review of the UK literature. *Br J Gen Pract*. 2021;71:e39-e46.
10. Discover-NOW. The Discover Dataset. Accessed February 8, 2024. https://discover-now.co.uk/the-data/#:~:text=The%20Discover%20Dataset,data%20feeds%20frequently%20being%20acquired
11. Bottle A, Cohen C, Lucas A, et al. How an electronic health record became a real-world research resource: comparison between London's Whole Systems Integrated Care database and the Clinical Practice Research Datalink. *BMC Med Inform Decis Mak*. 2020;20:71.
12. National Institute for Health and Care Excellence. *Obesity: How Should I Confirm if a Person Is Overweight or Obese?* Last revised in August 2023. Accessed June 4, 2024. https://cks.nice.org.uk/topics/obesity/diagnosis/identification-classification/
13. Curtis L, Burns A. *Unit Costs of Health and Social Care 2020*. Accessed January 30, 2023. https://www.pssru.ac.uk/project-pages/unit-costs/unit-costs-2020/
14. National Health Service Business Services Authority. *Prescription Cost Analysis—England 2020/21*. Accessed January 30, 2023. https://www.nhsbsa.nhs.uk/statistical-collections/prescription-cost-analysis-england/prescription-cost-analysis-england-202021
15. Eurostat. *Revision of the European Standard Population—Report of Eurostat's Task Force—2013 edition*. Accessed January 30, 2023. https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-RA-13-028
16. Evans M, Anupindi VR, DeKoven M, et al. Eight-year trends in obesity-related complications and health care cost progression in a US population with obesity: a retrospective cohort study. *Diabetes Obes Metab*. 2023;25:536-544.
17. Pearson-Stuttard J, Banerji T, de Laguiche E, et al. Cumulative 8-year direct healthcare costs of individuals with specific obesity-related complications in a US real-world population: a retrospective cohort study. *Obes Facts*. 2022;15:159-240.
18. Ward ZJ, Bleich SN, Long MW, Gortmaker SL. Association of body mass index with health care expenditures in the United States by age and sex. *PLoS One*. 2021;16:e0247307.
19. Kent S, Fusco F, Gray A, Jebb SA, Cairns BJ, Mihaylova B. Body mass index and healthcare costs: a systematic literature review of individual participant data studies. *Obes Rev*. 2017;18:869-879.
20. Haase CL, Lopes S, Olsen AH, Satylganova A, Schnecke V, McEwan P. Weight loss and risk reduction of obesity-related outcomes in 0.5 million people: evidence from a UK primary care database. *Int J Obes (Lond)*. 2021;45:1249-1258.
21. Khunti K, Schnecke V, Haase CL, et al. Weight change and risk of obesity-related complications: a retrospective population-based cohort study of a UK primary care database. *Diabetes Obes Metab*. 2023;25:2669-2679.
22. Bojke C, Capucci S, Haase CL, et al. Association between weight loss and health care resource utilization in adults living with obesity: evidence from a UK primary care database. *Diabetes Obes Metab*. 2023;25:3611-3620.
23. Pearson-Stuttard J, Holloway S, Polya R, et al. Variations in comorbidity burden in people with type 2 diabetes over disease duration: a population-based analysis of real world evidence. *EClinicalMedicine*. 2022;52:101584.

24. Bhaskaran K, Forbes HJ, Douglas I, Leon DA, Smeeth L. Representativeness and optimal use of body mass index (BMI) in the UK Clinical Practice Research Datalink (CPRD). *BMJ Open*. 2013; 3:e003389.

SUPPORTING INFORMATION

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

How to cite this article: Pearson-Stuttard J, Holloway S, Sommer Matthiessen K, Thompson A, Capucci S. Variations in healthcare costs by body mass index and obesity-related complications in a UK population: A retrospective open cohort study. *Diabetes Obes Metab*. 2024;1-10. doi:10.1111/dom.15785