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Impact of obesity on outcomes after total hip and knee replacement: A study on hospital length of stay and readmission rates in NHS Scotland

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ABSTRACT

Introduction: Obesity presents significant challenges in the perioperative management of patients undergoing total hip replacement (THR) and total knee replacement (TKR). This study investigates the association between BMI and the outcome measures length of stay and 30-day readmission rate, among National Health Service (NHS) patients in Scotland.

Methods: This analysis included data from 50,751 patients who underwent THR or TKR between July 2019 and February 2025. BMI was categorised into six groups then further divided into two categories: "Not Obese" and "Obese". LOS was classified as short or long. The analysis included a statistical method to visualise the relationship between BMI and the outcomes and logistic regression models that incorporated additional factors to assess their association with the outcomes.

Results: Patients with a BMI ≥40 had a longer mean length of stay (LOS) of 3.44 days and a median of 3 days, compared to a mean of 3.02 days and a median of 2 days among those with BMI <40 ($p < 0.001$). The odds of experiencing a prolonged hospital stay increased progressively with BMI thresholds: odds ratios were 1.43 for BMI ≥40, 1.53 for BMI ≥45, and 1.89 for BMI ≥50 (all $p < 0.001$). Patients with higher BMI, particularly those classified as Super Obese, demonstrated elevated 30-day readmission rates, reaching up to 17.5 %.

Conclusion: Higher BMI, especially in the morbidly and super obese ranges, is associated with extended hospital stays and increased 30-day readmission rates following THR and TKR.

1. Introduction

Enhanced recovery is a comprehensive approach designed to improve patient outcomes and accelerate recovery following surgical procedures. Enhanced recovery protocols include interventions implemented before, during, and after surgery to reduce physiological stress, maintain optimal bodily function, and promote early mobilisation and nutrition (Wainwright et al., 2020). In orthopaedic surgeries such as total hip replacement (THR) and total knee replacement (TKR), enhanced recovery principles prioritise early mobilisation, effective pain control, and reduced length of stay (LOS) (Wainwright et al., 2020). Following review of international literature and through national consensus meetings, National Health Service (NHS) Scotland has developed a national Enhanced Recovery After Surgery (ERAS) pathway for non-complex primary total hip, total knee, and unicompartmental knee replacements. This pathway defines nationally agreed essential elements across the perioperative period to support same-day and next-day discharge. It includes recommendations for preoperative education and optimisation, intraoperative practices such as regional anaesthesia and minimised opioid use, and postoperative elements like multimodal analgesia and early mobilisation (Centre for Sustainable Delivery, 2023).

Obesity, a global epidemic, poses a challenge withing the enhanced recovery pathway by increasing postoperative complications, LOS, and readmission rates (World Health Organization, 2023; Shalaby et al., 2025). In England, between 2022 and 2023, 64.0 % of adults aged 18 years and over were classified as overweight or obese—a figure that continues to rise (UK Health Security Agency, 2024). Obesity is commonly evaluated using BMI, a metric widely employed to categorise weight status. According to Scottish Committee for Orthopaedics &

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Trauma (SCOT) classifications, individuals are considered overweight with a BMI of 25–29.9 kg/m^2, obese with a BMI of 30–39.9 kg/m^2, morbidly obese at a BMI ≥40 kg/m^2, and super obese used to describe individuals with a BMI ≥50 kg/m^2 (Scottish Committee for Orthopaedics & Trauma, 2021). BMI has been associated with diverse health outcomes, particularly regarding resource utilisation within healthcare systems (Ma et al., 2016).

Managing patients with obesity in orthopaedic surgery is particularly challenging. For example, a review by Juhl et al. (2024) found that while weight loss in patients with hip or knee osteoarthritis may lead to slight improvements in pain and physical function, the extent of weight loss does not consistently correlate with better outcomes (Juhl et al., 2024). These findings underscore the complexity of treating patients with obesity and highlight the need for individualised approaches when implementing ERAS in joint replacement surgeries.

While BMI is widely used to classify obesity in research and clinical practice, relying on it alone has some limitations. First, BMI does not distinguish between fat and lean muscle mass, nor does it account for fat distribution or variation by age or sex. Also, although BMI is a convenient tool for population-level analysis, it may not fully capture individual-level risks or the complexity of obesity. Moreover, using only BMI can be challenging, as other factors such as comorbidities and clinical context may also influence outcomes.

This study aims to investigate the association between BMI categories and hospital outcomes, specifically LOS and 30-day readmission rates, following THR or TKR within NHS Scotland. It tests the hypothesis that a higher BMI (particularly BMI ≥40) negatively impacts recovery. Specifically, we hypothesise that patients with BMI ≥40 will have a longer LOS (LOS >2 days) and a higher 30-day readmission rate compared to those with BMI <40. The decision to use BMI ≥40 kg/m^2 as a primary cut-off for analysis is based on established clinical guidelines, where this threshold defines morbid obesity and indicates higher perioperative risk. We also aim to explore the distribution of BMI categories across different hospitals in Scotland and their impact on these outcomes.

2. Methods

2.1. Dataset

This retrospective analysis was conducted using anonymised data provided by NHS Scotland and is reported in accordance with the STROBE checklist (von Elm et al., 2007). The dataset included 50,751 patients who underwent THR or TKR procedures. Data were collected from 22 NHS hospitals across Scotland participating in the ERAS programme, from July 2019 to February 2025. All hospitals included were actively implementing ERAS pathways for primary elective joint replacement during the study period.

2.2. Inclusion and exclusion criteria

Inclusion criteria.

- Age ≥18 years
- Underwent primary elective THR or TKR between July 2019 and February 2025
- Complete data for BMI, admission, and discharge dates, and 30-day readmission status
- Available demographic data (sex, age, frailty score, ASA score)

Exclusion criteria.

- Missing or incomplete data for any key variable (BMI, admission/discharge dates, or 30-day readmission)
- BMI values outside the study range (BMI <10 or BMI ≥100)
- Non-elective or revision procedures

2.3. BMI classification

BMI was calculated and patients were categorised into six BMI classes following the guidelines set by SCOT (Scottish Committee for Orthopaedics & Trauma, 2021).

- Normal Weight: BMI 18.5–25
- Overweight: BMI 25–29.9
- Class I Obesity (Obese): BMI 30–34.9
- Class II Obesity (Severe Obesity): BMI 35–39.9
- Class III Obesity (Morbid Obesity): BMI 40–49.9
- Super Obesity: BMI ≥50

For analysis purposes, BMI was grouped into two categories using a cut-off of 40 kg/m^2, which distinguishes Class III obesity (severe/morbid obesity) from lower BMI categories. This threshold is widely used in orthopaedic research and clinical practice because patients with BMI ≥40 kg/m^2 are at significantly higher risk of postoperative complications following joint replacement surgery (Kheir et al., 2023).

The two groups were defined as follows.

- Obese: BMI ≥40 (Class III Obesity and Super Obesity)
- Not Obese: BMI <40 (Normal Weight to Class II Obesity)

2.4. Outcomes

2.4.1. Length of stay (LOS)

LOS was calculated by subtracting the admission date from the discharge date. LOS was then categorised into two categories as follow.

- Short Stay: LOS ≤2 days
- Long Stay: LOS >2 days

Note: It should be noted that the admission date does not always coincide with the day of surgery, which means that LOS may include days prior to the surgical procedure if patients were admitted earlier. The observed LOS in this study ranged from 0 to 100 days.

2.5. 30-Day readmission

Readmission within 30 days was defined as any hospital readmission occurring within 30 days following the initial discharge date. This outcome was coded as a binary variable (0 = no readmission, 1 = readmission).

Table 1
Description of the variables included in the analysis.

Variable Name	Description	Type	Categories/Units
Age	Age at admission	Continuous	Years
Sex	Patient gender	Categorical	Male, Female
BMI	Body Mass Index	Continuous	kg/m^2
BMI categories	Body Mass Index Category	Categorical	Normal weight, Overweight, Class I Obesity, Class II Obesity, Class III Obesity, Super obesity
Frailty Score	Frailty index score	Ordinal	1–9
ASA (American Society of Anaesthesiologists)	ASA Score	Ordinal	1–5

2.6. Study variables

The study included demographic and clinical variables for analysis. Table 1 provides a summary of the variables used in this study including their definitions, categories, and types.

2.7. Data analysis

For the analysis, visual tools were used to explore and better understand the distribution of data as follow.

- Flowchart: Shows the inclusion and exclusion criteria and number of patients excluded (Fig. 1).
- Count and Bar Charts: Illustrates the distribution of BMI Categories (Fig. 2). Second bar chart shows Proportion of LOS over 2 Days and 30-Day Readmissions by BMI Group (Fig. 3).
- Table: Summarises regression results (Table 3) and shows the percentage distribution of BMI categories, the average LOS, and the readmission rate for each hospital (Table 2).

2.8. Logistic regression

Following the visual analysis, a logistic regression model was used to assess the relationship between BMI and LOS. BMI was treated as the independent variable, while LOS (Short Stay vs. Long Stay) was the dependent variable. The regression model was implemented to quantify the likelihood of patients with higher BMI (BMI ≥40) experiencing a long hospital stay compared to those with BMI <40. By calculating odds ratios, we were able to estimate the relative likelihood of a long hospital stay for patients with BMI ≥40.

2.9. Bias

During the initial analysis, we identified a significant class imbalance

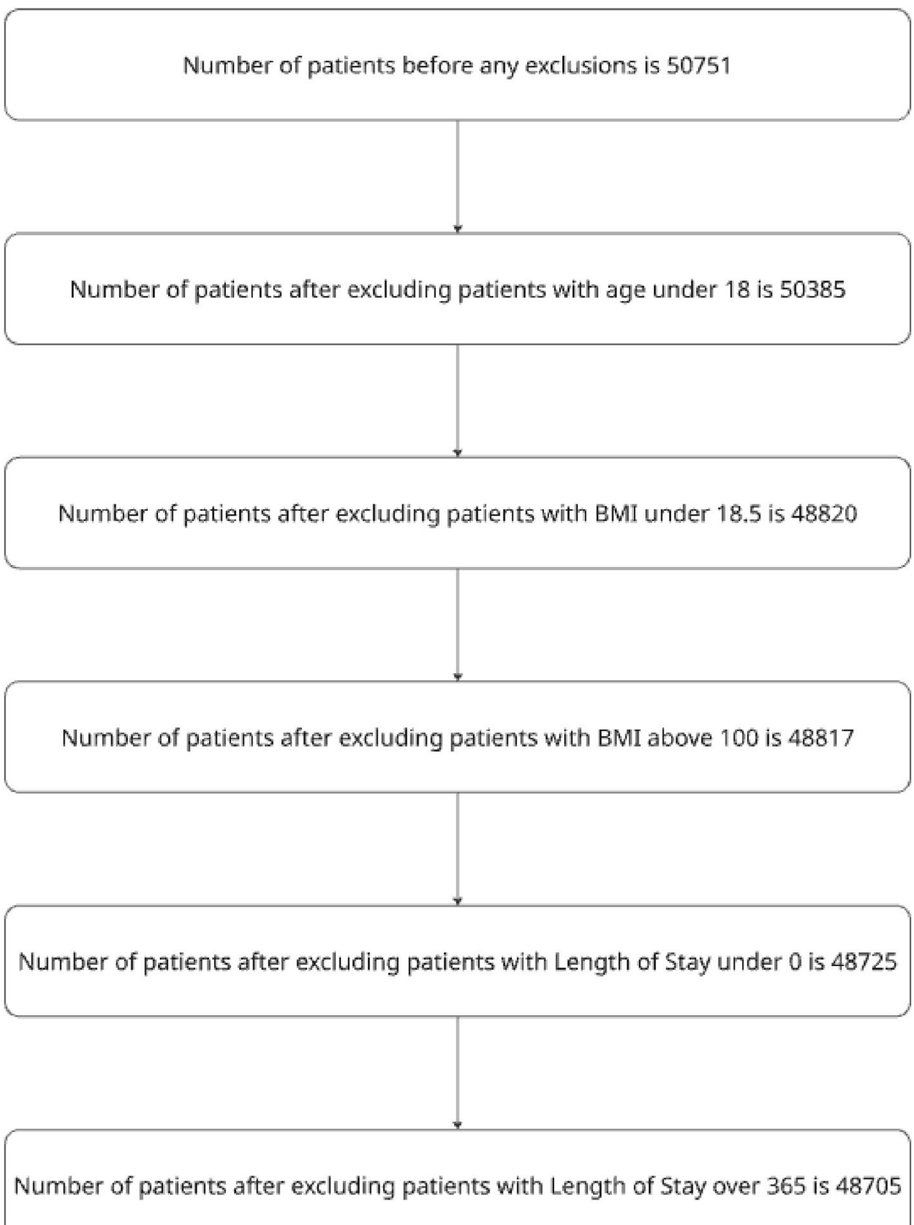

Fig. 1. Participants flowchart: Bmi data inclusion and exclusion criteria.

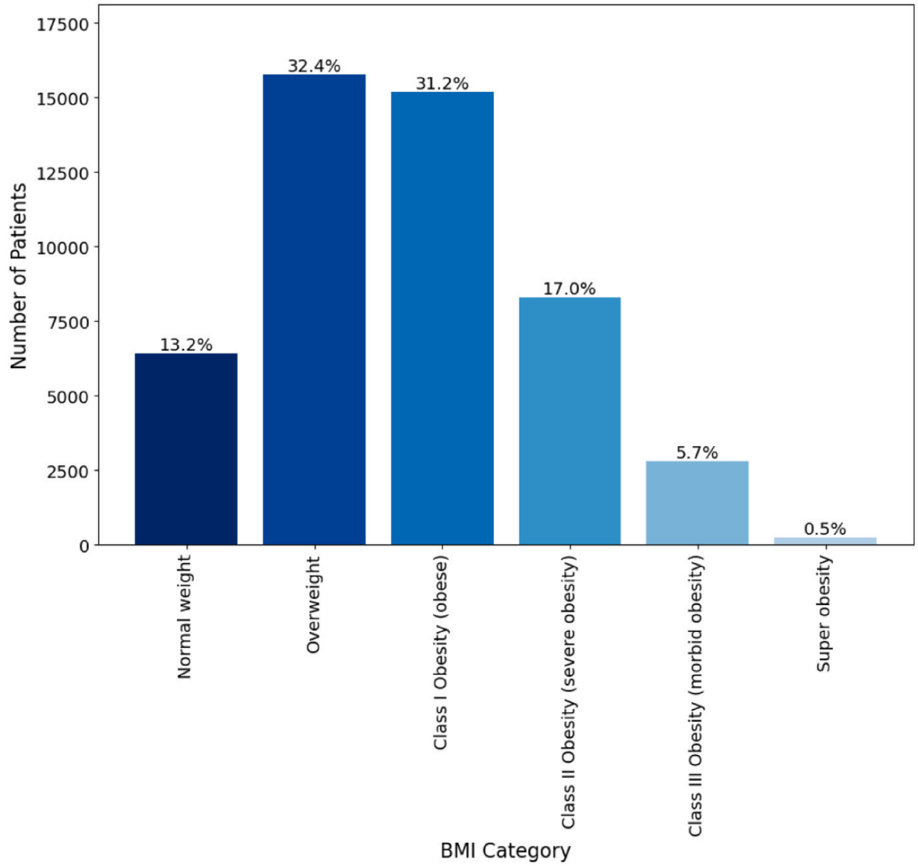

Fig. 2. Prevalence of BMI categories.

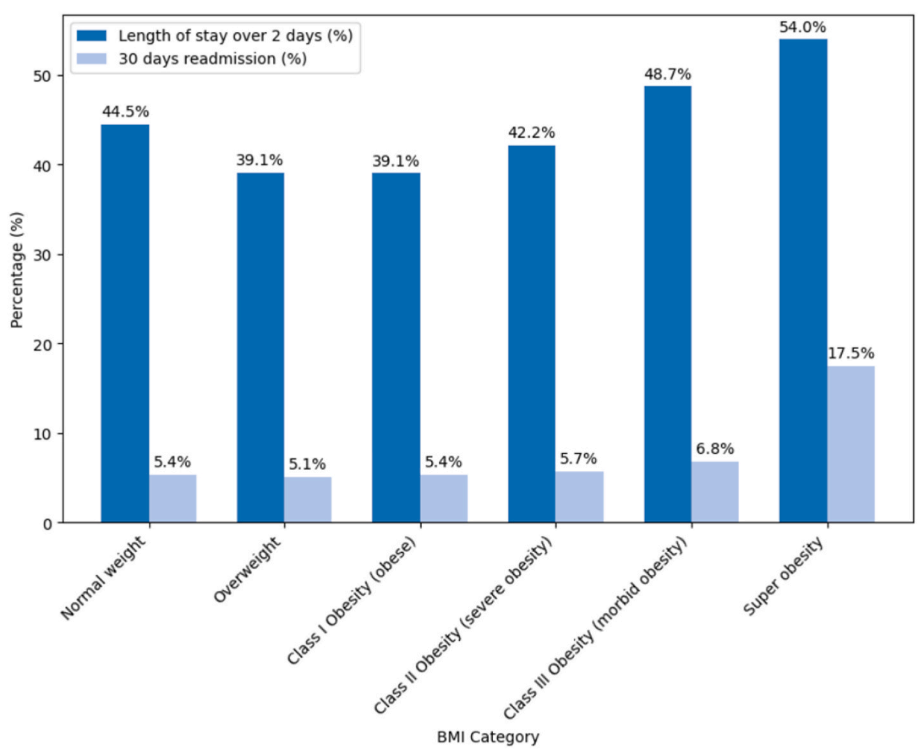

Fig. 3. Proportion of LOS over 2 Days and 30-day readmissions by BMI group.

Table 2
Length of stay statistics by BMI category.

BMI Category	Count	Mean	Median	SD	95 % CI Lower	95 % CI Upper	P-value
Normal weight	6429	3.35	2	6.88	3.18	3.52	<0.001
Overweight	15766	3.01	2	7.06	2.90	3.12	<0.001
Class I Obesity	15180	2.90	2	5.27	2.82	2.99	<0.001
Class II Obesity	8297	2.96	2	4.09	2.88	3.05	<0.001
Class III Obesity	2799	3.43	2	4.81	3.25	3.61	<0.001
Super obesity	237	3.65	3	3.73	3.18	4.13	<0.001
Not Obese (BMI ≤40)	2894	3.44	2	4.77	3.26	3.61	<0.001
Obese (BMI >40)	45814	3.02	3	6.01	2.96	3.07	<0.001

Table 3
Odds of Long Hospital Stay/30 days readmission by BMI Category Compared to BMI <40.

BMI Category	Length of Stay				30-Day Readmission			
	Odds Ratio	95 % CI Lower	95 % CI Upper	p-value	Odds Ratio	95 % CI Lower	95 % CI Upper	p-value
40 ≤ BMI < 45	1.369	1.261	1.487	<0.001	1.289	1.011	1.643	<0.05
45 ≤ BMI < 50	1.578	1.305	1.908	<0.001	1.363	0.829	2.241	0.2
BMI ≥ 50	1.750	1.130	2.711	<0.001	2.784	1.174	6.601	<0.05

within the BMI categories. Super obese patients made up only 0.5 % of the data, and Class III obese patients represented 5.7 %, while 32.9 % were classified as overweight. To manage this imbalance, we used bar charts and a heatmap to visually separate the categories, so we can evaluate each category independently. This step was used to present a clear visual representation of the disparities across categories and ensure that each category could be analysed without being overshadowed by the dominant classes.

In the logistic regression analysis, we further observed that most patients had a BMI <40, with 45,811 patients (94.06 %) in this category, while only 2894 patients (5.94 %) had a BMI ≥40. This imbalance risked a selection bias, as the model could favour the majority group and generate skewed predictions for the minority groups.

To avoid this bias, we applied two key techniques. First, oversampling was used to increase the representation of patients in the BMI ≥40 group and to ensure that both BMI categories were equally represented in the model and improving the accuracy of predictions. Oversampling was conducted by randomly duplicating cases from the BMI ≥40 group (random sampling with replacement) until the two groups were of equal size. Weighted logistic regression was also used by assigning higher weights to the BMI ≥40 group. This adjustment was applied to ensure that the minority group had sufficient influence in the analysis.

2.10. Data anonymisation

To protect the privacy of individuals and institutions, all data used in this report has been fully anonymised. Hospitals are represented by numbers instead of names, and all patient information has been anonymised to ensure complete anonymity. This process complies with ethical standards and data protection regulations to ensure that no personal or institutional details can be traced back.

2.11. Ethical considerations

Ethical approval was received from Bournemouth University on March 02, 2025 (Ethics ID – 62489) after previous review and approval from the Golden Jubilee National Hospital Audit Committee on January 29, 2024. Full NHS ethical review was not required for this study as it involved the retrospective analysis of anonymous secondary data provided by NHS Scotland. All data was anonymised in accordance with data protection regulations, and no individual patient or hospital identifiers were used in the analysis. This study was conducted in compliance with relevant ethical standards and the guidelines outlined in the STROBE checklist (von Elm et al., 2007).

3. Results

3.1. Participants

After applying the inclusion and exclusion criteria mentioned in the method section, 48,705 patients remained in the final analysis.

The following flow diagram summarises the selection process (Fig. 1).

3.2. BMI prevalence

The graph below presents the distribution of patients across BMI categories, including both the absolute number of patients and their corresponding percentages (Fig. 2).

Fig. 2 illustrates the distribution of BMI categories within the study population, which was skewed toward the middle BMI categories. Overweight and Class I Obese patients accounted for the largest proportions, representing 32.4 % (n = 15764) and 31.2 % (n = 15180) of the cohort, respectively. Class III Obese and Super Obese patients were less prevalent, comprising only 5.7 % (n = 2799) and 0.5 % (n = 237) of the population. Another interesting observation is that over 54 % of the patients are classified as obese (BMI ≥30).

3.3. Length of stay

Fig. 3 shows the relationship between BMI category and key postoperative outcomes, specifically the proportion of patients experiencing a prolonged hospital stay (LOS >2 days) and those readmitted within 30 days.

As illustrated in Fig. 3, normal weight group has 44.5 % (n = 2862) of patients staying longer than 2 days, with a readmission rate of 5.4 %. Both the Overweight and Class I Obesity groups have similar proportions, around 39.1 % (n = 6165, n = 5930), with readmission rates of about 5 % (n = 345). In the Class II Obesity group, 42.2 % (n = 3499) of patients stay longer than 2 days, with a readmission rate of 5.7 % (n = 194).

The Class III Obesity group shows a jump, with over half of 48.7 % (n = 1364) of patients staying longer than 2 days, and Super obesity has the highest proportion with 54 % (n = 128) staying longer and a readmission rate of 17.5 % (n = 14).

Fig. 4 shows the trend in average hospital LOS from 2020 to 2024 for the study cohort. By displaying annual changes in mean LOS, this figure

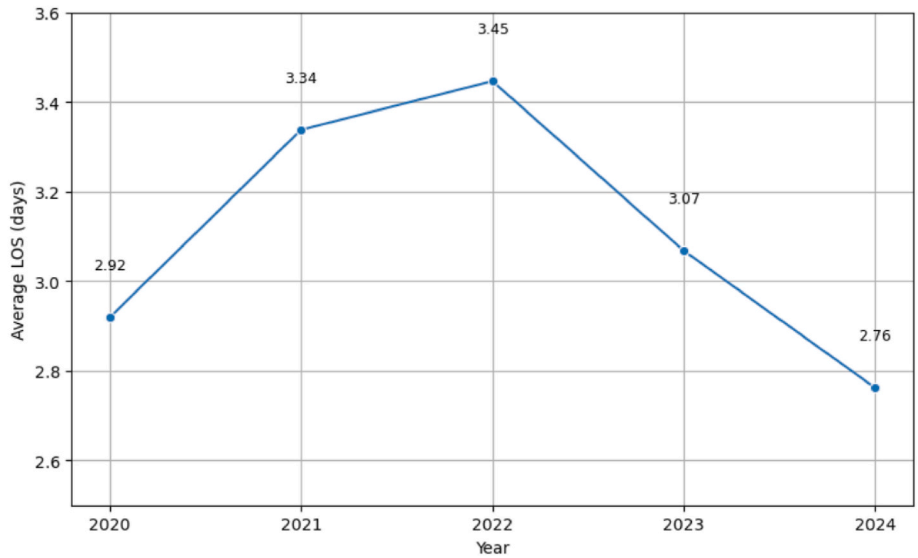

Fig. 4. Mean length of stay by year (2020–2024).

provides insight into how hospital stay durations have varied over time, potentially reflecting the impact of evolving clinical practices, patient characteristics, or external factors during the study period.

In 2020, the average LOS was 2.92 days. This figure increased steadily to 3.34 days in 2021 and peaked in 2022 at 3.45 days, indicating a temporary rise in hospital stays during that period. However, a notable decline followed, with the average LOS dropping to 3.07 days in 2023 and further decreasing to 2.76 days in 2024 (Fig. 4).

3.4. BMI impact on LOS

Table 2 presents a comprehensive overview of hospital LOS across different BMI categories and on patients grouped by BMI <40 and BMI ≥40.

Table 2 shows that for patients with BMI <40 (n = 29928), the mean LOS is 3.38 days, with a standard deviation of 24.71 days. The 95 % confidence limits range from 3.10 to 3.66 days, and the p-value is statistically significant at <0.001. In contrast, the BMI ≥40 category (n = 1753) shows a slightly higher mean LOS of 3.87 days. The 95 % confidence interval for this group ranges from 3.41 to 4.31 days, with a similarly significant p-value of <0.001. This indicates that patients with a BMI ≥40 tend to have longer hospital stays on average compared to those with BMI <40, though the variability in LOS is greater in the BMI <40 group. The data clearly highlights a trend of increased hospital stay durations in patients with higher BMI.

Table 3 presents the odds ratios for prolonged hospital stay across different BMI categories (40 ≤ BMI <45, 45 ≤ BMI <50, and BMI ≥50), using BMI <40 as the reference group. The estimates were obtained from a logistic regression model and include 95 % confidence intervals and p-values to assess statistical significance.

The likelihood of prolonged hospital stay increases progressively with higher BMI. Compared to patients with BMI <40, those with BMI 40–45 have 37 % higher odds of extended stay, 58 % higher for BMI 45–50, and 75 % higher for BMI ≥50 — all statistically significant ($p < 0.05$).

A similar trend is observed for 30-day readmission. Patients with BMI ≥50 have nearly 2.8 times higher odds of readmission ($p = 0.020$), indicating a strong association with extreme obesity. The increase is more modest and less consistent in lower obesity categories. (Fig. 3).

Table 4 presents the percentage distribution of patients across 23 hospitals based on BMI category (BMI <40 vs. BMI ≥40), hospital LOS (short vs. long), and 30-day readmission status (Yes vs. No).

The proportion of patients with BMI ≥40 varies between hospitals, ranging from 0.78 % (n = 18) in Hospital 18 to 16.13 % (n = 191) in Hospital 5. While most hospitals have a relatively small proportion of patients with BMI ≥40, the distribution of longer stays (LOS >2 days) shows greater variability. Hospitals such as Hospital 1 and Hospital 9 report high rates of longer stays (88.12 % (n = 89) and 76.92 % (n = 240), respectively), whereas others like Hospital 16 and Hospital 15 report very low long-stay proportions (1.46 % (n = 11) and 11.97 % (n = 34), respectively).

Readmission rates also vary, with several hospitals (e.g., Hospital 8, Hospital 13, Hospital 15, Hospital 20, and Hospital 23) reporting no readmissions within 30 days, while Hospital 9 and Hospital 21 have the highest readmission rates (11.22 % (n = 35) and 8.33 % (n = 112), respectively).

Table 4 shows that hospitals with a greater proportion of patients with BMI ≥40 tended to report higher rates of prolonged hospital stay and 30-day readmissions. For instance, Hospital 1, with 9.9 % (n = 10) of patients in the BMI ≥40 category, reported 88.1 % (n = 89) long stays and an 8.9 % (n = 9) readmission rate. In contrast, Hospital 15, where only 1.06 % (n = 3) of patients had BMI ≥40, had just 11.9 % (n = 12) long stays and no readmissions.

The study population had a mean age of 70 years, with 57.3 % female and 42.7 % male. Most patients were either overweight or obese, with 32.4 % classified as overweight and 53.1 % as obese. High frailty (frailty score ≥5) was observed in 10.4 % of the cohort. To address the limitations of BMI alone, demographic factors such as age, sex, frailty score, and ASA classification were incrementally added to the model. Table 5 presents the performance of four logistic regression models predicting length of stay (LOS) and 30-day readmission.

Table 5 reports the following key performance metrics: ROC AUC, accuracy, precision, and recall. The ROC AUC (area under the receiver operating characteristic curve) is a standard measure of how well a model can distinguish between patients with and without the outcome. An ROC AUC of 0.5 indicates no discriminative ability (equivalent to random chance), whereas a value of 1 represents perfect discrimination. Accuracy shows the proportion of overall correct predictions, precision measures the proportion of true positive predictions among all predicted positives, and recall (sensitivity) reflects the proportion of true positives identified by the model. Higher values for these metrics show better model performance. As shown in Table 5, model performance improved as more demographic factors were included, with the best results observed for models incorporating all available demographic predictors.

The characteristics of each model are summarised below.

Table 4
Hospital-level distribution of BMI, length of stay and 30-day readmission rates (percentages).

Hospital	BMI <40 (n, %)	BMI ≥40 (n, %)	Long stay (n, %)	Short stay (n, %)	Not readmitted (n, %)	Readmitted (n, %)
Hospital 1	91 (90.1 %)	10 (9.9 %)	89 (88.1 %)	12 (11.9 %)	92 (91.1 %)	9 (8.9 %)
Hospital 2	2769 (89.6 %)	320 (10.4 %)	1483 (48.0 %)	1606 (52.0 %)	3054 (98.9 %)	35 (1.1 %)
Hospital 3	681 (89.5 %)	80 (10.5 %)	481 (63.2 %)	280 (36.8 %)	718 (94.3 %)	43 (5.7 %)
Hospital 4	947 (95.8 %)	42 (4.2 %)	471 (47.6 %)	518 (52.4 %)	955 (96.6 %)	34 (3.4 %)
Hospital 5	993 (83.9 %)	191 (16.1 %)	569 (48.1 %)	615 (51.9 %)	1132 (95.6 %)	52 (4.4 %)
Hospital 6	1932 (89.8 %)	219 (10.2 %)	1126 (52.3 %)	1025 (47.7 %)	2046 (95.1 %)	105 (4.9 %)
Hospital 7	2687 (93.6 %)	183 (6.4 %)	1197 (41.7 %)	1673 (58.3 %)	2739 (95.4 %)	131 (4.6 %)
Hospital 8	2241 (95.0 %)	119 (5.0 %)	1158 (49.1 %)	1202 (50.9 %)	2360 (100 %)	0 (0.0 %)
Hospital 9	285 (91.3 %)	27 (8.7 %)	240 (76.9 %)	72 (23.1 %)	277 (88.8 %)	35 (11.2 %)
Hospital 10	2988 (92.7 %)	235 (7.3 %)	667 (20.7 %)	2556 (79.3 %)	3124 (96.9 %)	99 (3.1 %)
Hospital 11	447 (95.5 %)	21 (4.5 %)	305 (65.2 %)	163 (34.8 %)	437 (93.4 %)	31 (6.6 %)
Hospital 12	3302 (91.2 %)	320 (8.8 %)	1667 (46.0 %)	1955 (54.0 %)	3489 (96.3 %)	133 (3.7 %)
Hospital 13	14912 (96.4 %)	555 (3.6 %)	6883 (44.5 %)	8584 (55.5 %)	15467 (100 %)	0 (0.0 %)
Hospital 14	2645 (91.9 %)	232 (8.1 %)	776 (27.0 %)	2101 (73.0 %)	2873 (99.9 %)	4 (0.1 %)
Hospital 15	281 (98.9 %)	3 (1.1 %)	34 (12.0 %)	250 (88.0 %)	284 (100 %)	0 (0.0 %)
Hospital 16	739 (98.4 %)	12 (1.6 %)	11 (1.5 %)	740 (98.5 %)	728 (96.9 %)	23 (3.1 %)
Hospital 17	1541 (96.9 %)	49 (3.1 %)	1124 (70.7 %)	466 (29.3 %)	1481 (93.1 %)	109 (6.9 %)
Hospital 18	760 (99.2 %)	6 (0.8 %)	144 (18.8 %)	622 (81.2 %)	716 (93.5 %)	50 (6.5 %)
Hospital 19	2642 (97.7 %)	61 (2.3 %)	346 (12.8 %)	2357 (87.2 %)	2637 (97.6 %)	66 (2.4 %)
Hospital 20	164 (94.8 %)	9 (5.2 %)	136 (78.6 %)	37 (21.4 %)	173 (100 %)	0 (0.0 %)
Hospital 21	1198 (89.1 %)	147 (10.9 %)	623 (46.3 %)	722 (53.7 %)	1233 (91.7 %)	112 (8.3 %)
Hospital 22	1204 (97.3 %)	33 (2.7 %)	220 (17.8 %)	1017 (82.2 %)	1170 (94.6 %)	67 (5.4 %)
Hospital 23	362 (94.8 %)	20 (5.2 %)	198 (51.8 %)	184 (48.2 %)	382 (100 %)	0 (0.0 %)

- BMI only: Used as a baseline for comparison.
- BMI + Age: Adding age improved prediction of both LOS and 30-day readmission, wich highlights age as an important factor.
- BMI + Age + Sex: Including sex led to further improvement, which suggest that sex-related physiological differences influence outcomes.
- BMI + All Demographics: The best performance was achieved when including age, sex, frailty score, and ASA classification, emphasising the value of a comprehensive demographic profile for accurate outcome prediction.

4. Discussion

Our findings show extended LOS and elevated readmission rates among patients classified as Class III (morbid obesity) and Super Obesity. These results support the recommendations of Scottish Intercollegiate Guidelines Network (SIGN), which advocate for individualised interventions to manage the complex care needs of obese patients, particularly those in higher BMI categories (Scottish Intercollegiate Guidelines Network, 2010). Further clinical recommendations from orthopaedic bodies such as SCOT suggest adapting enhanced recovery pathways to provide more intensive perioperative management for high-risk patients, including those with BMI ≥40 (Scottish Committee for Orthopaedics & Trauma, 2021).

There is ongoing debate in the literature regarding the relationship between BMI and postoperative outcomes, with studies presenting mixed findings. A recent scoping review highlighted considerable variation in reported outcomes and noted that the impact of obesity on total joint arthroplasty outcomes remains uncertain (Jester et al., 2021). While some studies suggest that BMI has little or no impact on outcomes, others—including our own—indicate a significant association. For example, Richard et al. reported that only extreme obesity (BMI over 50) was linked to an increased risk of extended LOS or readmission after THA or TKR (Richard et al., 2018). Our results further support this, demonstrating that patients with a BMI over 50 are 75 % more likely to experience extended hospital stays and are nearly 2.8 times more likely to be readmitted within 30 days compared to those with a BMI below 40.

Further supporting these findings, a study by Fusco et al. found that severely obese individuals were more likely to be admitted to the ICU and had hospital stays 50 % longer than their non-obese counterparts (Fusco et al., 2017). Similarly, research on readmission rates by Schuller reported that obese patients had a higher likelihood of readmission, with non-obese individuals being 21 % less likely to be readmitted (Schuller, 2020).

Our results also indicate that patients in the Overweight and Class I Obesity categories had the lowest LOS and readmission rates. This suggests that some excess fat may be protective, potentially helping in coping with surgical stress and enhancing recovery. This aligns with previous research by Mullen et al., which shows that moderate increases in BMI can be beneficial in certain surgical populations (Mullen et al., 2009). It is also important to acknowledge that BMI is not always a perfect proxy for body composition, as individuals with higher BMI may have increased muscle mass rather than excess adiposity, which could further contribute to better post-surgical outcomes (Li et al., 2022).

However, the large variability in LOS among patients suggests that BMI alone does not fully explain hospital stay durations and readmission. Other factors, such as patient-related characteristics (e.g., age, sex, comorbidities), surgical factors (e.g., medical or surgical complications), and contextual influences (e.g., clinical pathways, care delivery, organisational processes), should be considered with BMI to better assess their impact. In our study, incorporating additional demographic variables—age, sex, frailty score, and ASA classification—progressively improved the model's performance. The results indicate that including all demographic factors yielded the highest predictive accuracy. These findings support previous research, such as a study by Cutti et al. (2020) which developed the Surgical Mortality

Table 5
Comparison of Model Performance Metrics for Predicting Length of Stay (LOS) and 30 days readmission Using BMI and Demographic Predictor Sets.

	Length of stay				30 Days Readmission			
	ROC AUC	Accuracy	Precision	Recall	ROC AUC	Accuracy	Precision	Recall
BMI Only	0.503	0.506	0.392	0.475	0.56	0.54	0.066	0.55
BMI + Age	0.621	0.584	0.476	0.616	0.59	0.52	0.07	0.61
BMI + Age + Sex	0.631	0.587	0.478	0.601	0.60	0.53	0.07	0.60
BMI + All Demographics	0.673	0.626	0.520	0.595	0.66	0.64	0.09	0.58

Assessment and sTraTification (SMATT) score. This score incorporates key variables, including age, BMI, ASA score, surgical complexity, and comorbidities. The study demonstrated that integrating these factors into a multivariable model significantly enhanced the prediction of perioperative mortality, achieving an impressive area under the curve (AUC) of 0.941 (Cutti et al., 2020). Similarly, the study by Faklet et al., examined predictors of postoperative complications. The researchers included age, sex, BMI, ASA score, and creatinine levels in their multivariable analysis and found that these factors were significantly associated with postoperative complications (Fakler et al., 2016).

Another observation in this study is the variability in hospital outcomes, which highlights the interplay between institutional practices and other contextual factors that affect the recovery of obese patients. The results shows that 44.73 % of patients stayed in the hospital longer than 2 days, while readmission rates varied between 0 % and 11.22 %. Some hospitals despite having a higher proportion of obese patients, managed to maintain shorter LOS and lower readmission rates. This suggests that effective strategies and protocols, along with favourable contextual conditions, can mitigate the challenges posed by obesity. Factors such as surgical expertise, tailored postoperative care protocols, and patient management strategies can play a role in determining recovery outcomes (Gustafsson et al., 2012). This aligns with existing research, as a study by Kannan et al. demonstrates that the implementation of enhanced recovery protocols effectively reduces LOS. Their findings show that hospitals using ERAS protocols experience significantly shorter hospital stays compared to those following conventional care (Kannan et al., 2025). Another study by Siddique et al. suggests that differences in surgical expertise and tailored postoperative care protocols influence patient recovery outcomes. Hospitals with specialised teams and structured care pathways tend to achieve better results, even among high-risk obese populations (Siddique et al., 2021).

While all the findings in this study provide important insights into the clinical sector, they are specific to NHS Scotland, where standardised enhanced recovery protocols play an important role in surgical recovery (Centre for Sustainable Delivery, 2023). Although the relationship between higher BMI and longer hospital stays aligns with existing literature, these results may not fully apply to other healthcare systems with different perioperative care models, patient demographics, or discharge criteria. Variations in hospital resources, rehabilitation services, and obesity prevalence may also influence how BMI impacts LOS and readmission rates. However, given the consistency of similar trends in previous research, the findings offer valuable insights that could be relevant to other healthcare settings with structured recovery protocols.

It is also important to acknowledge that while the addition of demographics improved model performance, the predictive metrics indicate room for further enhancement. Future research could explore the inclusion of additional clinical and contextual variables, such as comorbidities, socioeconomic factors, or surgical complexity, to further improve predictive accuracy. Moreover, validation across diverse patient populations and healthcare settings would ensure generalisability and robustness.

4.1. Limitations

This study has limitations that should be considered in future research. While BMI is often used to represent obesity, it is important to recognise that a high BMI does not always mean poor health. BMI does not differentiate between fat and muscle mass (Nuttall, 2015). Therefore, individuals with a high BMI may be more muscular or have a larger frame, none of which indicate poor health. This limitation may lead to misclassification of certain individuals as obese when, in fact, they may have been healthy (Nuttall, 2015).

The spread of the data and the presence of outliers, particularly in the LOS variable, suggest that factors other than BMI might also significantly influence hospital stays. While BMI is an important variable, other factors such as pre-existing conditions, the nature of the surgical procedure, the clinical pathways implemented in the hospital, and the healthcare setting—whether a day-case unit or an inpatient ward—can also impact LOS (Husted et al., 2008; Rotter et al., 2008; Malahias et al., 2021). Additionally, the distribution of patients across BMI categories was uneven, with fewer patients in the “Super Obesity” category, which limits the reliability of conclusions for this group. Comparisons between this smaller group and other BMI categories may not fully capture the nuances of patient outcomes in this population.

5. Conclusion

This study investigated the impact of BMI on hospital LOS and 30-day readmission rates for THR and TKR patients. The findings demonstrate that higher BMI categories, particularly Class III and Super Obesity, are associated with longer and more variable hospital stays, highlighting the significant medical complexity associated with obesity.

While BMI is an important factor, it should not be viewed solely as a demographic characteristic but rather as a morbidity, given its influence on hospital outcomes and resource use. Future analyses should incorporate additional variables, such as age and body composition, to better understand the determinants of LOS and enhance patient care planning (Wu et al., 2024). For instance, older adults may have high body fat despite normal BMI, making BMI alone less reliable in aging populations.

Further research with more diverse datasets, particularly those including super obese patients, is needed to uncover the mechanisms linking BMI to hospital outcomes and to develop targeted strategies to mitigate the impact of obesity on patient health. These findings can inform clinical decision-making to reduce extended stays and prevent readmissions among obese patients.

CRediT authorship contribution statement

Wissem Tafat: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **David McDonald:** Supervision, Data curation. **Marcin Budka:** Supervision. **Thomas W. Wainwright:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Corrigendum to "Impact of obesity on outcomes after total hip and knee replacement: A study on hospital length of stay and readmission rates in NHS Scotland" [Int. J. Orthopaedic Trauma Nurs. 58 (2025) 101216]

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The authors regret that we have made a mistake in Table 2, in which the categories "obese" and "non-obese" were inadvertently switched. Specifically, the values in the first row should correspond to the "obese" category, and the values in the second row should correspond to the "non-obese" category. This error does not affect any conclusions of the work but is sufficiently important to require correction.

The authors would like to apologise for any inconvenience caused.

Table 2
Length of Stay Statistics by BMI Category

BMI Category	Count	Mean	Median	SD	95 % CI Lower	95 % CI Upper	P-value
Normal weight	6429	3.35	2	6.88	3.18	3.52	<0.001
Overweight	15766	3.01	2	7.06	2.90	3.12	<0.001
Class I Obesity	15180	2.90	2	5.27	2.82	2.99	<0.001
Class II Obesity	8297	2.96	2	4.09	2.88	3.05	<0.001
Class III Obesity	2799	3.43	2	4.81	3.25	3.61	<0.001
Super obesity	237	3.65	3	3.73	3.18	4.13	<0.001
Obese (BMI > 40)	2894	3.44	2	4.77	3.26	3.61	<0.001
Not Obese (BMI ≤ 40)	45814	3.02	3	6.01	2.96	3.07	<0.001

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