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Title: "Potential positive effects of bariatric surgery on health care resource utilisation."

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Abstract

Objectives: To determine whether a bariatric surgical procedure is associated with a reduction in healthcare utilisation among patients with obesity and high pre-procedural healthcare needs.

Design: Retrospective cohort study.

Setting: Tertiary Victorian public hospital.

Participants: Twenty-nine adults who underwent publicly funded primary bariatric surgery between 2008 and 2018 at the Alfred Hospital, Melbourne and had high resource use over the year prior to surgery, defined as at least two of ≥3 hospital admissions, ≥7 inpatient bed days for obesity related co-morbidities or inpatient hospital costs ≥ $10,000.

Main outcome measures: Change in inpatient and outpatient resource use.

Results: After one year following bariatric surgery, total hospital bed days decreased from 663 to 80 and the median [Q1, Q3] per patient decreased from 7 [4.5, 15] to 5 [2.25, 9.75]; p=0.001) and the total number of hospital admissions fell from 118 to 67 (p <0.001). The median cost of inpatient care decreased from $11,405 [$4,408, $22,251] to $3,974 [$0, $4,325] per annum (p<0.001).

The total and median number of outpatient attendances did not significantly change 12 months after bariatric surgery, but the demand for outpatient services unrelated to bariatric surgery declined by a median of 4 visits per patient (p=0.013)

Conclusions: The evidence from this small pilot study suggests that Bariatric surgery has the potential to decrease resource use and inpatient hospital costs over a one-year time frame for obese patients with high resource use. These data will be used to design a prospective randomised controlled trial to provide more definitive information on this important issue.

Introduction:

Obesity accounts for 7% of the national burden of disease[1]. The latest Australian Bureau of Statistics census figures show that 36% of adult Australians are overweight and 31% are obese[1]. The prevalence of obesity has increased dramatically in the last two decades from 19% in 1995. Nationally, obesity-related complications account for up to 9% of all hospital stays with 95% of hospital admissions listing obesity as a secondary diagnosis[1]. Between 2008 and 2015, obesity cost the Australian economy an annual average of $3.8 billion in direct healthcare, and $4.8 billion in indirect healthcare[2].

High health resource consumers account for approximately 68% of health expenditure costs[3]. These individuals are typically of lower socio-economic status, older, and have multiple chronic conditions. Obesity is a significant risk-factor that contributes to this burden[3,4]. As such, prioritising the treatment of obesity may be an opportunity to improve other co-morbidities, reduce the need for hospital bed days and clinic visits, thereby providing a cost saving for public hospitals in addition to improving health.

Bariatric surgery is effective in durably reducing weight as well as providing significant metabolic and quality of life improvements[5]. Bariatric surgery has also been demonstrated to be a cost-effective intervention, with the magnitude of benefit in one analysis being similar to that of tobacco cessation[6].

Despite these benefits, access to bariatric surgery in public hospitals is limited[7,8]. Data from the Australian and New Zealand Bariatric Surgery Registry for the 2018/2019 financial year shows that only 5.1% of bariatric procedures were performed in Australian public hospitals[9]. Our public health care system is resource limited, with a large number of competing demands. The high prevalence of obesity means that bariatric surgery has the potential to overwhelm limited public hospital resources. A strategic paradigm to ensure care is delivered to those who are most likely to benefit is urgently required to ensure equity of access and value to the community.

The majority of the highest health resource consumers are treated in the public setting[16]. For those where obesity is a primary driver of ill health, weight loss has the potential to be an effective intervention and provides cost-savings through improved health and wellbeing. However, given that high resource consumers are also likely to be at higher risk of surgical and anaesthetic complications, it is possible that the risks and cost of bariatric surgery could exceed its potential benefit.

We hypothesise that public hospital resource use could be decreased by offering bariatric surgery to obese patients with high preoperative resource use in whom such surgery was deemed medically appropriate. This study aimed to identify high resource use patients and determine their hospital health costs over the year before and after bariatric surgery.

Methods

This was a retrospective cohort analysis of prospectively collected data from 998 patients who underwent bariatric surgery at The Alfred Hospital, a Victorian state-wide referral centre for bariatric surgery, from 2008-2018. Ethical approval was obtained from the Alfred Hospital Human Research Ethics Committee (Ref 494/16).

Patient data were downloaded from a prospectively maintained database of all patients seen and admitted under the Oesophago-Gastric Bariatric Surgery Unit (Microsoft Access, Microsoft Corporation, Redmond, WA, USA). Details were verified by cross reference to electronic medical records maintained by the Alfred Hospital (Cerner, North Kansas City, MO, USA). Cost data related to inpatient care were sourced from The Alfred Hospital's clinical costing department which uses the Weighted Inlier Equivalent Separation (WEIS) detailed by Victoria's Casemix health funding policy. The hospital admission encounter for each patient was grouped into pre and post surgical based on the date of the primary bariatric surgery.

Cohort selection

Currently there is no validated consensus definition of a high health resource consumer for bariatric surgery. Preliminary data from our record search demonstrated that a threshold of two out of three criteria (≥three hospital admissions, ≥7 inpatient hospital bed days and/or ≥$10,000 health care costs each year) represented a high health care resource consumer at the Alfred Hospital (ie the top 3% of resource consumers).

Inclusion Criteria

The patient had:

- received their primary bariatric surgery at The Alfred Hospital
  AND
- fulfilled 2 or more criteria for high resource consumption

Exclusion Criteria

Participants were excluded if they had ANY of the following:

- More than one bariatric surgical procedure
- Failure to attend 12 months of postoperative surgical follow up at The Alfred Hospital.

Outcomes Measure Definitions:

- Weight loss – change in weight in kilograms from time of booking for surgery to weight recorded at 12-month outpatient clinic visit.
- Surgical complications –any deviation from normal post-operative recovery and classified using the Clavien Dindo[17] grading system.
- Hospital Bed days- length of inpatient hospital stay in days calculated from admission and discharge timestamp on electronic medical record.
- Outpatient attendance – the number of attendances, recorded on the patient electronic medical record, to an outpatient clinic or investigation (radiology, endoscopy, Emergency department attendances that were less than 24 hours and did not require hospital admission)
- Inpatient attendance/ Hospital admission – any interaction in which the patient was admitted as an inpatient including Emergency department short stay admissions.
- Attendances related to bariatric surgery –any hospital interaction directly relating to bariatric surgery work-up or aftercare.
- Attendances unrelated to bariatric surgery – any other hospital interaction.

Statistical analysis:

Data was analysed using Mann Whitney U or the Wilcoxon Signed Rank Test. Data are expressed as median (interquartile range). All statistical analysis was performed using IBM SPSS version 22 (SPSS Inc, Chicago, IL, USA). A significant result was defined as a *p*-value less than 0.05.

Results:

In the 11 years between 2008 and 2018, 998 patients underwent primary bariatric surgery at the Alfred Hospital. The 12-month follow-up rate for this cohort of 998 patient was 90.7% with 93 patients failing to attend their 12month follow up appointment.

There were 29 patients who fulfilled the criteria for high resource use patients (2.9%). There was 100% follow up at 12 months of these individuals (figure 1). Excluding the hospital admission for primary surgery, they collectively incurred 577 total hospital interactions during the 12 months before and after bariatric surgery (admissions, presentations and investigations) (figure 2). While this cohort of individuals made up only 3% of all patients receiving primary bariatric surgery at our institution, their care represented 31.3% of the total inpatient costs 12 months before and after surgery for patients who underwent a primary bariatric procedure at The Alfred hospital during this period. There were three hospital admissions related to bariatric surgery that occurred preoperatively; two patients required inpatient admission for preoperative Optifast™ and one patient who underwent laparoscopy with laparoscopic adjustable gastric band (LAGB) insertion abandoned due to severe hepatic steatosis.

The median [Q1, Q3] age of the cohort was 49[44, 59] years, ranging from 26 to 67 years, and 45% were male. Preoperative body mass index (BMI) was 46.14 [39.98, 52.93] kg/m^2 (range 35-107 kg/m^2). The 29 operations comprised three laparoscopic sleeve gastrectomies (LSG) and 26 LAGB insertions. The median hospital stay for surgery was 1 [1, 3] days and percentage weight loss at 12 months was 16.75 [9.06, 21.21] ($p<0.0001$), equating to a median BMI reduction of 8.31kg/m^2 ($p<0.0001$).

The median hospital cost associated with the index admission for bariatric surgery was $11,546 [$8,326, $16,779]. Three individuals experienced a prolonged admission at the time of primary bariatric surgery: One patient experienced post-surgical bleeding following sleeve gastrectomy that required a blood transfusion (Clavien Dindo IIb). One patient was admitted to hospital the week prior to bariatric surgery for management of acute renal injury secondary to dehydration associated with a very low calorie diet. The remaining patient required intensive social work and allied health input due to complex social circumstances.

Table 1 summarises the inpatient admissions and hospital bed days utilised in the 12 months before and 12 months after bariatric surgery. In the year following bariatric surgery, there were no hospital readmissions related to bariatric surgery (Figure 2). There was a significant reduction in overall bed use, with 14 (48%) participants not requiring hospital admission in the year following surgery. The median length of hospital stay for the 15 patients who were admitted for hospital treatment in the year following surgery decreased from 7 [5, 15] to 5 [2, 10] days ($p=0.001$).

Prior to bariatric surgery, the median annual cost of inpatient care per patient was $11,405 [$4,408, $22,251]. In the 12 months after bariatric surgery, the inpatient costs of the 15 patients who required admission to hospital was significantly lower at $3,974 [$653.5, $23,871]; $p= 0.014$). When all 29 participants were considered, the median inpatient cost per patient in the year following surgery was $213.17 [$0, $4,325] $p<0.001$.

The total number of outpatient visits each year was similar before and after surgery: 465 attendances before and 459 attendances during the year after surgery. However, the types of outpatient encounters changed (Table 2). There was a statistically significant increase in the frequency of bariatric surgery outpatient attendances (median of 3 [2,4] before surgery vs. 7 [3.5,8.5] after surgery; $p=0.0002$) but fewer visits to non-bariatric surgery (8[6, 14.5] pre operatively vs. 4 [2, 20.5] post operatively; $p=0.013$) (Figure 3).

Discussion:

Public hospitals function in a resource-limited environment. For this reason, there has been a move towards providing care to individuals who are most likely to obtain value from any intervention.

The demand for primary bariatric surgery in the public sector currently outweighs supply significantly with only 5% of separations in Australia occurring in public settings[9]. Our institution receives approximately 1200 new community referrals annually for bariatric surgery and performs approximately 250 primary bariatric procedures. Directing care to patients who will receive maximal health benefit and where hospital resources can be saved will be of considerable interest to many stakeholders in the Australian public hospital system.
Adopting a value-based strategy for bariatric case selection has the potential to enable effective case selection if the health benefits translate to cost-benefits for the community[11,12].

We hypothesised that one group of patients with obesity that might gain the most from bariatric surgery were those patients with co-morbidities related to obesity that meant that they had high healthcare resource requirements.

Our inclusion criteria for this study were based upon clinical experience and a pragmatic approach to what might be considered “high healthcare resource use” as there are currently no validated definitions.

Surgery was performed safely, and patients achieved a weight loss that was comparable with the published literature[10]. This translated to less demand for hospital bed days, and a reduction in outpatient visits at 12 months. Bariatric surgery did, however, increase the demand for outpatient services relating to the procedure. Overall direct health care costs associated with hospital bed days fell, however, due to the small sample size this effect is difficult to interpret.

These data suggest that individuals who are obese and high healthcare consumers may be an appropriate group to prioritise for bariatric surgery. This group of patients have the potential to provide an early return on investment following bariatric surgery in the public hospital system. We are not suggesting that high healthcare consumption be the only criterion for access to public bariatric surgery, nor that it is the primary criterion. Other clinical and socioeconomic factors should also be considered. These include co-morbidities that are likely to remit following bariatric surgery, such as diabetes and non-alcoholic steatohepatitis [18,19].

Due to the extended timeframe of Public Hospital operative waiting lists, patients can wait for a prolonged period of time prior to undergoing surgery. Given the timeframe of our study the data supports that in the year preceding surgery patients did not achieve weight loss nor did they receive focused hospital based management of co-morbidities preoperatively. It is possible that GP and community prehabilitation interventions occurred however the communication received from these health care providers to our institution sourced from patient hospital records does not reflect this.

Our study has several limitations. First, we defined ‘high healthcare resource use’ arbitrarily, given that there is no standard definition. However, a proportion of healthcare utilisation (55%) to proportional representation (3%) is used commonly to define this group[3] and the fact that their healthcare costs represented 31% of the total confirms their relative needs. In an attempt to validate the definition we have analysed different combinations of criteria (supplemental table 1) and the current definition seems reasonable. Secondly, our analysis was limited to only 29 patients. While the majority of our analyses were associated with very small probabilities of Type I statistical error, the representativeness of a cohort of only 29 people given sample selection bias is questionable. The latter issue also arises from our sample having been drawn from only a single site. Hence, these findings will require confirmation in other populations to ensure the findings are more broadly applicable to the Australian public health care system. Thirdly, there may have been data misclassification in our study, with there being potential inaccuracy in administrative data. However, any misclassification would unlikely have been differential (that is, unlikely to be more common in either of the pre or post-surgical period), and hence if present, would only have biased the results towards the null.

There are a number of potential confounders relating to the effect of being on a surgical waiting list may have on a patient's health care utilisation which we believe have been minimised due to strict cost and resource allocation during data collection. Our patient cohort had 115 inpatient separations and 370 outpatient episodes not related to bariatric surgery in the twelve months prior to bariatric surgery (Figures 2 & 3b). Specialist cardiology and respiratory interactions represented 50.5% of the 29 outpatient departments accessed by our patient cohort pre-operatively. Cardiology, respiratory and medical day unit admissions accounted for 64.3% of pre-operative inpatient separations not related to bariatric surgery (Figure 2). The diagnoses necessitating these reviews were made prior to the patients' referral to the bariatric surgery unit. Therefore, the specialist medical interaction that these patients received in the 12 months prior to bariatric surgery relate to the standard of care required to manage complex medical conditions, rather than the patient being on a surgical waiting list. Ten patients were referred for sleep studies after review in the bariatric surgery outpatient clinic. To limit the confounding effect relating to the investigation of obstructive sleep apnoea (OSA) on resource consumption in these 10 patients, the cost was absorbed by the referring bariatric surgical unit, presented in the preoperative bariatric surgery associated cost analysis and the UGIS outpatient interaction count (Figure 3a). There were no inpatient admissions associated with the investigation of OSA in this patient subgroup. Finally, all bariatric surgery was performed in an elective setting. This eliminates the potential for acute inpatient referrals for weight loss surgery, and associated inpatient transfer between care teams perioperatively, to confound our results.

LAGB was the main weight loss surgery performed in this cohort due to the practice of the hospital's bariatric surgical unit during the study timeframe and relates to establishment of the bariatric program in the public system. Subsequently LSG has become the predominant weight loss surgery performed at our institution. However, despite the more modest weight loss than might be expected with resectional procedures, LAGB provided this cohort of multi-morbid patients with increased perioperative risk a safe surgical weight loss operation with substantial health benefit.

The question of whether or not bariatric surgery decreases subsequent healthcare utilisation and costs needs to be more definitively addressed by larger prospective studies. We plan to use the results from the present study to inform the design of a randomised controlled trial to determine whether cost effectiveness can be maximised by establishing streamlined preoperative pathways that effectively and proactively identify high resource obese individuals who will achieve a sustained response to bariatric surgery.

Conclusion

Weight loss following bariatric surgery has the potential to reduce the healthcare requirements of individuals with obesity who have high healthcare requirements. This change is valuable not only to the individual, but may also ultimately reduce the burden on public healthcare services and contribute to overall health sector efficiency. People with obesity and high healthcare resource requirements represent a group that could be prioritised for bariatric surgical care in the public sector.

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Table 1. Hospital admissions and hospital bed days

	Pre-operative	**Post-operative**	**p-value**
Inpatient admissions			
Bariatric related	3	0	
Non Bariatric Related	115	67	
Total	**118**	**67**	
- ***Median (IQR)***	**3 (3)**	***1 (2)***	0.003
Hospital Bed Days			
Bariatric related	11	0	
Non Bariatric Related	652	80	
Total	**663**	**80**	
- ***Median (IQR)***	7 (10.5)	4 (7.5)	***0.0005***

Table 2: Pre-operative versus post-operative outpatient visits

	Pre-operative	Post-operative	P value
Total outpatient visits	465	459	
- median (IQR)	12 (10)	10 (17.5)	0.79
Bariatric surgery related outpatient visits	95	183	
- median (IQR)	3 (2)	7 (5)	0.0002
Non bariatric surgery related outpatient visits	370	276	
-median (IQR)	8 (8.5)	4 (18.5)	0.013

Figure 1: Cohort selection

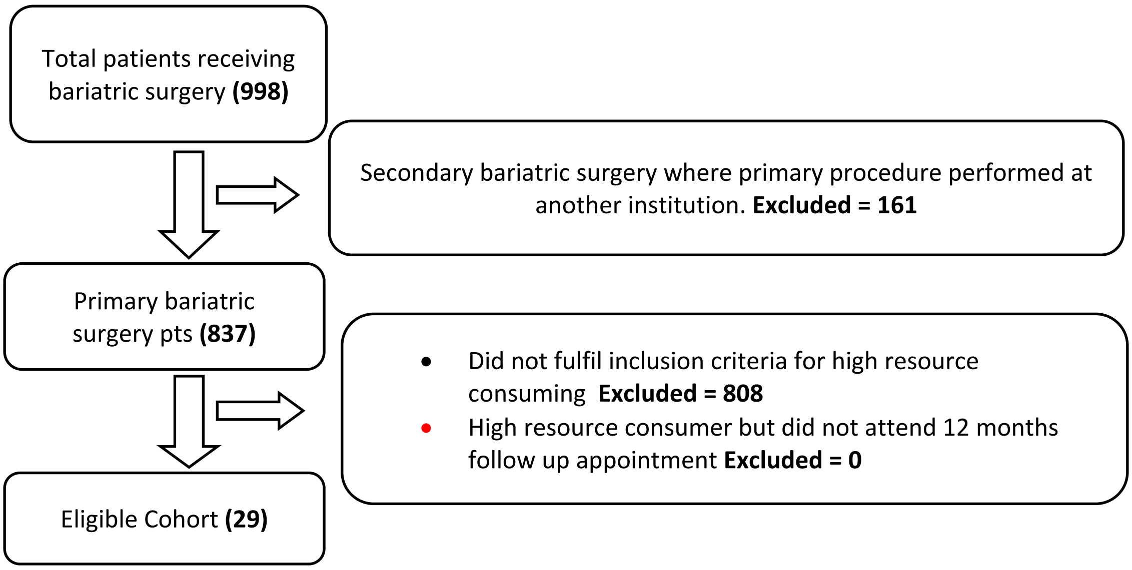


Figure 2: Inpatient admission diagnoses: Non-bariatric surgery related

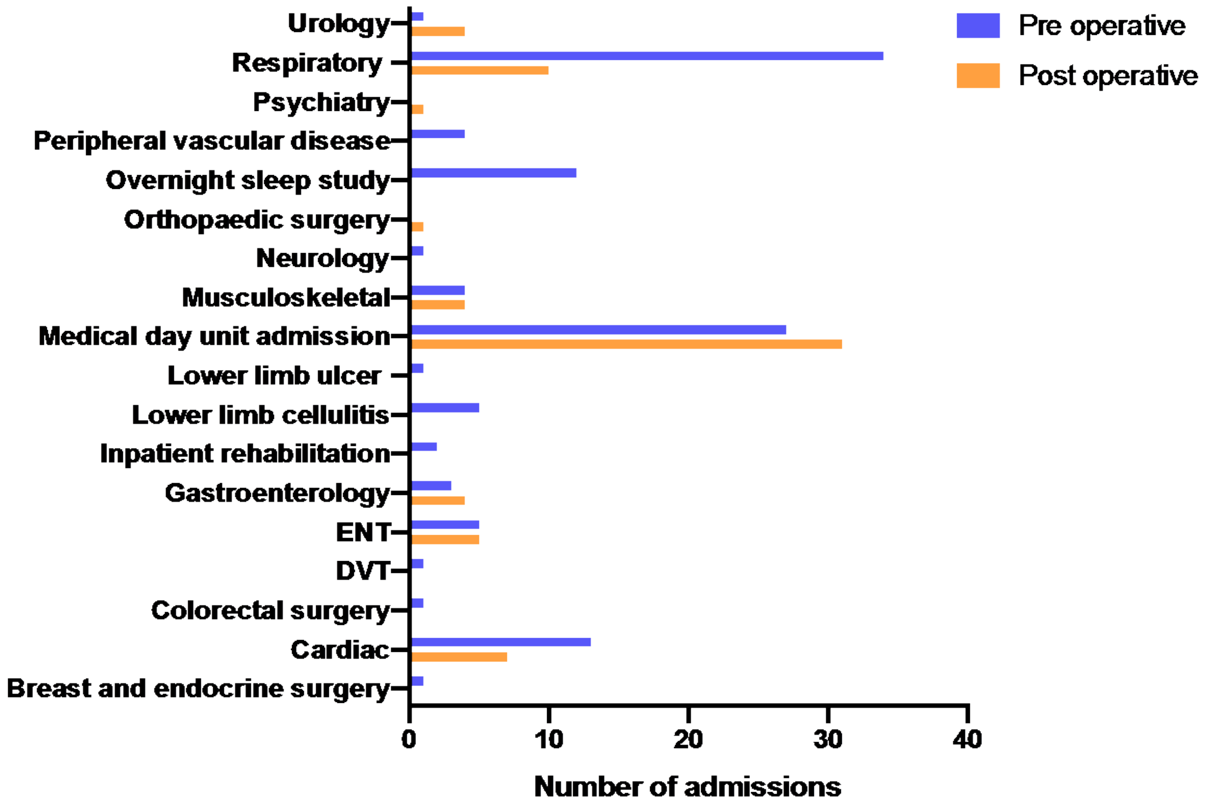
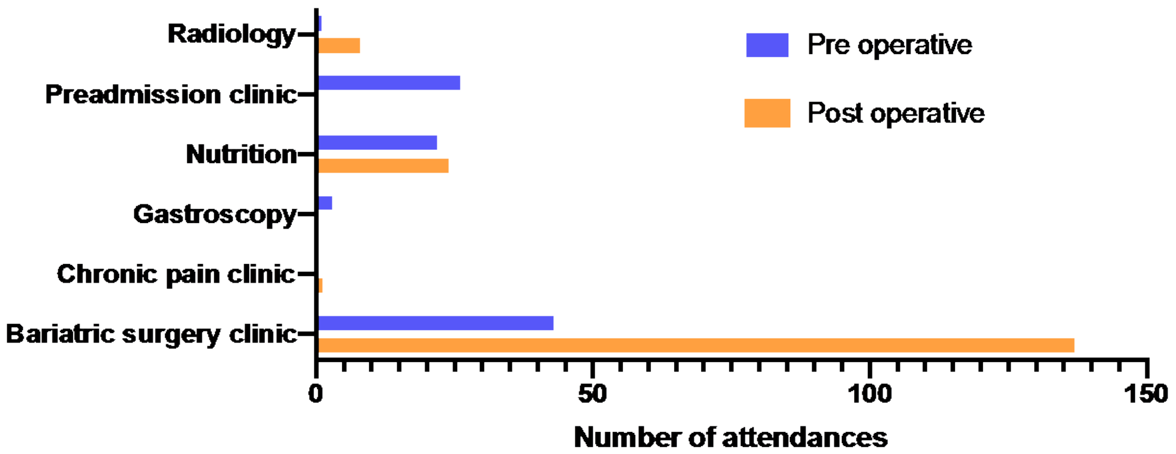
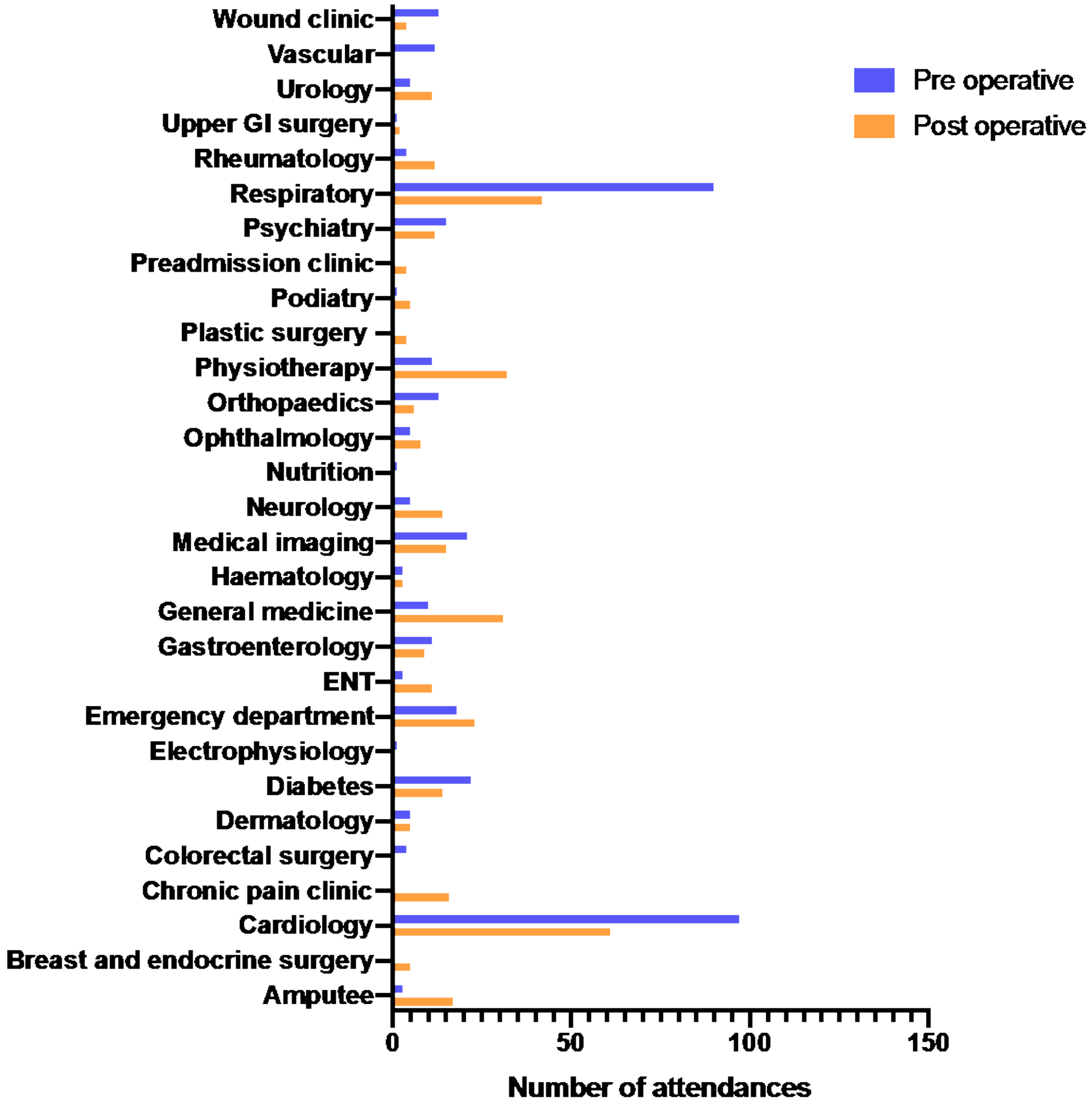


Figure 3: Outpatient attendances

a) Bariatric Surgery related



b) Non-Bariatric Surgery Related



Supplementary Table: Selection criteria validation

In an attempt to validate our pragmatic definition of 'high resource user' we considered the contributions of each of the three criteria. There were statistically significant reductions across all criteria and the "2 or more" criteria provided sample size and significant statistical representation (*p value <0.05, **p value <0.01, ***p value <0.005, ****p value <0.001).

	1 criterion only	2 criteria only	≥2 criteria	3 criteria
Sample size	33	21	**29**	8
Hospital bed days pre-bariatric surgery				
- Total	675 days	259 days	**663 days**	404 days
- Median (IQR)	7 (3) days	7 (8.5) days	**7 (10.5) days**	12.5 (10.5) days
Hospital bed days post bariatric surgery				
- Total	128 days	59 days	**84 days**	25 days
- Median (IQR)	5 (7.75) days	5 (7.5) days	**5 (7.5) days**	1 (7.75) days
Change in hospital bed days				
- Total	-547 days	-200 days	**-579 days**	-379 days
- Median difference ($CI_{95\%}$)	-7 (-10, -3) days****	-6 (-8,0) days*	**-7 (-10, -2) days******	-10 (-312, 0) days*
Cost pre bariatric surgery				
- Total	$711,010	$249,774	**$653,783**	$404,009
- Median (IQR)	$12,697 ($17,843)	$5,986 ($10,764)	**$11,405 ($17, 843)**	$22,251 ($36,569)
Cost post bariatric surgery				
- Total	$159,050	$90,722	**$134,888**	$44,165
- Median (IQR)	$544.61 ($5,056)	$0 ($3,728)	**$213 ($4,325)**	$1,739 ($9,726)
Change in cost				
- Total	-$551,960	-$159,052	**-$518,895**	-$359,844
- Median difference ($CI_{95\%}$)	-$5,624 (-14,326, -3,312)****	-$3,997 (-14,326, -1,541)*	**-$5,280 (-15,456, -2,775)****	-$15,820 (-240,353, -1,507)**

Outpatient visits pre bariatric surgery				
- Total	508 visits	256 visits	**465 visits**	209 visits
- Median (IQR)	13 (11.25) visits	10 (8) visits	**12 (10) visits**	19.5 (21.25) visits
Outpatient visits post bariatric surgery				
- Total	505 visits	287 visits	**459 visits**	172 visits
- Median (IQR)	10 (16.25) visits	10 (12) visits	**10 (16.5) visits**	15.5 (25) visits
Change in outpatient visits				
- Total	-3 visits	+31 visits	**-6 visits**	-37 visits
- Median difference ($CI_{95\%}$)	-1 (-5, -2) visits	0 (-4, 3) visits	**-1 (-5, 3) visits**	-11 (-17, 15) visits
Non-bariatric outpatient visits pre bariatric surgery				
- Total	400 visits	191 visits	**370 visits**	179 visits
- Median (IQR)	12.12 (12.39) visits	9.09 (6.27) visits	**12.76 (12.96) visits**	22.38 (20.35) visits
Non-bariatric outpatient visits post bariatric surgery				
- Total	304 visits	145 visits	**276 visits**	131 visits
- Median (IQR)	9.21 (11.30) visits	6.91 (8.26) visits	**9.52 (11.79) visits**	16.38 (16.96) visits
Change in non-bariatric outpatient visits				
- Total	-96 visits	-46 visits	**-94 visits**	-48 visits
- Median difference ($CI_{95\%}$)	-4 (-6, -2) visits**	-3 (-5, -2)*	**-4 (-6, -2) visits***	-9 (-17, 15) visits

Figure 1: Cohort selection

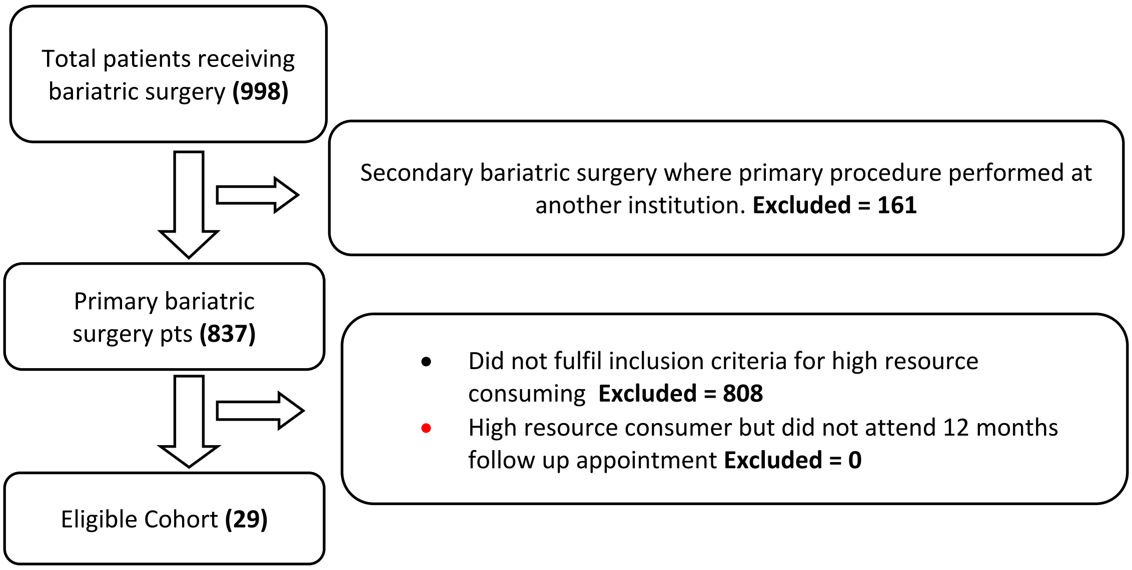


Figure 2: Inpatient admission diagnoses: Non-bariatric surgery related

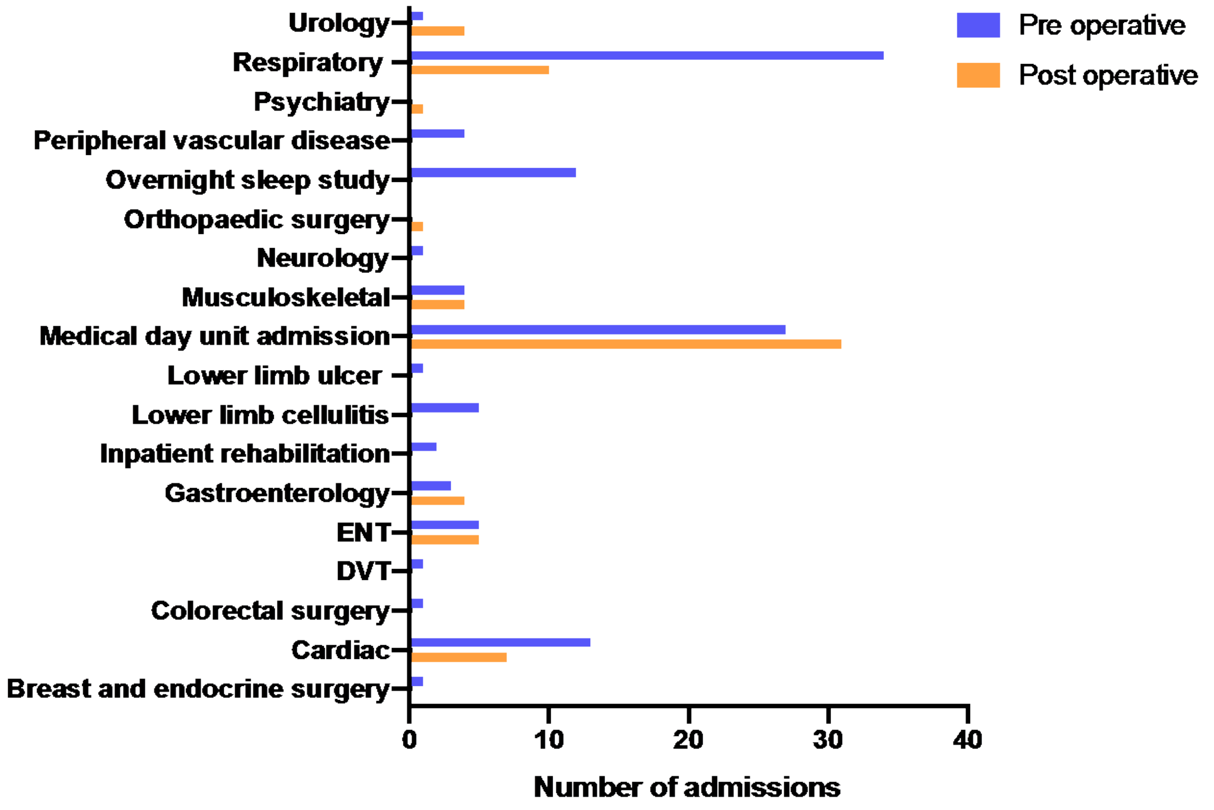


Figure 3: Outpatient attendances

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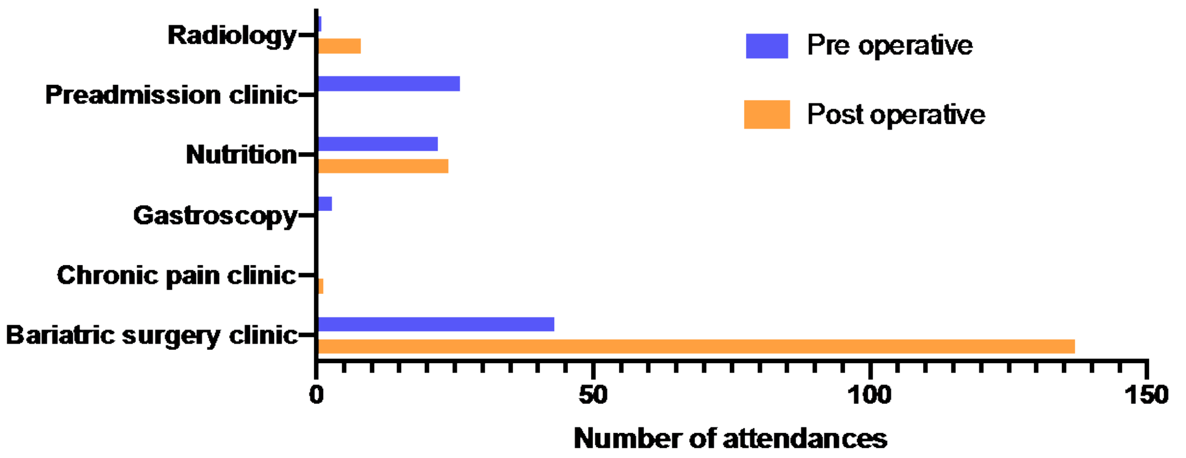
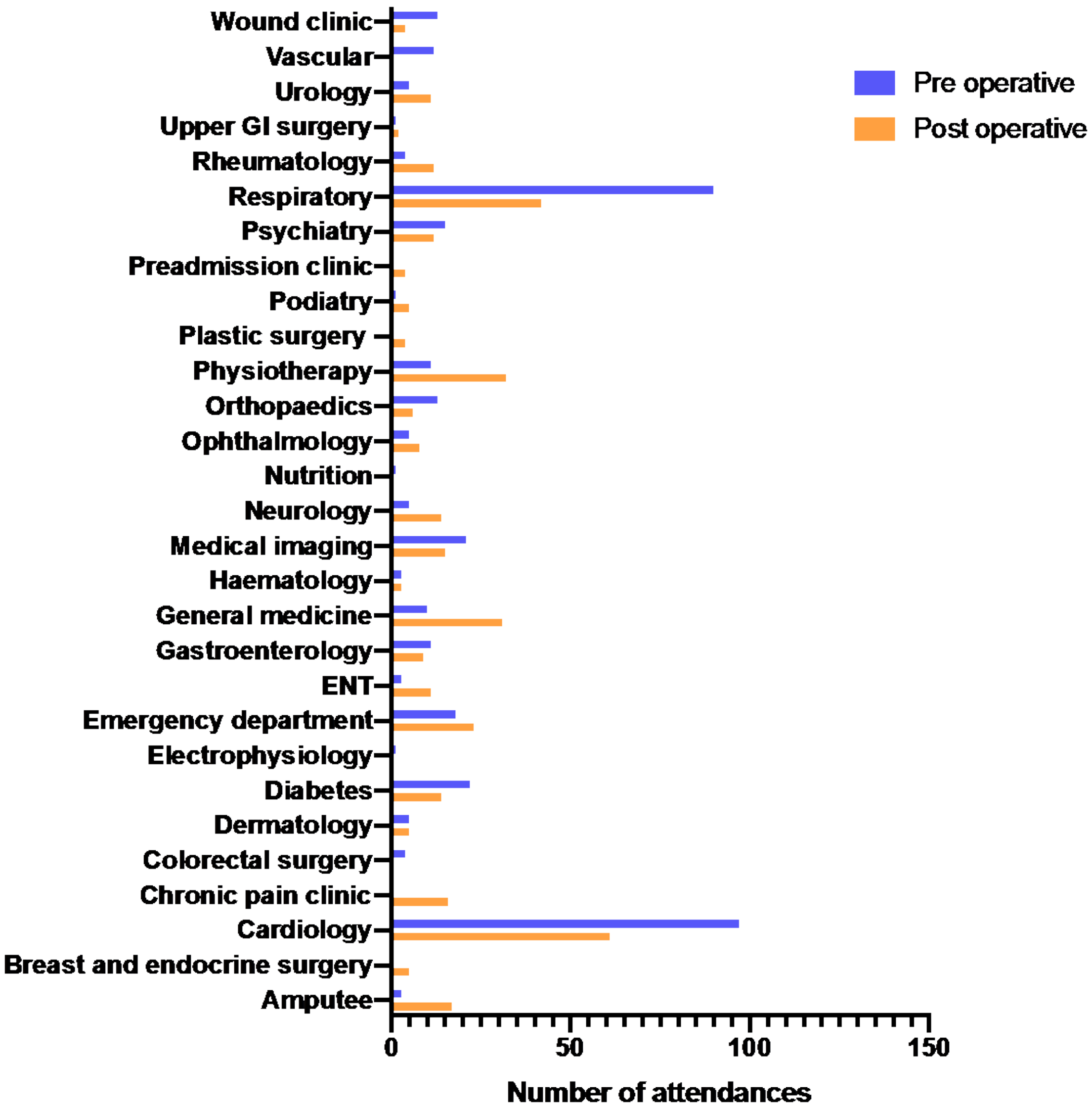


b) Non-Bariatric Surgery Related



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