



The Effect of Participation in Tier 3 Services on the Uptake of Bariatric Surgery

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Abstract

Background Despite the recognised advantages of bariatric and metabolic surgery, only a small proportion of patients receive this intervention. In the UK, weight management systems are divided into four tiers. Tier 3 is a clinician-lead weight loss service while tier 4 considers surgery. While there is little evidence that tier 3 has any long-term benefits for weight loss, this study aims to determine whether tier 3 improves the uptake of surgery.

Method A retrospective cohort study of all referrals to our unit between 2013 and 2016 was categorised according to source—tier 3, directly from the general practitioner (GP) or from another speciality. The likelihood of surgery was calculated using a regression model after considering patient demographics, comorbidities and distance from our hospital.

Results Of the 399 patients, 69.2% were referred directly from the GP, 21.3% from tier 3, and 9.5% from another speciality of which 69.4%, 56.2%, and 36.8% progressed to surgery ($p = 0.01$). On regression analysis, patients from another speciality or GP were more likely to decide against surgery (OR 2.44 CI 1.13–6.80 $p = 0.03$ and OR 1.65 CI 1.10–3.12 $p = 0.04$ respectively) and more likely to be deemed not suitable for surgery by the MDT (OR 6.42 CI 1.25–33.1 $p = 0.02$ and OR 3.47 CI 1.11–12.9 $p = 0.03$) compared with tier 3 referrals.

Conclusion As patients from tier 3 were more likely to undergo bariatric and metabolic surgery, this intervention remains a relevant step in the pathway. Such patients are likely to be better informed about the benefits of surgery and risks of severe obesity.

Keywords Weight management services · Tier 3 · Surgery

Introduction

Obesity is a major economic burden in the UK, costing £6.1 billion to the NHS between 2014 and 2015 [1]. It is associated with a number of medical conditions and is now considered the second highest risk factor for cancer in the UK, behind smoking [2]. The prevalence of obesity is set to increase further, with a predicted 35% of the population in England suffering from obesity by 2030, a rise from 27% in 2015 [3]. In addition, the COVID-19 pandemic has highlighted obesity as a major risk factor for COVID-related hospital admission and death [4], making it a target for recent health policy initiatives [5].

Although bariatric surgery is considered to be the most effective treatment for severe obesity and its associated conditions [6, 7], it is estimated that in the UK, only 0.002% of eligible patients received this intervention in 2014 [8]. NICE guidance from the same year concluded that patients could be considered for bariatric surgery if their BMI was $\geq 40\text{kg/m}^2$ or $\geq 35\text{kg/m}^2$ with a comorbidity that could improve with weight loss. This same guidance also described the tier system of weight management services: Tier 1 covers population-level services such as national health promotion, tier 2 includes intervention by the primary care physician, tier 3 is a tailored programme led by a team specialising in weight management (usually constitutes physicians, nurses, dieticians and psychologists, although this varies across the country) and tier 4 is the multidisciplinary team (MDT) that offers bariatric surgery [9]. A patient should only be considered for surgery once they have completed a tier 3 programme [10], entry into which must be requested by the primary care physician. It was expected that this process would filter out patients who did not require surgery, while optimising those who do.

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Studies into tier 3 services provide conflicting reports on their effectiveness [11]. Weight loss during this period does not reliably equate to improved weight loss after surgery [12]. Unfortunately, the majority of patients regain weight by 6 months [13], questioning whether tier 3 programmes should be any longer than this. More recently, the provision of tier 3 services has been taken over by Clinical Commissioning Groups (CCG), so the design of such services varies according to location [14].

Although the evidence for tier 3 services as an aid for preoperative weight loss may be weak, alternative benefits have not been well researched, such as improved conversion rate to surgery. Studies have demonstrated higher deprivation, older age and female gender are associated with increased likelihood to miss hospital appointments [15]. The aim of this study is to determine whether these factors, along with tier 3 involvement, influence the proportion of patients who progress to bariatric surgery.

Method

Study Design and Population

This study used a retrospective cohort design with a population consisting of all patients referred between 2013 and 2016 to our tertiary bariatric centre situated in the UK. The unit was established in 2013 and is based in an area of relatively high socioeconomic deprivation. As the NICE criteria regarding tier 4 were introduced in 2014 [10], during the study period, patients would have been referred from three possible sources: Tier 3 services, directly from the patient's general practitioner (GP) or from another specialist (AS) within the trust, for example from orthopaedics or endocrine physicians. Patients referred from the latter two sources would be reviewed by our MDT with the aim to manage comorbidities and psychological issues that would aid preoperative and postoperative weight loss.

Patient Variables and Outcomes

Data was collected prospectively for all referrals, with outcomes updated as patients progressed through the bariatric pathway. Independent variables included gender, age, initial BMI, referral source and distance from home to our base hospital. Comorbidities included type 2 diabetes, ischaemic heart disease, hypertension, hypercholesterolemia, psychiatric history, asthma and obstructive sleep apnoea (OSA). Socioeconomic status was derived from the Indices of Multiple Deprivation (IMD; 2010) [16], categorised into tertiles (least, middle and most deprivation). Smoking history was also recorded.

The three outcomes from the bariatric pathway were surgery, patient deemed not suitable for surgery by the MDT or patient's decision to leave the pathway. The latter included those that informed the department of their decision and those who failed to attend appointments.

Statistical Analysis

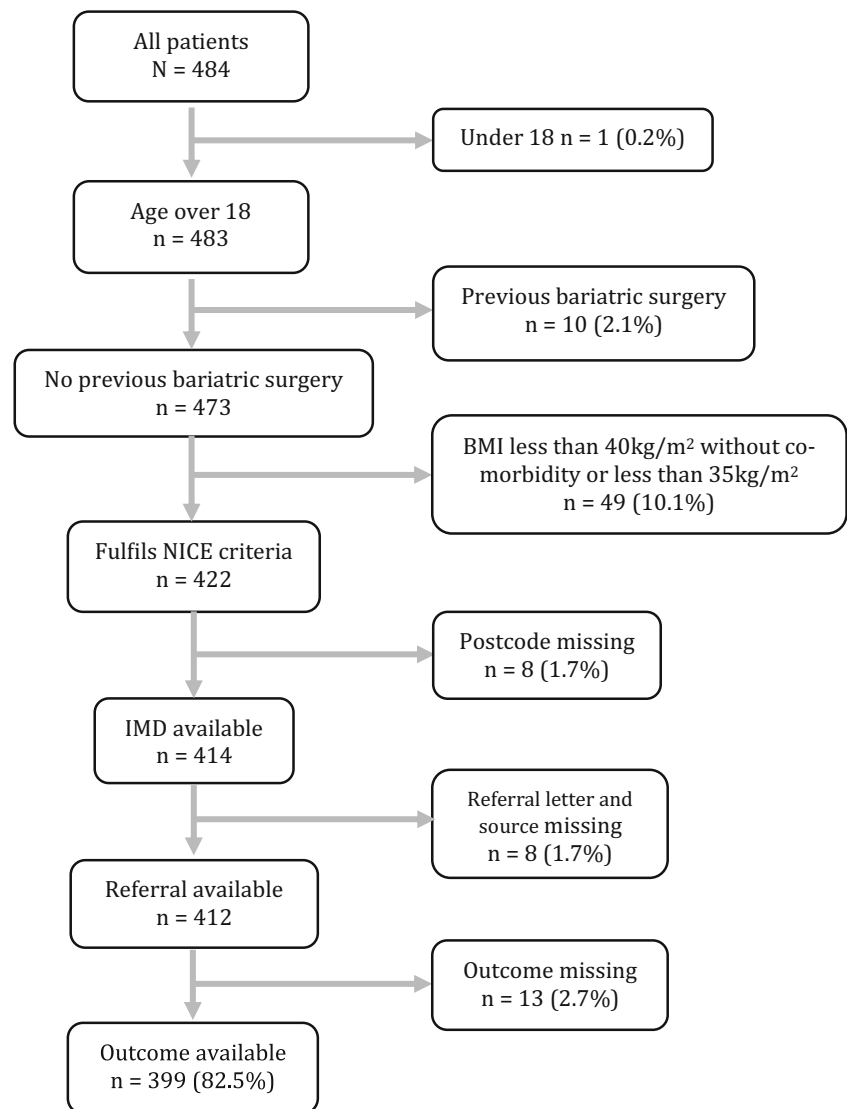
Univariate analysis using a chi-squared statistical test for categorical data compared the abovementioned factors (patient characteristics and comorbidities) between the sources of referrals. A similar analysis was carried out to describe how the three possible outcomes varied according to these factors. The Kruskal-Wallis test was used to compare medians while analysis of variance compared mean values. A generalised multinomial regression model described the characteristics most likely to lead to surgery as the dependent reference category (primary outcome), after taking into account all covariates (secondary outcomes) with a $p < 0.1$ significance on univariate analysis. Analysis was carried out with SPSS v26.

Results

Between 2013 and 2016, 484 patients were referred to our bariatric unit. After including only patients with a BMI of over 35 kg/m² with an obesity-related comorbidity or BMI over 40 kg/m², and excluding those with missing data or previous bariatric surgery, 399 (82.5%) patients formed the basis for analysis (Fig. 1). Overall, 297 (74.4%) were female, with an average age of 45.1 years (95% CI 44.0–46.3) and initial median BMI of 47.2 kg/m² (IQR 42.9–52.9). Two hundred forty-seven patients (61.9%) were from the most deprived areas, 124 (31.1%) from the middle tercile with the remaining 28 (7.0%) from the least deprived areas. The majority of patients were referred directly from the GP ($n = 276$, 69.2%), followed by referral from a tier 3 service ($n = 85$, 21.3%) and from another speciality ($n = 38$, 9.5%). After embarking on the bariatric pathway, 228 (57.1%) underwent surgery, 41 (10.3%) were deemed not fit for surgery at the time of the MDT meeting, with the remaining 130 (32.6%) opting not to undergo surgery.

The average age for the AS group (50.2 years 95% CI 45.8–54.7) was significantly higher than both the GP (44.7 years 95% CI 43.3–46.1) and tier 3 (44.3 years 95% CI 41.7–46.8) groups ($p = 0.04$). Patients from tier 3 included the highest proportion of BMI 50 kg/m² and over (45.9%), compared with 35.1% from GPs and 31.6% from other specialities. The proportion of female patients was similar across the groups. Although the vast majority of tier 3 patients were from within 10 km from our base hospital (92.9%), this group also included the highest proportion of patients who lived over 50 km away (5.9%) (Table 1).

Fig. 1 Flowchart showing the numbers excluded. Percentages of original 484 patients



Of those referred from AS, 47.4% ($n = 18$) suffered from type 2 diabetes. This was significantly higher than both tier 3 (34.1% $n = 29$) and GP referrals (27.9% $n = 77$) ($p = 0.04$) (Table 1). The AS group also included the highest proportion of patients suffering from osteoarthritis (42.1% $n = 16$, $p = 0.02$), previous cerebrovascular event (10.5% $n = 4$, $p = 0.04$) and CKD (10.5% $n = 4$, $p = 0.03$). Both GP and tier 3 referrals had similar proportion of patients who were on medication for depression (19.2% ($n = 53$) and 12.9% ($n = 11$) respectively), which were significantly lower than those in AS (26.3% $n = 10$) ($p = 0.04$). Tier 3 patients had the highest proportion of vitamin D deficiency (43.5% $n = 37$, $p = 0.01$). Patients referred from GPs were more likely to have undergone a previous abdominal operation (44.9% $n = 124$), with the lowest in the AS group (21.1% $n = 8$). There was no difference in the IMD between the three groups, or the other comorbidities listed in Table 1 including hypertension and obstructive sleep apnoea. There was a higher proportion of patients suffering

from PCOS in the tier 3 service (16.2% $n = 11$), although this did not reach significance (Table 1).

Of those who had participated in a tier 3 service, 59 (69.4%) progressed to an operation compared with 155 (56.2%) referred from the GP and 14 (36.8%) referred in house (AS group) ($p = 0.01$) (Table 2). The group with the highest proportion of patients deemed not suitable for surgery when discussed in the MDT was from the AS group (21.1% $n = 8$), followed by patients from the GPs ($n = 30$ 10.9%) and then tier 3 (3.5% $n = 3$). 42.1% ($n = 16$) patients from AS group decided against surgery, compared with 33.0% ($n = 91$) of the GP referral group (32.6% $n = 91$) and 27.1% ($n = 23$) from tier 3. The mean age was significantly lower for patients who underwent surgery (43.9 years) compared with those refused by the MDT (50.2 years) or if the patient refused (45.7 years). A higher proportion of females (60.6%) went ahead with surgery compared with males (47.1%), while a history of CVA or IHD was associated with a higher percentage of

Table 1 Patient demographics and comorbidities according to referral group. Figures are *n* (% of group) unless stated. *AS*, another speciality; *GP*, general practitioner; *IMD*, Index of Multilevel Deprivation

		All <i>N</i> = 399	Tier 3 <i>n</i> = 85	GP <i>n</i> = 276	AS <i>n</i> = 38	<i>p</i>
Body mass index kg/m ²	35–39.9	40 (10.0)	3 (3.5)	28 (10.1)	9 (23.7)	0.01
	40–49.9	211 (52.9)	43 (50.6)	151 (54.7)	17 (44.7)	
	50 and over	148 (37.1)	39 (45.9)	97 (35.1)	12 (31.6)	
Mean age, years (95% CI)		45.1 (44.0–46.3)	44.3 (41.7–46.8)	44.7 (43.3–46.1)	50.2 (45.8–54.7)	0.04
Gender	Female	297 (74.4)	68 (80.0)	207 (75)	22 (57.9)	0.03
	Male	102 (25.6)	17 (20)	69 (25)	16 (42.1)	
IMD tercile	Most	247 (61.9)	46 (54.1)	178 (64.5)	23 (60.5)	0.52
	Middle	124 (31.1)	31 (36.5)	81 (29.3)	12 (31.6)	
	Least	28 (7.0)	8 (9.4)	12 (1.6)	3 (7.9)	
Distance from base hospital, km	0–10	275 (69.1)	79 (92.9)	175 (63.4)	21 (56.8)	< 0.005
	10–20	105 (26.4)	1 (1.2)	88 (31.9)	16 (43.2)	
	20–50	10 (2.5)	-	10 (3.6)	-	
	50 and over	8 (2.0)	5 (5.9)	3 (1.1)	-	
Smoking history	Never	261 (65.4)	48 (56.5)	185 (67.0)	28 (73.7)	0.04
	Stopped	68 (17.0)	18 (21.2)	44 (15.9)	6 (15.8)	
	Current	70 (70.5)	19 (22.4)	47 (17.0)	4 (10.5)	
Comorbidities						
Type II diabetes	Yes	124 (31.1)	29 (34.1)	77 (27.9)	18 (47.4)	0.04
	No	275 (68.9)	56 (65.9)	199 (72.1)	20 (52.6)	
Hypertension	Yes	161 (40.4)	29 (34.1)	111 (40.2)	21 (55.3)	0.09
	No	238 (59.6)	56 (65.9)	165 (59.8)	17 (44.7)	
Hypercholesterolemia	Yes	124 (31.1)	27 (31.8)	87 (31.5)	10 (26.3)	0.80
	No	275 (68.1)	58 (68.2)	189 (68.5)	28 (73.7)	
Obstructive sleep apnea	Yes	84 (21.1)	19 (22.4)	55 (19.9)	10 (26.3)	0.63
	No	315 (78.9)	66 (77.6)	221 (80.1)	28 (73.7)	
Chronic obstructive pulmonary disease	Yes	14 (3.5)	4 (4.7)	9 (3.3)	1 (2.6)	0.78
	No	385 (96.5)	81 (95.3)	267 (96.7)	37 (97.4)	
Asthma	Yes	67 (16.8)	9 (10.6)	53 (19.2)	5 (13.2)	0.15
	No	332 (83.2)	76 (89.4)	223 (80.8)	33 (86.8)	
Osteoarthritis	Yes	103 (25.8)	15 (17.6)	72 (26.1)	16 (42.1)	0.02
	No	296 (74.2)	70 (82.4)	204 (73.9)	22 (57.9)	
Polycystic ovarian disease (fem only)	Yes	38 (12.8)	11 (16.2)	25 (12.2)	2 (9.1)	0.59
	No	269 (87.2)	57 (83.8)	182 (87.9)	20 (90.9)	
Gastroesophageal reflux disease	On PPI	61 (15.3)	7 (8.2)	48 (17.4)	6 (15.8)	0.28
	Yes but not on PPI	55 (13.8)	11 (12.9)	40 (14.5)	4 (10.5)	
	Never	283 (70.9)	67 (78.8)	188 (68.1)	28 (73.7)	
Cerebrovascular accident	Yes	15 (3.8)	1 (1.2)	10 (3.6)	4 (10.5)	0.04
	No	384 (96.2)	84 (98.8)	266 (96.4)	34 (89.5)	
Ischaemic heart disease	Yes	20 (5.0)	3 (3.5)	13 (4.7)	4 (10.5)	0.24
	No	379 (95.0)	82 (86.5)	263 (95.3)	34 (89.5)	
Chronic kidney disease	Yes	14 (3.5)	1 (1.2)	9 (3.3)	4 (10.5)	0.03
	No	385 (96.5)	84 (98.8)	267 (96.7)	34 (89.5)	
Vitamin D deficiency	Yes	131 (32.8)	37 (43.5)	88 (31.9)	6 (15.8)	0.01
	No	268 (67.2)	48 (56.5)	188 (61.9)	32 (84.2)	
Previous surgery	Yes	165 (41.4)	33 (38.8)	124 (44.9)	8 (21.1)	0.02
	No	234 (58.6)	52 (61.2)	152 (55.1)	30 (78.9)	
Depression	No	245 (61.4)	56 (65.9)	163 (59.1)	26 (68.4)	0.04
	Yes without medication	74 (18.5)	11 (12.9)	53 (19.2)	10 (26.3)	
	On medication	80 (20.1)	18 (21.2)	10 (26.3)	2 (5.3)	

Table 2 Outcome according to patient demographics and comorbidities. Figures are *n* (% of group) unless stated. *MDT*, multidisciplinary team; *km*, kilometres; *IMD*, Index of Multilevel Deprivation

		Surgery	Refused by MDT	Patient refused	<i>p</i>
Source of referral	Tier 3	59 (69.4)	3 (3.5)	23 (27.1)	0.01
	GP	155 (56.2)	30 (10.9)	91 (33.0)	
	AS	14 (36.8)	8 (21.1)	16 (42.1)	
Body mass index kg/m ²	35–39.9	25 (62.5)	6 (15.0)	9 (22.5)	0.37
	40–49.9	123 (58.7)	17 (8.1)	71 (33.6)	
	50 and over	80 (54.1)	18 (12.2)	50 (33.8)	
Mean age, years (95% CI)		43.9 (42.5–45.4)	50.2 (46.2–54.2)	45.7 (43.4–47.9)	0.01
Gender	Female	180 (60.6)	31 (10.4)	86 (29.0)	0.03
	Male	48 (47.1)	10 (9.8)	44 (43.1)	
IMD tertile	Most	132 (53.4)	28 (11.3)	87 (35.2)	0.38
	Middle	80 (64.5)	10 (8.1)	34 (27.4)	
	Least	16 (57.1)	3 (10.7)	9 (32.1)	
Distance from base hospital, km	0–10	147 (53.5)	28 (10.2)	100 (36.4)	0.08
	10–20	69 (65.7)	10 (9.5)	26 (24.8)	
	20–50	6 (60.0)	3 (30.0)	1 (10.0)	
	50 and over	5 (62.5)	0 (0.0)	3 (37.5)	
Smoking history	Never	139 (53.3)	23 (8.8)	99 (37.9)	0.03
	Stopped	44 (64.7)	8 (11.8)	16 (23.5)	
	Current	45 (64.3)	10 (14.3)	15 (21.4)	
Type II diabetes	Yes	62 (50.0)	19 (15.3)	43 (34.7)	0.04
	No	166 (60.4)	22 (8.0)	87 (31.6)	
Hypertension	Yes	87 (54.0)	23 (14.3)	51 (31.7)	0.09
	No	141 (59.2)	18 (7.6)	79 (33.2)	
Hypercholesterolemia	Yes	74 (59.7)	15 (12.1)	35 (28.2)	0.40
	No	154 (56.0)	26 (9.5)	95 (34.5)	
Obstructive sleep apnea	Yes	50 (59.5)	16 (19.0)	18 (21.4)	< 0.005
	No	178 (56.5)	25 (7.9)	112 (35.6)	
Chronic obstructive pulmonary disease	Yes	4 (28.6)	4 (28.6)	6 (42.9)	0.03
	No	224 (58.2)	37 (9.6)	124 (32.2)	
Asthma	Yes	36 (53.7)	8 (11.9)	23 (34.3)	0.80
	No	192 (57.8)	33 (9.9)	107 (32.2)	
Osteoarthritis	Yes	56 (54.4)	19 (18.4)	28 (27.2)	0.01
	No	172 (58.1)	22 (7.4)	102 (34.5)	
Polycystic ovarian disease (fem only)	Yes	27 (71.1)	4 (10.5)	7 (18.4)	0.29
	No	153 (59.1)	27 (10.4)	79 (30.5)	
Gastroesophageal reflux disease	On PPI	27 (44.3)	15 (24.6)	19 (31.1)	< 0.005
	Yes but not on PPI	44 (80.0)	5 (9.1)	6 (10.9)	
	Never	157 (55.5)	21 (7.4)	105 (37.1)	
Cerebrovascular accident	Yes	4 (26.7)	7 (46.7)	4 (26.7)	< 0.005
	No	224 (58.3)	34 (8.9)	126 (32.8)	
Ischaemic heart disease	Yes	6 (30.0)	7 (35.0)	7 (35.0)	< 0.005
	No	222 (58.6)	34 (9.0)	123 (32.5)	
Chronic kidney disease	Yes	6 (42.9)	4 (28.6)	4 (28.6)	0.07
	No	222 (57.7)	37 (9.6)	126 (32.7)	
Vitamin D deficiency	Yes	94 (71.8)	11 (8.4)	26 (19.8)	< 0.005
	No	134 (50.0)	30 (11.2)	104 (38.8)	
Previous surgery	Yes	115 (69.7)	18 (10.9)	32 (19.4)	< 0.005
	No	113 (48.3)	23 (9.8)	98 (41.9)	
Depression	No	132 (53.9)	19 (7.8)	94 (38.4)	0.01
	Yes without medication	42 (56.8)	10 (13.5)	22 (29.7)	
	On medication	54 (67.5)	12 (15.0)	14 (17.5)	

patients being refused surgery by the MDT. There was no statistical significance in outcome for BMI, distance from our hospital, level of deprivation, hypertension, hypercholesterolemia, CKD, PCOS.

On regression analysis, patients from AS or GP were more likely to decide against surgery (OR 2.44 95%CI 1.13–6.80 $p = 0.03$ and OR 1.65 95% CI 1.10–3.12 $p = 0.04$) and more likely to be deemed not suitable for surgery by the MDT (OR 6.42 95% CI 1.25–33.1 $p = 0.02$ and OR 3.47 95% CI 1.11–12.9 $p = 0.03$) compared with those referred from tier 3. A BMI of over 50 was more likely to lead to a patient refusing surgery (OR 3.14 95% CI 1.19–8.28 $p = 0.02$). Patients with a vitamin D deficiency (OR 0.37 95% CI 0.21–0.66 $p < 0.005$) or previous abdominal surgery (OR 0.38 95% CI 0.22–0.67 $p < 0.005$) were less likely to decide against surgery. There was no association between the other comorbidities, age, gender, IMD, smoking history or distance from base hospital and the failure to proceed to surgery between the three groups (Table 3).

Discussion

The provision of bariatric and metabolic surgery in the UK remains poor. The aim of this study was to determine the factors that could improve the uptake of this intervention, in the wake of a worsening obesity pandemic. Our study demonstrates that a tier 3 programme reduced the drop-out rate and so patients were more likely to progress to surgery in tier 4, even after taking into consideration comorbidities, demographics and distance from the hospital, compared to those referred directly from their GP or other specialities. Of note, higher levels of socioeconomic deprivation made no significant difference in the likelihood of surgery. This study improves our understanding of the barriers to bariatric surgery and suggests there may be a role of the tier 3 service in preparing patients for this intervention.

This study includes patients from when our unit was first opened in 2013, which predates the 2014 NICE guidelines mandating the requirement for tier 3 intervention [10]. As a result, there is a relatively high proportion of patients in the GP group, a figure that has reduced in recent years (data not provided). Subsequently, this study gives an insight into the benefits of tier 3 services.

In a recent systematic review, Alkharaiji et al. [13] demonstrated that 39.2% of tier 3 participants demonstrated $\geq 5\%$ weight loss by 6 months, which increased marginally to 43.4% at 12 months. Although there was also an improvement in the obesity-related comorbidities, 33.4% of patients had dropped out by 6 months, increasing to 44.1% by the end of the first year. These findings confirmed the earlier systematic review by Brown et al. [17] who also showed that using low-

calorie diets made the most significant difference to weight loss in the tier 3 setting. Neither of these reviews considered whether the weight loss or participation in a tier 3 programme improved the uptake of surgery in tier 4.

In a review of the current NHS England policy on obesity services, Hazlehurst et al. [11] concluded that tier 3 services would not reduce the proportion of patients seeking bariatric surgery as the modest weight loss in tier 3 is unlikely to meet a patient's expectations when they seek weight reduction interventions. Although a number of studies have demonstrated that weight loss in tier 3 does not necessarily correspond to better weight loss after bariatric surgery [12, 18], to our knowledge, there are no studies which have investigated the benefit of tier 3 services in improving surgery uptake. As demonstrated in our study, tier 3 services seemed to reduce the drop-out rate from 33 to 27% when compared to those that are referred directly from the GP. Essentially, the GP group represents patients who are at the beginning of their bariatric pathway, and so differ from tier 3 patients, who should be more informed about the risks of obesity and benefits and possible complications associated with surgery. This correlates with the finding that patients referred by other specialities were least likely to undergo surgery—they would have been referred for an obesity-related comorbidity, such as osteoarthritis, and so were not initially considering bariatric surgery. In addition, patients from this group were also most likely to be refused surgery, reflecting the higher levels of comorbidities seen in this group.

Higher levels of deprivation, extreme age, and female gender are known to be associated with worse non-attendance rates to outpatient clinics [15]. Although this may be the case with stand-alone clinics, our findings demonstrate this is not a significant bearing on patients on the bariatric pathway. The latter is a longer, more involved process that requires building a relationship between the patient and the bariatric team. Interestingly, patients with a BMI of over 50 kg/m² were more likely to refuse surgery. This may be due to the higher perceived risk associated with such BMIs, although we were unable to elucidate the reasons in this study.

In essence, the findings of our study should be used to support the principles of tier 3, rather than accepting the current structure of obesity service. Our opinion aligns with that of Hazlehurst et al. [11] in that pre-tier 4 services should be more efficient in identifying and preparing patients who wish to proceed to surgery rather than insisting on barriers to surgery such as a certain time or percentage weight loss during the tier 3 programme. During this period, patients' expectations of surgery can be managed [19], with realistic goals outlined. In countries that do not follow such a formalised system, this study highlights the importance of programmes that aim to prepare and educate patients before surgery.

Table 3 Odd ratio (OR) of a patient characteristic or comorbidity being associated with the patient refusing surgery or not being suitable for surgery as deemed by the MDT compared with those who underwent surgery. *AS*, another speciality; *GP*, general practitioner

		Not suitable by MDT		Patient refused	
		OR	<i>p</i>	OR	<i>p</i>
Age		1.02 (0.98–1.06)	0.38	1.01 (0.99–1.04)	0.44
Distance from base hospital		1.00 (0.96–1.03)	0.78	0.99 (0.97–1.01)	0.46
Body mass index	50 and over	0.86 (0.24–3.10)	0.81	3.14 (1.19–8.28)	0.02
	40–49.9	0.50 (0.15–1.70)	0.27	2.33 (0.93–5.87)	0.07
	35–39.9	Ref		Ref	
Gender	Female	1.62 (0.56–4.67)	0.37	0.59 (0.31–1.10)	0.10
	Male	Ref		Ref	
Source of referral	AS	6.42 (1.25–33.1)	0.02	2.44 (1.13–6.80)	0.03
	GP	3.47 (1.11–12.9)	0.03	1.65 (1.10–3.12)	0.04
	Tier 3	Ref		Ref	
Smoking history	Current	1.78 (0.64–4.95)	0.27	0.72 (0.34–1.52)	0.39
	Ex-smoker	1.03 (0.36–2.95)	0.96	0.57 (0.27–1.19)	0.13
	No	Ref		Ref	
Type II DM	Yes	1.62 (0.69–3.81)	0.27	1.36 (0.76–2.44)	0.30
	No	Ref		Ref	
Hypertension	Yes	0.99 (0.40–2.43)	0.98	0.81 (0.45–1.43)	0.46
	No	Ref		Ref	
Chronic obstructive pulmonary disease	Yes	1.42 (0.19–10.7)	0.73	7.13 (1.37–37.1)	0.02
	No	Ref		Ref	
Obstructive sleep apnea	Yes	1.69 (0.65–4.35)	0.28	0.28 (0.13–0.59)	< 0.005
	No	Ref		Ref	
Osteoarthritis	Yes	1.65 (0.69–3.94)	0.26	0.71 (0.37–1.33)	0.28
	No	Ref		Ref	
Cerebrovascular accident	Yes	3.43 (0.70–16.8)	0.13	0.83 (0.16–4.30)	0.82
	No	Ref		Ref	
Ischaemic heart disease	Yes	3.40 (0.73–15.8)	0.12	1.79 (0.42–7.70)	0.43
	No	Ref		Ref	
Chronic kidney disease	Yes	2.95 (0.48–18.0)	0.24	1.15 (0.21–6.41)	0.87
	No	Ref		Ref	
Depression	On medication	1.94 (0.74–5.09)	0.18	0.55 (0.26–1.13)	0.10
	Yes without medication	1.74 (0.66–4.61)	0.27	0.70 (0.36–1.39)	0.31
	No	Ref		Ref	
Gastroesophageal reflux disease	On PPI	2.78 (1.09–7.22)	0.03	1.37 (0.65–2.92)	0.41
	Yes but not on PPI	0.62 (0.19–2.01)	0.43	0.22 (0.09–0.57)	< 0.005
	No	Ref		Ref	
Vitamin D deficiency	Yes	0.54 (0.23–1.26)	0.16	0.37 (0.21–0.66)	< 0.005
	No	Ref		Ref	
Previous abdominal surgery	Yes	0.51 (0.22–1.22)	0.13	0.38 (0.22–0.67)	< 0.005
	No	Ref		Ref	

Strengths and Limitations

Despite the retrospective analysis, the data analysed in this study was recorded prospectively as each patient progressed through the bariatric pathway. Due to the robustness of the database, our demographic and comorbidity data was fairly complete, including the outcome.

The findings of this study should be interpreted after considering the following limitations. Although patients failed to attend appointments, and therefore were discharged, it is possible that they underwent surgery elsewhere. However, the number of such patients is expected to be low. In 2017, the department made a concerted effort to call all patients who failed to attend appointments. Although this represents a change in practice over the course of the study period, this intervention was similar despite the source of referral. As the

tier 3 service was provided outside of our hospital, by different providers, the duration, heterogeneity of interventions and the drop-out rate were not available for this study. Therefore, the influence on engagement by variation in practice during tier 3 cannot be evaluated. Weight loss was not included in this study, as a primary or secondary outcome, as it was not consistently available. It is possible improved weight loss may have led to a patient deciding that surgery was no longer needed, although this is likely to represent the minority of patients. In addition, this would be expected to impact the number proceeding from tier 3 rather than the other groups. A future prospective study recording the specific reasons patients decide to no longer attend or decide against surgery would further improve our understanding, including the influence of information gathered from fellow patients, possibly from social media.

Conclusions

Although bariatric and metabolic surgery has been shown to be the most effective intervention for sustained weight loss and remission of comorbidities, the vast majority of suitable patients in the UK are currently not being offered the opportunity to undergo such procedures. This study adds to our understanding of why patients may decide against bariatric surgery and re-iterates the importance of using tier 3 services as a preparation, rather than a barrier, to surgery.

Authors' Contribution All authors take equal responsibility for the accuracy and integrity of this study. C. A.: Study design, analysis and wrote the manuscript. C. K.: Data collection, analysis and wrote the manuscript. L. H.: Study design, data collection analysis and approved the final draft. M. S.: Study design and approved the final draft. C-M.B.: Study design, data collection, analysis and approved the final draft

Declarations

Ethics Approval and Consent to Participate Ethical Approval was not required and informed consent was not necessary for this study

Conflict of Interest The authors declare no conflict of interest.

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