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Post-bariatric surgery nutritional follow-up in primary care: a population-based cohort study

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Abstract

Background

Bariatric surgery is the most effective treatment for severe obesity. However, without recommended follow-up it has long-term risks.

Aim

To investigate whether nutritional and weight monitoring in primary care meets current clinical guidance, post-specialist discharge.

Design and setting

Retrospective cohort study**.** Primary care practices contributing to IQVIA Medical Research Data (IMRD)–UK (1/1/2000-17/1/2018).

Methods

Participants were adults who had had bariatric surgery with a minimum of three years' follow-up post-surgery as this study focused on patients discharged from specialist care (at 2yrs post-surgery). Outcomes were annual proportion of patients from 2yrs post-surgery with a record of recommended nutritional screening blood tests, weight measurement and prescription of nutritional supplements, and proportions with nutritional deficiencies based on blood tests,.

Results

3137 participants were included and median follow-up post-surgery was 5.7 (4.2-7.6) years. 45-59% had an annual weight measurement. The greatest proportions of patients with a record of annual nutritional blood tests were for tests routinely conducted in primary care, e.g. recorded haemoglobin measurement varied between 44.9% (n=629/1400) and 61.2% (n=653/1067). Annual proportions of blood tests specific to bariatric surgery were low, e.g. recorded copper measurement varied between 1.2% (n=10/818) and 1.5% (n=16/1067)

(where recommended). Results indicated that the most common deficiency was anemia. Annual proportions of patients with prescriptions for recommended nutritional supplements were low.

Conclusions

Our study suggests that bariatric surgery patients are not receiving recommended nutritional monitoring post-specialist discharge. GPs and patients should be supported to engage with follow-up care. Future research should aim to understand reasons underpinning our findings.

Keywords: general practice, THIN, bariatric surgery, follow-up, nutrition, cohort

How it fits in

- Post-bariatric surgery clinical guidelines recommend lifelong annual nutritional and weight monitoring under a shared care model between primary care and bariatric specialists.
- Lack of post-bariatric surgery follow-up can lead to poorer outcomes and detrimental health impacts.
- Our findings suggest that most post-bariatric surgery patients, do not receive recommended annual nutritional reviews or weight monitoring within general practice.
- There is an urgent need to support GPs and patients to undertake these reviews and to investigate our findings further to improve outcomes and patient safety.

Introduction

Obesity is a healthcare priority with overweight and obesity related ill-health estimated to cost the National Health Service (NHS) £6.1 billion/year(1,2). Bariatric surgery is recognised as the most clinically and cost-effective treatment for severe and complex obesity(3,4). Globally, the annual rate of bariatric surgery procedures is increasing, leading to a growing cohort of patients living with a history of bariatric surgery(5). Bariatric surgery is associated with multiple health benefits such as type 2 diabetes mellitus remission, improvements in cardiovascular disease and reduction in all-cause mortality(6,7). However, despite these benefits, without adequate follow-up bariatric surgery has long-term risks including significant nutritional deficiencies and weight regain, and for some, the consequences can be significant(8-10). For example, there are case reports of nutritional deficiencies leading to night-blindness, cardiomyopathy and neuropathy, including permanent disability or death in some cases(11-15). These case reports commonly cite inadequate follow-up or adherence to supplements as a contributing factor. There is also evidence from cohort studies and systematic reviews that poor follow-up care and adherence to supplements have negative impacts on outcomes(16-18).

The importance of follow-up care is recognised in clinical guidance. In the UK, the National Institute for Health and Care Excellence (NICE) Clinical Guidance 189 (CG189) recommends that patients stay under specialist surgical care for the first two years post-bariatric surgery, and then discharged to primary care for annual reviews under a shared care model with a bariatric specialist(3,19). NICE also recommended that annual reviews include nutritional monitoring as a minimum, but did not give any detailed guidance as to what constitutes an adequate nutritional review(3). The European Association for the Study of Obesity (EASO)

has also published guidance on post-bariatric surgery management, which highlighted the need for long-term follow-up and did include recommendations on monitoring and supplementation(5). In the UK the British Obesity and Metabolic Surgery Society (BOMSS) nutritional guidelines are the most detailed clinical guidance available for nutritional monitoring and supplementation post-bariatric surgery(20).

Both NICE and EASO suggest that long-term care be delivered within primary care(5). However, there is no specific healthcare funding or services available to support general practitioners (GPs) to undertake long-term care annual reviews and there are concerns that patients are not being reviewed, resulting in risk of avoidable harms and outcomes not being optimised(3,5).

To date there has been no research into the long-term routine care and monitoring currently received by patients following bariatric surgery in primary care. This study aims to investigate whether the nutritional care and weight monitoring delivered by GPs to patients two years post-bariatric surgery meets current UK national clinical guidance.

Methods

Study Design

A retrospective cohort study of patients who have had bariatric surgery was conducted using routinely collected primary care data, starting follow-up from the second year post-surgery (when care is transferred back to within primary care) to estimate the annual proportion of patients with a record of:

- weight measurement
- measurement of nutritional screening blood tests recommended by BOMSS guidelines(20)

- prescription of nutritional supplements recommended by BOMSS guidelines(20)

A secondary aim was to examine the proportion of patients whose test result indicated a nutritional deficiency.

Data source: IQVIA Medical Research Data (IMRD)–UK

IMRD database is an electronic primary care database, which contains pseudo-anonymised electronic medical records of patients from 787 general practices. It provides longitudinal patient records of over 15 million patients and covers around 6.2% of the UK population(21). IMRD is generalizable to the UK population, including medical records of patients from all ages, genders and socio-economic groups(22). It has previously been validated for the purpose of studying chronic conditions such as obesity and type 2 diabetes mellitus(23).

Study population

The study population was extracted from GP practices that had met the following inclusion criteria: used the Vision electronic medical record system for at least a year and shown Acceptable Mortality Recording for at least a year before being considered for data extraction. From the eligible GP practices, cohort entry was restricted to adult patients (≥18yrs) with a body mass index (BMI) ≥30kg/m^2 prior to surgery and a Read code record of a bariatric surgery procedure in their medical records at any time between 1/1/2000-1/1/2015 (Read codes are in Supplementary Table 1). This study focused on patients who had been discharged from specialist care at 2yrs post-surgery. Therefore patients needed to have had a minimum of 3yrs follow-up since surgery for inclusion. We focused on the procedures most commonly conducted in the UK: laparoscopic adjustable gastric banding

(LAGB), gastric bypass and sleeve gastrectomy. To be eligible for inclusion, study participants must have been registered with their practice for at least a year before study entry to ascertain documentation of concomitant diseases and treatments. We included the restriction that patients needed to have a BMI ≥30kg/m^2 to minimise the inclusion of patients who might have had bariatric surgery for a reason other than obesity.

Outcomes

We estimated the annual proportion of patients in the third, fourth and fifth year of follow-up post-surgery for whom nutritional screening blood tests were requested as recommended by BOMSS guidelines, a measurement of weight/BMI was recorded and records for prescriptions of BOMSS recommended nutritional supplements were available (Table 1 summarises BOMSS nutritional guidance for each procedure) (20). Study follow-up was from index date (2yrs post-bariatric surgery) until the earliest of the following end points: death date, date patient left the practice, date practice ceased to contribute to the database and study end date (17/1/2018).

The nutritional screening blood tests recommended by BOMSS(20) were defined by Read codes (Supplementary Table 2) or based on the availability of blood test measurements. In order to summarise the results as concisely as possible, creatinine level was used as a proxy for measurement of urea and electrolytes (U&Es) (as serum levels usually only measured as part of the panel of tests included in U&Es). Similarly, protein was used as a proxy for liver function tests (LFTs) measurement. Protein was chosen as it is a clinically important measurement for patients post-bariatric surgery due to risks of protein malnutrition. Haemoglobin (Hb) was used as a proxy for measurement of full blood count (FBC) (as usually only measured as part of the panel of tests in FBC). Prescriptions of nutritional supplements

recommended by BOMSS nutritional guidance were defined by drug codes (Supplementary Table 3). We included prescriptions for all possible relevant nutritional supplements as listed in the British National Formulary(24). For those patients who had a nutritional screening blood test, we estimated the proportion whose test result indicated nutritional deficiency. Nutrient levels that indicated a deficiency were based on laboratory levels used in the Tier 3/4 bariatric services across University Hospitals Birmingham NHS Foundation Trust.

Analysis

Descriptive analysis of the baseline characteristics was performed and expressed as mean (standard deviation (SD)) or frequency (%) depending on whether the variable was continuous or categorical.

The annual proportion of patients who received nutritional blood test screening, weight screening or nutritional supplement prescriptions was estimated. The proportion of patients who had had a nutritional screening blood test with a nutritional deficiency was also estimated. We analyzed the compliance with recommended nutritional and weight monitoring and nutritional supplement prescriptions, by conducting sequential analysis for serial 12 month periods starting from 2yrs post-surgery. When estimating screening compliance in years 2-3, 3-4 and 4-5, patients were restricted to those with a minimum follow-up post-surgery of 3, 4 and 5yrs, respectively. Therefore, for example, for year three compliance estimation, the denominator was patients who underwent bariatric surgery and were followed-up in the IMRD database until 3yrs post-surgery. Numerator was the number of those patients with a record of a given screening test/nutritional prescription/weight measurement from Read codes/test results/drug codes between year 2-3 post-bariatric surgery. This was repeated for years four and five. Annual proportions were also estimated

stratified by the type of surgical procedure since guidance varies with surgical procedure. A Cochran–Armitage test was used to assess whether any observed temporal trends in annual proportions were statistically significant. Stata (version 15) statistical software was used for data analysis.

Results

After excluding patients with a BMI <30kg/m^2 before surgery (n=186), 3137 patients with a Read code record of a bariatric surgery procedure and a minimum follow-up of 3yrs post-surgery were eligible for inclusion. Of these, 1400 (44.6%) had a Read code for LAGB, 1067 (34.0%) for gastric bypass, 446 (14.3%) for sleeve gastrectomy and 224 (7.1%) patients had a record of other bariatric surgery procedures. 20% of the cohort were male and mean age at surgery was 48.4yrs (SD 10.3). The mean BMI pre-surgery was 45.3kg/m^2 (SD 8.9) and mean BMI post-surgery was 36.8kg/m^2 (SD 8.8). 19.5% of the cohort were in the most affluent Townsend deprivation quintile. The majority of patients were of Causcasian ethnicity (52%) with only very small numbers from other ethnicities. Baseline characteristics between the different procedures were similar (see Table 2). Median follow-up post-surgery was 5.7yrs (interquartile range (IQR) 4.2-7.6).

Weight measurements

54.5% of patients who had had a LAGB had a weight recorded in year 2-3 post-surgery (the first year following specialist discharge). This remained steady in years 3-4 and 4-5 post-surgery (p=0.250 for temporal trend).

59.2% of patients who had had a gastric bypass had a record of a weight in year 2-3 post-surgery. This fell to 52.0% at year 3-4 post-surgery and 50.1% at year 4-5 post-surgery (p=0.001 for temporal trend).

51.1% of patients who had had a sleeve gastrectomy had a recorded weight measurement in year 2-3 post-surgery, 45.0% at year 3-4 and 46.5% at year 4-5 (p=0.176 for temporal trend). See Figure 1a-c and Table 3.

Nutritional monitoring blood tests

Records of a measurement of nutritional monitoring blood tests recommended for LAGB varied between 29.7% (protein) to 47.6% (creatinine) in year 2-3 post-surgery. 44.9% had a record of Hb measured in year 2-3 post-surgery. These annual proportions were similar in year 3-4 post-surgery with a small increase in the proportions with a record of Hb or creatinine measurement and a larger increase in the proportion with a record of a protein measurement in year 4-5 (p=0.024, p=0.008 and p<0.001 for Hb, creatinine and protein temporal trends, respectively). For both gastric bypass and sleeve gastrectomy, there was a marked difference in the annual proportions of patients with a record of a measurement of a routinely requested blood tests (such as Hb, creatinine) and the proportions with a record of a measurement of a blood test more specific to bariatric surgery. For example, the proportion with a record of creatinine measurement (59.7-64.2%) compared with zinc (4.3-5.3%) or copper (1.2-1.5%) measurements for gastric bypass. See Figure 1a-c and Table 3.

Symptom or diagnosis dependent blood tests

Annual proportions with a record of one of the blood tests recommended depending on patient symptoms were all very low with several (*e.g.* vitamins A, E, K , selenium) recorded for <1% of patients.

Nutritional deficiencies

Where results were available, records indicated that the most common deficiencies were low haemoglobin varying between 40.5% (sleeve gastrectomy) and 50.6% (gastric bypass,

LAGB) of patients, and low ferritin levels varying between 18.9% (LAGB) and 35.0% (gastric bypass, LAGB). Full results of records indicating a nutritional deficiency are in Table 4.

Prescription of nutritional supplements

Only 5.9-6.9% of patients who had had a LAGB had a record of a prescription for a multivitamin prescription in each given year (Figure 2a).

For gastric bypass, the annual proportion of patients with a record of a multivitamin prescription was 42.4-43.7%, while the annual proportions with a record of a prescription for iron or vitamin B12 were 37.8-42.6% and 37.2-40.0%, respectively. The annual proportions with a record of a prescription for folic acid varied between 10.0-10.4% and between 48.5-53.8% for prescriptions of calcium/vitamin D (Figure 2b).

Annual proportions of patients who had had a sleeve gastrectomy with a record of a prescription for each of the supplements were all lower than those who had undergone a gastric bypass and varied between 8.3% (folic acid year 2-3) to 31.2% (vitamin D year 2-3) (Figure 2c).

Annual proportions of supplement prescriptions for all the procedures did not vary appreciably with time ($p>0.05$ for trend over time, except for a decrease in the proportion of calcium prescriptions among patients who underwent bypass surgery ($p=0.034$ for trend)).

Discussion

Summary

Our results suggest that patients are not receiving the long-term nutritional care recommended in national guidance. There was a marked contrast between the proportion having routine blood tests and the very low proportion having blood tests more specific to

bariatric surgery follow-up. It is possible that these more specific blood tests are a truer reflection of the incidence of post-bariatric surgery annual nutritional reviews since tests routinely carried out in primary care could be requested for a multitude of reasons other than bariatric surgery follow-up. If results for the more specific tests are used as a proxy for an annual bariatric surgery review, it would suggest that only around 5% of patients are receiving recommended long-term follow-up reviews within primary care.

Strengths and limitations

To our knowledge, this is the first study to investigate the care patients receive in primary care post-bariatric surgery after specialist discharge and whether it meets current clinical guidelines. By using the IMRD database we were able to use routinely collected data that included a large number of patients with good national coverage over 3yrs follow-up in primary care. These data should be representative of the current routine clinical care received by patients. However, we could not obtain data on indications for blood tests or supplement prescriptions so they could have been requested or prescribed for reasons unrelated to bariatric surgery. We did not investigate if the correct dose of a given nutritional supplement was being prescribed only if a prescription had been issued. It is also possible that some nutritional supplements are obtained over the counter or from specialist services so our data may underestimate supplement use. However, generally specialist bariatric services are not commissioned for long-term follow-up so it is likely that this is only very small numbers of patients. Read codes for bariatric surgery may have included patients having surgery for reasons other than obesity, such as stomach cancer. However, our feasibility check suggested they represented <1% of patients.

Comparison with existing literature

Previous studies have shown that adherence to follow-up care and nutritional supplements can be poor and leading to increased risk of nutritional deficiencies and weight regain(16-18,25). Levels of deficiencies reported in these studies were generally lower than those reported here(17). This may be due to multiple reasons including differences in study population, and study design.

There has been little previous research on the long-term care patients receive in primary care following discharge from specialist follow-up. In 2019 by Mahawar *et al.* conducted a survey of UK adult patients who had had bariatric surgery regarding adherence to nutritional supplements(26). They reported that as well as forgetting to take medication, GPs not prescribing supplements was a barrier and that both patient and GP education may help(26). Several survey studies have consistently reported a lack of confidence amongst GPs in managing bariatric surgery patients and a desire for more education(27,28). This suggests that GP confidence and education may be barriers to patients receiving long-term care post-bariatric surgery. There have been some attempts to improve GP awareness of the management of patients following bariatric surgery in primary care in the UK(29, 30). However, any impact these resources may have had is not clear.

Implications for research and practice

There is international clinical consensus that long-term follow-up care following bariatric surgery is important to optimise patient outcomes and reduce risk of preventable harms(3,5,8-10). Our study suggests that patients are not receiving recommended nutritional care post-specialist discharge in terms of monitoring and treatment, increasing the risk of preventable adverse outcomes. The importance of appropriate follow-up post-

bariatric surgery should be emphasised to healthcare professionals and patients and GPs supported to provide this care. Future research should aim to understand the reasons underpinning the apparent lack of follow-up to help to develop appropriate strategies to improve the care of patients post-bariatric surgery.

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Ethical approval

Use of IMRD is approved by the UK Research Ethics Committee (reference number: 18/LO/0441); in accordance with this approval, the study protocol was reviewed and approved by an independent Scientific Review Committee (SRC) (reference number: 18THIN097). IMRD incorporates data from The Health Improvement Network (THIN), A Cegedim Database. Reference made to THIN is intended to be descriptive of the data asset licensed by IQVIA. This work used de-identified data provided by patients as a part of their routine primary care.

Conflict of Interest Statement

None declared.

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Statement of Authorship

HMP developed the original idea for the study. Read codes were identified by HMP, SA, AAT and KN. AS performed the data extraction and statistical analyses with oversight from NJA and KN. HMP drafted the paper with input from all authors. All authors read, commented and approved the final manuscript.

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Figure and Table Legends

Table 1: Abbreviated summary of BOMSS post-surgery nutritional guidance for blood tests and supplements

Table 2: Baseline characteristics

Table 3: Records of blood tests and weight measurements

Table 4: Records of a result indicating a deficiency

Figure 1a-c: Records of blood tests and weight measurements

Figure 2:a-c Records of a prescription of recommended nutritional supplements

Table 1: Abbreviated summary of BOMSS post-surgery nutritional guidance for blood tests and supplements (20)

	Annual screening blood tests			**Nutritional supplementation**		
	LAGB	**Gastric bypass**	**Sleeve gastrectomy**	**LAGB**	**Gastric bypass**	**Sleeve gastrectomy**
FBC	**x**	**x**	**x**			
U&Es	**x**	**x**	**x**			
LFTs	**x**	**x**	**x**			
Ferritin		**x**	**x**			
Folate		**x**	**x**			
Calcium		**x**	**x**			
Vitamin D		**x**	**x**			
PTH		**x**	**x**			
Thiamine		**S**	**S**			
Vitamin B12		**x**	**x**			
Zinc		**x**				
Copper		**x**				
Vitamin A		**S**				
Vitamin E		**S**				
Vitamin K		**S**				
Selenium		**S**				
Multivitamin supplement				**x**	**x**	**x**
Iron supplement					**x**	**x**
Folic acid supplement					**x**	**x**
Vitamin B12 supplement					**x**	**x**
Calcium and vitamin D supplement					**x**	**x**

LAGB= laparoscopic adjustable gastric band

U&Es=urea and electrolytes, FBC=full blood count, LFTs=liver function tests, PTH=parathyroid hormone

S=measure if concerning signs or symptoms

Table 2: Baseline characteristics

	Total (n=3137)	**LAGB (n=1400)**	**Gastric bypass (n=1067)**	**Sleeve Gastrectomy (n=446)**
Age at the time of surgery [mean(SD)]	48.4 (10.3)	47.3 (9.9)	48.8 10.3	50.6 (10.6)
Male Sex [n(%)]	633 (20.2)	206 (14.7)	246 (23.1)	120 (26.9)
Number of patients with available BMI pre-surgery data	3076 (98.1%)	1373 (98.1%)	1050 (98.4%)	437 (98.0%)
BMI pre-surgery [mean(SD)]^	45.3 (8.9)	43.3 (8.5)	46.8 (7.9)	47.6 (9.1)
BMI pre-surgery [median[IQR)]^	44.6 (39.3-50.2)	42.3 (37.9-47.3)	46.7 (41.4-51.5)	46.8 (41.7-52.8)
Number of patients with available BMI post-surgery data	2097 (66.9%)	1031 (73.6%)	680 (63.7%)	245 (54.9%)
BMI post-surgery [mean(SD)]*^	36.8 (8.8)	37.2 (8.8)	34.9 (7.9)	38.3 (8.5)
BMI post-surgery [median[IQR)]*^	36.1 (30.7-41.7)	36.3 (30.9-42.3)	34.2 (29.5-39.1)	38.2 (32.3-43.5)
Year of last available BMI recording post-surgery [mean(SD)]^	2.7 (2.1)	3.3 (2.3)	2.1 (1.7)	1.9 (1.6)
Year of last available BMI recording post-surgery [median(SD)]^	2.3 (1.0-4.0)	3.0 (1.5-4.7)	1.8 (0.7-3.2)	1.5 (0.7-2.4)
Townsend Deprivation quintile				
1	610 (19.5)	312 (22.3)	190 (17.8)	73 (16.4)
2	526 (16.8)	251 (17.9)	170 (15.9)	66 (14.8)
3	594 (18.9)	280 (20.0)	196 (18.4)	79 (17.7)
4	559 (17.8)	213 (15.2)	214 (20.1)	88 (19.7)
5	405 (12.9)	157 (11.2)	151 (14.2)	61 (13.7)
Missing data	443 (14.1)	187 (13.4)	146 (13.7)	79 (17.7)
Ethnicity				
White	1637 (52.2)	692 (49.4)	585 (54.8)	244 (54.7)
Afro-Caribbean	61 (1.9)	19 (1.4)	29 (2.7)	11 (2.5)
South Asian	48 (1.5)	14 (1.0)	24 (2.3)	6 (1.4)
Mixed Race	11 (0.4)	7 (0.5)	3 (0.3)	0 (0.0)
Chinese/Middle Eastern/Other	14 (0.5)	10 (0.71)	2 (0.2)	2 (0.5)
Missing data	1366 (43.5)	658 (47.0)	424 (39.7)	183 (41.0)

BMI=body mass index, SD=standard deviation, IQR=interquartile range, LAGB=laparoscopic adjustable gastric band

*Last recording available in the database

^ Summary statistics based on available data only.

Table 3: Records of blood tests and weight measurements

	2-3 years post-surgery			3-4 years post-surgery			4-5 years post-surgery		
n (%)	**LAGB (n=1400)**	**Gastric bypass (n=1067)**	**Sleeve Gastrectomy (n=446)**	**LAGB (n=1213)**	**Gastric bypass (n=818)**	**Sleeve Gastrectomy (n=300)**	**LAGB (n=1020)**	**Gastric bypass (n=565)**	**Sleeve Gastrectomy (n=202)**
Weight	763(54.5%)	632(59.2%)	228(51.1%)	635(52.4%)	425(52.0%)	135(45.0%)	533 (52.3%)	283 (50.1%)	94 (46.5%)
Blood tests recommended by BOMSS for all patients									
Creatinine	667(47.6%)	667(62.5%)	247(55.4%)	587(48.4%)	525(64.2%)	183(61.0%)	544(53.3%)	337(59.7%)	118(58.4%)
Albumin	607(43.4%)	624(58.5%)	216(48.4%)	519(42.8%)	490(59.9%)	160(53.3%)	486(47.7%)	314(55.6%)	98(48.5%)
Parathyroid hormone	6(0.4%)	51(4.8%)	7(1.6%)	6(0.5%)	29(3.6%)	6(2.0%)	5(0.5%)	13(2.3%)	8(4.0%)
Folate	215(15.4%)	383(35.9%)	100(22.4%)	175(14.4%)	270(33.0%)	68(22.7%)	171(16.8%)	184(32.6%)	55(27.2%)
Calcium	291(20.8%)	369(34.6%)	102(22.9%)	236(19.5%)	264(32.3%)	82(27.3%)	223(21.9%)	189(33.5%)	55(27.2%)
Hb	629(44.9%)	653(61.2%)	223(50.0%)	554(45.7%)	498(60.9%)	164(54.7%)	507(49.7%)	326(57.7%)	111(55.0%)
Ferritin/iron	222(15.9%)	413(38.7%)	116(26.0%)	193(15.9%)	267(32.6%)	82(27.3%)	197(19.3%)	185(32.7%)	70(34.7%)
Protein	416(29.7%)	373(35.0%)	126(28.3%)	341(28.1%)	276(33.7%)	96(32.0%)	514(50.4%)	335(59.3%)	114(56.4%)
Vitamin B12	242(17.3%)	565(53.0%)	169(37.9%)	199(16.4%)	426(52.1%)	111(37.0%)	194(19.0%)	283(50.1%)	79(39.1%)
Vitamin D	65(4.6%)	180(16.9%)	57(12.8%)	56(4.6%)	110(13.5%)	31(10.3%)	59(5.8%)	78(13.8%)	24(11.9%)
Copper	1(0.07%)	16(1.5%)	4(0.9%)	6(0.5%)	10(1.2%)	2(0.7%)	1(0.1%)	7(1.2%)	3(1.5%)
Zinc	14(1.0%)	54(5.1%)	11(2.5%)	17(1.4%)	43(5.3%)	9(3.0%)	8(0.8%)	24(4.3%)	5(2.5%)
Blood tests recommended by BOMSS depending on symptoms and diagnoses									
Vitamin E	0(0.0%)	1(0.1%)	0(0.0%)	2(0.2%)	2(0.2%)	1(0.3%)	0(0.0%)	1(0.2%)	1(0.5%)
Vitamin K	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)
Vitamin A	2(0.1%)	3(0.3%)	2(0.5%)	3(0.3%)	5(0.6%)	2(0.7%)	0(0.0%)	5(0.9%)	4(2.0%)
Magnesium	26(1.9%)	53(5.0%)	12(2.7%)	21(1.7%)	38(4.7%)	11(3.7%)	18(1.8%)	33(5.8%)	4(2.0%)
Selenium	3(0.2%)	5(0.5%)	2(0.5%)	3(0.3%)	11(1.3%)	3(1.0%)	3(0.3%)	7(1.2%)	3(1.5%)
Thiamine	0(0.0%)	1(0.1%)	2(0.5%)	0(0.0%)	1(0.1%)	2(0.7%)	0(0.0%)	0(0.0%)	1(0.5%)

LAGB=laparoscopic adjustable gastric band, Hb = haemoglobin, BOMSS= British Obesity and Metabolic Surgery Society

Table 4: Records of a result indicating a deficiency

	2-3 years post-surgery			3-4 years post-surgery			4-5 years post-surgery		
	LAGB n/N (%)	**Gastric bypass n/N (%)**	**Sleeve Gastrectomy n/N (%)**	**LAGB n/N (%)**	**Gastric bypass n/N (%)**	**Sleeve Gastrectomy n/N (%)**	**LAGB n/N (%)**	**Gastric bypass n/N (%)**	**Sleeve Gastrectomy n/N (%)**
Folate (AHD <3.1 microgram/L)	15/192 (7.8%)	12/361 (3.3%)	7/98 (7.1%)	11/158 (6.9%)	13/257 (5.1%)	6/67 (9.0%)	16/157 (10.2%)	3/173 (1.7%)	2/55 (3.6%)
Calcium (AHD <2.2 mmol/L)	22/262 (8.4%)	53/325 (16.3%)	11/92 (12.0%)	25/213 (11.7%)	33/238 (13.9%)	6/77 (7.8%)	23/200 (11.5%)	26/172 (15.1%)	7/51 (13.7%)
Anaemia (AHD <133(male)/110 (female)g/L)	283/623 (45.4%)	327/646 (50.6%)	89/220 (40.5%)	277/548 (50.6%)	247/496 (50.0%)	75/162 (46.3%)	233/498 (46.8%)	162/325 (49.9%)	46/110 (41.8%)
Ferritin (AHD <15 microgram/L)	32/169 (18.9%)	89/347 (25.7%)	20/95 (21.1%)	48/137 (35.0%)	69/224 (30.8%)	22/72 (30.6%)	43/153 (28.1%)	57/163 (35.0%)	18/61 (29.5%)
Protein (AHD <60 g/L)	7/415 (1.7%)	11/372 (3.0%)	2/125 (1.6%)	5/339 (1.5%)	6/276 (2.2%)	1/96 (1.0%)	4/320 (1.3%)	7/188 (3.7%)	0/61 (0.0%)
Vitamin B12 (AHD <187 ng/L)	22/190 (11.6%)	52/360 (14.4%)	14/99 (14.1%)	20/154 (13.0%)	40/280 (14.3%)	6/68 (8.8%)	16/156 (10.3%)	25/186 (13.4%)	4/52 (7.7%)
Parathyroid (AHD >7.2 pmol/L)	1/6 (16.7%)	15/51 (29.4%)	0/7 (0.0%)	1/6 (16.7%)	11/29 (37.9%)	3/6 (50.0%)	2/5 (40.0%)	7/13 (53.9%)	2/8 (25.0%)

LAGB=laparoscopic adjustable gastric band, AHD=additional health data