Original article

Cost–utility analysis of bariatric surgery

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Background: **The objective of the study was to evaluate the cost–utility of bariatric surgery in England.**

Methods: **A state-transition Markov model was developed to compare the costs and outcomes of two treatment approaches for patients with morbid obesity: bariatric surgery, including gastric bypass, sleeve gastrectomy and adjustable gastric banding; and non-surgical usual care. Parameters of the effectiveness of surgery and complications were informed by data from the UK National Bariatric Surgery Registry, the Scandinavian Obesity Registry and the Swedish Obese Subjects study. Costs and utilities were informed by UK sources.**

Results: **Bariatric surgery was associated with reduced mean costs to the health service by €2742 (£1944), and gain of 0·8 life-years and 4·0 quality-adjusted life-years (QALYs) over a lifetime compared with usual care. Bariatric surgery also had the potential to reduce the lifetime risks of obesity-related cardiovascular diseases and diabetes. Delaying surgery for up to 3 years resulted in a reduction of 0·7 QALYs and a minor decrease of €2058 (£1459) in associated healthcare costs.**

Conclusion: **Currently used surgical methods were found to be cost saving over the lifetime of individuals treated in England.**

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Introduction

Obesity is a risk factor for diabetes[1,2], cardiovascular[3–5] and musculoskeletal[6] disorders, gynaecological problems[7,8] and cancer[9]. According to the results of Health Survey for England in 2014[10], the prevalence of obesity in males is 24 per cent and in females 27 per cent, whereas the prevalence of morbid obesity is 1·8 and 3·6 per cent respectively. In the same report, the prevalence of obesity was noted to have increased by 85 per cent for males and 69 per cent for females between 1993 and 2014.

When conservative treatments for obesity fail, bariatric surgery can achieve weight loss and may improve common obesity-related co-morbidities. The UK National Institute for Health and Care Excellence (NICE)[11] recommends bariatric surgery for patients with a BMI over 35 kg/m^2 and type 2 diabetes or another obesity-related co-morbidity, for patients with a BMI exceeding 40 kg/m^2 after failure of non-surgical methods for at 6 months, and as the first-line option for people with a BMI of more than 50 kg/m^2. Additionally, an assessment for bariatric surgery is considered for patients with a BMI of at least 30 kg/m^2 who have recent onset of type 2 diabetes.

In April 2013, the National Health Service (NHS) Commissioning Board[12] set more strict indications for surgery. These require participation in a mandatory weight loss programme for 12–24 months for patients with a BMI of 40 kg/m^2 and above, and for minimum of 6 months for those with BMI of at least 50 kg/m^2. There was a 25 per cent reduction in the amount of bariatric surgery completed in 2014–2015 compared with 2012–2013[13].

The objective of this study was to evaluate the cost–utility of bariatric surgery in England over 10 years and over a lifetime.

Methods

A state-transition decision analytic (Markov) model[14] was constructed to compare the costs and benefits of two strategies: bariatric surgery *versus* usual care. Full details of the modelling approach, data inputs and validation activities have been reported elsewhere[15]. In brief, obese patients who fulfil NICE criteria may undergo surgery or continue with usual care (consisting of drug therapy, diet and physical exercise), experience postoperative complications or have no complications, develop type 2 diabetes or obesity-associated cardiovascular diseases (angina, myocardial infarction, stroke, heart failure and peripheral artery disease), have type 2 diabetes remission, or die (*Fig. 1*). In each model cycle, lasting 1 month, patients may move from one state to another or remain in the same state. Transition probabilities between health states were obtained from the literature[16–21] or calculated using the Framingham Heart Study's equation for risk of cardiovascular complications[22,23].

Methods and results are reported in accordance with the CHEERS statement[24]. Additional description of methods is provided in *Appendix S1* (supporting information).

Input data

Data on clinical effectiveness and complications

The model utilized 10-year and lifetime risks of obesity-related cardiovascular events and type 2 diabetes, and 30-day (short-term) and 2-year (mid-term) risks of surgical complications, as predictors of clinical outcomes and health benefits. The lifetime and 10-year risk of obesity-related cardiovascular diseases in the model is dependent on patient characteristics, including age, sex, systolic BP measurements, BMI, presence of type 2 diabetes and smoking status. The effect of bariatric surgery, considered to reduce the risk of obesity-related complications and mortality, was determined by the change in BMI and systolic BP and the incidence of diabetes.

Thirty-day rates of short-term complications, mortality and reoperations were informed by the UK Second National Bariatric Surgery Registry (NBSR) report[25]. Mid-term complications occurring within 2 years of surgery included cholecystectomy, abdominal hernia repair, leakage and abscess, gastric stricture, gastric ulcer, skin surgery and conversion surgery (*Table S1*, supporting information). At the time of analysis, rates of mid-term complications were not available from the NBSR report and were therefore extracted from the Swedish Obesity Registry (SOReg) 2014 annual report[26]. Conversion rates were informed by the results of a controlled study of gastric bypass (GBP) and adjustable gastric banding (AGB)[27].

Three of the most common surgical operations were considered in the model: GBP, sleeve gastrectomy (SG) and AGB. The reduction in BMI after surgery was informed by the NBSR report[25] for the base-case analysis. At the time of analysis, data on efficacy of surgery were available as relative reduction in excess weight (%EWL) at 2, 6, 12, 24 and 36 months. The %EWL was transformed into a relative reduction in BMI. Missing values for 1- and 3-month time points were made to fit using ordinary least squares regression. Details of transformation and regression analysis are available in *Appendix S1* (supporting information).

The effect of surgery on BMI during the first 3 years was informed by the NBSR; after that it was extrapolated using data from the Swedish Obese Subjects (SOS) study[18] until the time point of 15 years. After 15 years, BMI was assumed to remain at a constant level until death. Changes in BMI for patients receiving usual care were informed by changes in BMI in the control arm of the SOS study[18]. The main clinical inputs are presented in *Table 1*; additional inputs are listed in *Table S1* (supporting information).

Data on resource utilization and cost

Resource utilization and cost data were obtained from UK sources as described below. Only direct medical costs were included in the analysis. The cost of the bariatric surgery procedure was informed by the Department of Health's Reference Costs 2014–2015 (Healthcare Resource Group (HRG) FZ84Z for GBP, and HRG FZ85Z for SG and AGB)[29]. Thirty-day complications did not lead to a change of HRG. It was assumed that patients in the surgical arm would participate in the tier 3 weight management programme before surgery[30]. Before surgery, all patients were expected to visit a surgeon, a dietitian, a psychologist, and have a blood test and ECG. Operated patients were visited by a nurse at 1 month, 6 months, 1 year and 2 years after surgery. In the usual care arm, no resource use in relation to the management of obesity was assumed. The distribution of surgical methods for the base-case analysis (GBP 56 per cent, SG 22 per cent, AGB 22 per cent) was obtained from the NBSR report (operations 2011–2013)[25].

Resource use for the treatment of mid-term complications (leakage and abscess, obstruction, stricture, abdominal hernia and cholecystitis) was based on the expert opinion of one of the authors (A.R.A.). Unit costs were obtained from the Reference Costs 2014–2015[29]. Leakage and abscess (ICD-10 code K91.8) were assumed to be treated differently in patients who had GBP and those who had SG. Patients who had GBP were considered to be treated with an operative drain (OPCS codes T45.3 and G47.3) in 70 per cent of instances and with an image-guided drain (OPCS codes T34.3 and G47.3) in 30 per cent. It was assumed that leakage after SG would be treated with an image-guided drain with stenting (OPCS codes T45.3, G47.3 and G44.1) in 50 per cent of patients, and with an operative drain (OPCS T45.3 and G47.3) and image-guided drain (OPCS T34.3 and G47.3) in 35 and 15 per cent respectively. Obstruction (ICD-10 codes 91.3 and 56.5) was assumed to be treated by endoscopic division of adhesions (OPCS T42.3). Stricture (ICD-10 K91.8

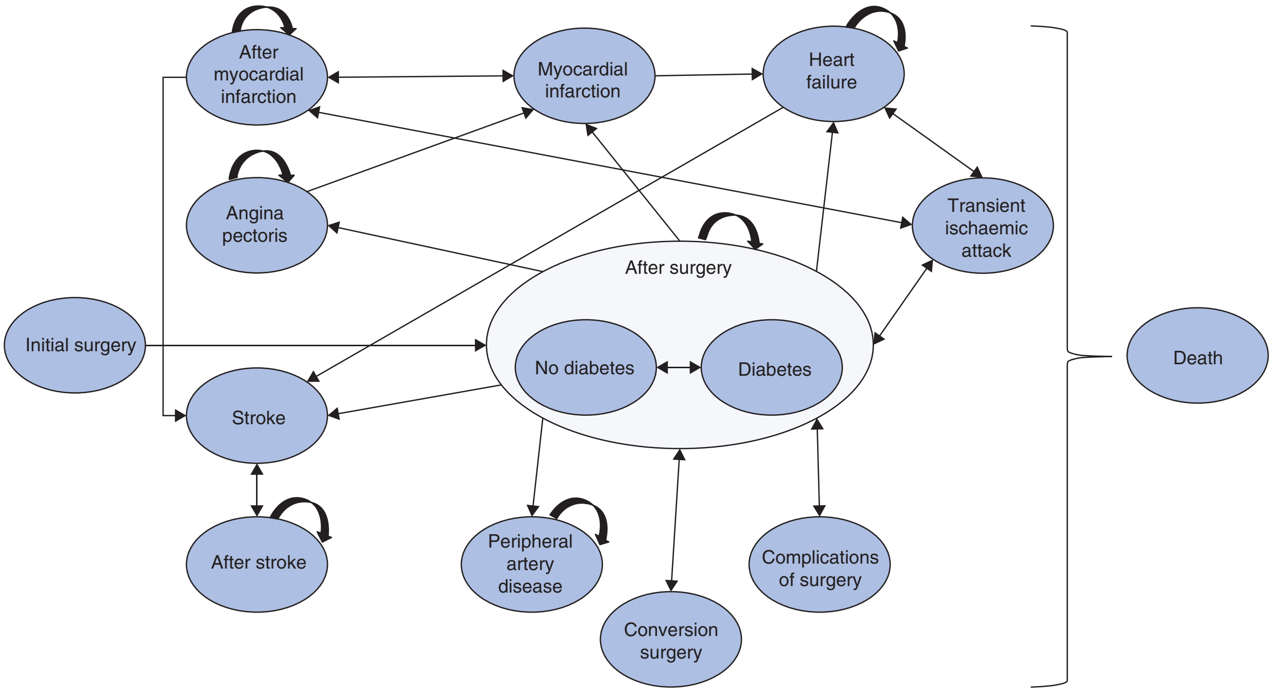

Fig. 1 Structure of the Markov model. Reprinted from Borisenko *et al.*[15], with permission

Table 1 Patient baseline characteristics

	Mean	Range for one-way sensitivity analysis	Distribution for probabilistic sensitivity analysis	Source
Age (years)	45·4	25–65	Normal (s.d. 4·6)	National Bariatric Surgery Registry[25]
Men (%)	24	n.a.	β (α = 1200; β = 3800)	
BMI (kg/m²)	50·5	30–60	Normal (s.d. 5·0)	
Diabetes mellitus (%)	30	n.a.	β (α = 1500; β = 4500)	
Systolic BP (mmHg)	140·1	125–200	γ (α = 55·53; λ = 2·52)	Sjöström *et al.*[18]
Smoker (%)	19	n.a.	β (α = 950; β = 4050)	Statistics on Smoking, England[28]

n.a., Not applicable.

and K56.6) was considered to be treated with fibre-optic endoscopic dilatation (OPCS G44.3). The weighted average of resulting HRGs was used in the analysis. Cost inputs for preoperative diagnostic tests, surgical procedures and postoperative complications are shown in *Table 2*. The costs of obesity-associated co-morbidities were extracted from the UK literature[16,34–38], and those associated with acute stroke, transient ischaemic attack and acute myocardial infarction from the Reference Costs 2014–2015[29]. The cost of gastric ulcer was assumed to be comprised of the cost of drug therapy with proton pump inhibitors, the cost of a single visit to the general practitioner and the cost of a single endoscopic diagnostic procedure, according to the NICE guidelines[39]. Cost inputs for obesity-related co-morbidities are listed in *Table 3*.

All costs in this analysis were evaluated in UK pounds sterling at 2015 prices and converted to euros (£1 = €1·42; www.bloomberg.com, exchange rate 27 November 2015). Adjustment for inflation was made using the Hospital and Community Health Services Index[32].

Utility data

The utility value for each health state depended on BMI and presence of type 2 diabetes[40]. Additionally, the model considered the quality-of-life decrement associated with obesity-related co-morbidities[41]. Data on utility decrements are available in *Table S1* (supporting information).

Cohort description

The primary base-case analysis included summary characteristics of candidates being considered for surgery in England. The characteristics of these so-called multiple cohorts were extracted from the NBSR report[25], the SOS

Table 2 Cost inputs of primary surgery and post-surgery complications, pre-surgery diagnostic tests and weight management program

	Mean (€)	Range for one-way sensitivity analysis (€)	Distribution for probabilistic sensitivity analysis	Source
Cost of gastric bypass	6871	5497–8245	Fixed	DoH[29]; HRG tariff FZ84Z
Cost of sleeve gastrectomy	6727	5382–8072	Fixed	DoH[29]; HRG tariff FZ85Z
Cost of adjustable gastric banding	6727	5382–8072	Fixed	DoH[29]; HRG FZ85Z
Cost of removal/revision of gastric band	6727	5382–8072	Fixed	DoH[29]; HRG FZ85Z
Cost of tier 3 preoperative weight management programme	1444	1155–1733	Fixed	Gulliford *et al.*[30]
Cost of leakage	4348	3478–5218	Fixed	DoH[29]; weighted average of HRGs FZ12Q, YF04C, FZ81E
Cost of obstruction	2812	2250–3374	Fixed	DoH[29]; weighted average of HRGs YF01A, FZ59Z
Cost of stricture	1717	1374–2060	Fixed	DoH[29]; doubled cost of HRG FZ70Z
Cost of gastric ulcer (8-week course of non-proprietary omeprazole 20 mg daily, 1 GP visit, 1 diagnostic test)	282	226–338	Fixed	NHS Electronic Drug Tariff[31], Unit Costs of Health and Social Care 2015 (GP visit)[32], DoH[29]; HRG FZ60Z (outpatient services, general medicine)
Cost of abdominal hernia repair	4248	3398–5098	Fixed	DoH[29]; weighted average of HRGs FZ17E, FZ17F, FZ17G
Cost of cholecystectomy	3632	2906–4358	Fixed	DoH[29]; HRG GA13A
Cost of blood test (complete blood count, blood urea nitrogen, cortisol, creatinine, electrolytes, thyroid-stimulating hormone)	13	10–16	Fixed	DoH[29], directly accessed pathology services; HRG tariff DAPS05 (haematology), DAPS04 (clinical biochemistry)
Cost of ECG	240	192–288	Fixed	National Tariff[33], outpatient procedure tariff, EA47Z (ECG monitoring and stress testing)

DoH, Department of Health; HRG, Healthcare Resource Group; GP, general practitioner.

Table 3 Cost inputs for obesity-associated co-morbidities

	Mean (€)	Range for one-way sensitivity analysis (€)	Distribution for probabilistic sensitivity analysis	Source
Annual cost of type 2 diabetes	3046	2436–3655	γ ($\alpha = 100$; $\lambda = 30{\cdot}5$)	Williams *et al.*[34]
Cost of acute stroke	4567	3654–5480	Fixed	DoH[29]; weighted average of HRG AA35A, AA35B, AA35C, AA35D, AA35E, AA35F
Annual cost of poststroke care, first year	8813	7050–10 575	γ ($\alpha = 100$; $\lambda = 88{\cdot}1$)	Luengo-Fernandez *et al.*[35]
Annual cost of poststroke care, second year and onwards	2260	1808–2712	γ ($\alpha = 100$; $\lambda = 22{\cdot}6$)	Luengo-Fernandez *et al.*[35] (average of cost for 2–5 years)
Cost of transient ischaemic attack	1366	1093–1640	Fixed	DoH[29]; weighted average of HRGs AA29C, AA29D, AA29E, AA29F
Cost of acute myocardial infarction	2071	1657–2486	Fixed	DoH[29]; weighted average of HRGs EB10A, EB10B, EB10C, EB10D, EB10E
Annual cost of postmyocardial infarction care	919	735–1103	γ ($\alpha = 100$; $\lambda = 9{\cdot}2$)	Picot *et al.*[16]
Annual cost of heart failure	4160	3328–4991	γ ($\alpha = 100$; $\lambda = 41{\cdot}6$)	McMurray *et al.*[36]
Annual cost of peripheral artery disease	2747	2197–3296	γ ($\alpha = 100$; $\lambda = 27{\cdot}5$)	Beaudet *et al.*[37]
Annual cost of angina pectoris	2245	1796–2694	γ ($\alpha = 100$; $\lambda = 22{\cdot}5$)	Stewart *et al.*[38]

DoH, Department of Health; HRG, Healthcare Resource Group.

study (mean systolic BP)[18] and a Health and Social Care Information Centre document (proportion of the smoking population)[28]. The baseline analysis was performed for a cohort of 45·4-year-old patients, 24 per cent men, with a mean BMI of 50·5 kg/m^2 and mean systolic BP of 140·1 mmHg, of whom 30 per cent had type 2 diabetes and 19 per cent were smokers. A further analysis was performed for 16 cohorts of 45·4-year-old non-smoking men and women with moderate (starting BMI 33 kg/m^2), severe (starting BMI 37 kg/m^2), morbid (starting BMI 42 kg/m^2) and super (starting BMI 52 kg/m^2) obesity, with or without type 2 diabetes.

Validation

The model underwent a three-step validation process. In the first stage, face validity assessment was undertaken, wherein model structure, data sources,

Table 4 Base-case results of cost-effectiveness analysis

	Cost (€)	Difference in cost* (€)	Life-years gained	Difference in life-years gained*	QALYs	Difference in QALYs*	ICER (€ per QALY)
10 years							
Usual care	9588	5599	8·4	0·0	2·9	1·7	3294
Surgery	15 187		8·4		4·6		
Lifetime							
Usual care	29 147	−2742	18·0	0·8	6·0	4·0	Dominates
Surgery	26 405		18·8		10·1		

*Usual care − surgery. QALY, quality-adjusted life-year; ICER, incremental cost-effectiveness ratio.

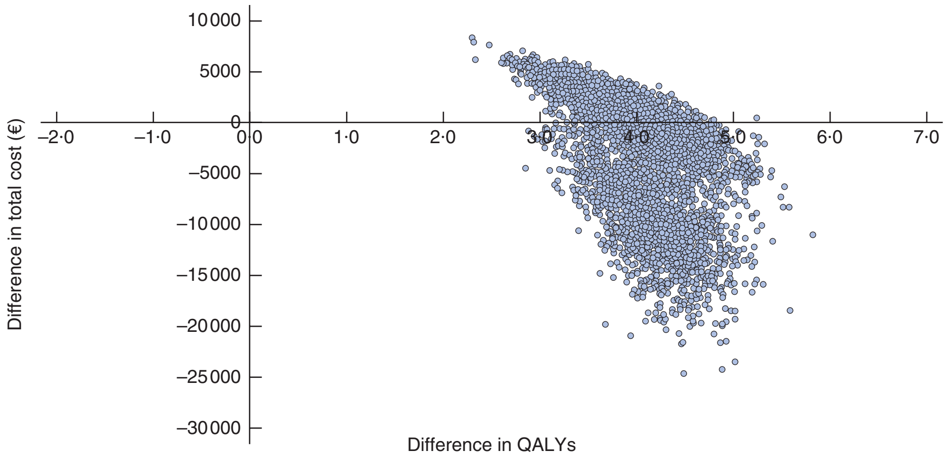

Fig. 2 Probabilistic sensitivity analysis showing the clinical benefit of bariatric surgery. QALY, quality-adjusted life-year

assumptions and results were evaluated. In the second stage, a number of stress tests were conducted to validate the model's technical performance. Finally, the model underwent external validation, whereby the results were compared with actual event data from three large epidemiological studies (Anglo-Scandinavian Cardiac Outcomes Trial – Blood Pressure Lowering Arm, ASCOT-BPLA[42]; Look AHEAD: Action for Health in Diabetes[43]; Action to Control Cardiovascular Risk in Diabetes, ACCORD[44]) and the interventional quality registry SOReg[21]. Details of the validation process have been reported elsewhere[15].

Analysis

The present analysis was performed from the perspective of the NHS over 10 years and over a lifetime. In line with NICE recommendations[45], all costs and outcomes beyond the first year were discounted 3·5 per cent annually. Surgery was considered cost-effective if the incremental cost-effectiveness ratio (ICER), calculated by dividing the difference in costs between the two arms by the difference in quality-adjusted life-years (QALYs), was below the willingness-to-pay threshold of £30 000 per QALY. The impact of a 1-, 2- or 3-year delay in the provision of surgery on clinical (life-years and QALYs gained) and economic outcomes was studied. Patients were initially allocated to the usual care arm and then switched to the surgical arm after 1, 2 and 3 years. The results were compared with those of patients who underwent surgery immediately. The model was constructed using Microsoft Excel® 2010 (Microsoft, Redmond, Washington, USA). Ordinary least squares regression analysis was conducted using STATA® version 13 (StataCorp, College Station, Texas, USA).

Sensitivity and scenario analysis

The first-order uncertainty around the data used for input parameter values was addressed by one-way deterministic sensitivity analysis. This involved altering a single variable within a predetermined range, while the remaining parameters were unaltered, to determine the impact on the resulting model (ICER). One-way deterministic sensitivity analysis was performed using the mean patient characteristics (45·4-year-old non-smoking men, with a BMI of 50·5 kg/m^2, systolic BP 140 mmHg and absence of type 2 diabetes). Specific conditions were applied to the binary input parameters (sex, smoking and type 2 diabetes status). For sex, male was considered as the maximum input, and female as the minimum input. For type 2 diabetes and smoking, their presence was considered as the maximum, and their absence as the minimum input.

A probabilistic sensitivity analysis was undertaken by varying all input parameters simultaneously across distributions to evaluate multivariable and stochastic uncertainties in the model. Distribution parameters were dependent on the nature of inputs; a β distribution was used for the probabilities, utilities and decrements, and a log-normal distribution for relative risks. Costs were assigned with a γ distribution, assuming 10 per cent standard deviation around the mean values. A normal distribution was assigned to patient age and BMI, whereas systolic BP was assumed to follow a γ distribution. Reimbursement tariffs were not tested in probabilistic analysis. During the probabilistic sensitivity analysis, 5000 iterations of the model were run over a lifetime. The result is presented in the form of a scatterplot of the incremental cost-effectiveness of surgery (current mix of 3 types) compared with usual care. A total of 13 additional scenarios were tested following one-way and probabilistic sensitivity analyses.

Results

Base-case results in multiple cohorts

In the base-case analysis over 10 years, bariatric surgery was associated with higher costs of €5599 (£3971) and an additional 1·7 QALYs, resulting in an ICER of €3294 (£2336) compared with usual care. In the base-case analysis over the lifetime of the patient cohort, bariatric surgery produced cost savings of €2742 (£1944) and generated an additional 0·8 life-years and 4·0 QALYs (*Table 4*). Bariatric surgery was associated with a reduction in stroke, myocardial infarction, peripheral arterial disease, transient ischaemic attack, heart failure and diabetes (*Table S2*, supporting information).

Results in specific patient cohorts

Results for all cohorts are shown in *Tables S3–S10* (supporting information). The analysis showed that, over 10 years, bariatric surgery was cost-saving in six cohorts considered as diabetic, including moderately and super obese men and all cohorts of women. In the remaining diabetic cohorts (severely and morbidly obese men) surgery was cost-effective. In the non-diabetic cohorts, surgery was cost-effective in all groups, namely in moderately obese men (ICER €12 449 per QALY) and women (ICER €12 360 per QALY), severely obese men (ICER €12 315 per QALY) and women (ICER €12 324 per QALY), morbidly obese men (ICER €5617 per QALY) and women (ICER €6446 per QALY), and super obese men (ICER €3027 per QALY) and women (ICER €2931 per QALY). The cost-effectiveness of surgery increased with increase in baseline BMI of the cohort.

Over a lifetime, bariatric surgery was cost-saving in all eight cohorts considered as diabetic. In the non-diabetic cohorts, bariatric surgery was cost-saving only for super obese women and men. For all other groups, bariatric surgery was a cost-effective alternative to usual care, namely in moderately obese men (ICER €3200 per QALY) and women (ICER €2708 per QALY), severely obese men (ICER €3403 per QALY) and women (ICER €2630 per QALY), and morbidly obese men (ICER €1209 per QALY) and women (ICER €1512 per QALY).

Impact of waiting lists on the clinical and economic benefits of bariatric surgery

Delaying surgery for up to 3 years was associated with a reduction in clinical benefits. There was a difference of 0·1 life-years and 0·7 QALYs between immediate operation and 3-year watchful waiting (*Fig. S1*, supporting information). In addition, the cost of delayed provision of surgery was associated with a decrease in lifetime healthcare costs. The cost of the surgery over a lifetime was €26 405 (£18 727) with immediate operation, and €24 670 (£17 497) with a 1-year, €24 430 (£17 326) with a 2-year and €24 347 (£17 268) with a 3-year delay.

Sensitivity analysis

In one-way deterministic sensitivity analysis, the most sensitive parameters were age (surgery was less cost-effective in older patients), presence of type 2 diabetes (surgery was less cost-effective in the absence of type 2 diabetes), baseline BMI (surgery was more cost-effective with increase in BMI) and sex (surgery was more cost-effective in women) (*Fig. S2*, supporting information).

Probabilistic sensitivity analysis showed that bariatric surgery produced clinical benefits (defined as additional QALYs) in all patients; it had a cost-saving effect in 59 per cent, whereas it was cost-effective in the remaining 41 per cent (*Fig. 2*). An additional 13 scenario analyses showed that the uncertainty in the model inputs and structure did not affect the main results significantly (*Appendix S2* and *Tables S11–S24*, supporting information).

Discussion

This analysis of current bariatric surgical approaches in England showed that bariatric surgery, even under conservative assumptions around efficacy and resource use, is cost-effective over 10 years and can save the healthcare system money over a lifetime.

The cost-effectiveness ratio of bariatric surgery favours diabetic patients, concurring with the ideas previously expressed by Welbourn and colleagues[46]. Extrapolating the demonstrated lifetime clinical and economic benefits to the cohort of 5466 patients who underwent surgery in England between 2011 and 2013 would result in savings of about €14·97 million (£10·62 million), and generate an additional 4488 person-years or 21 941 QALYs over the course of a lifetime of the operated cohort.

The results of this study are partly in agreement with previous health economic evaluations of bariatric surgery in the UK[16,40,47]. In the health technology assessment performed by Picot and co-workers[16], the ICER for bariatric surgery ranged between €1833 (£1300) and €5640 (£4000) per QALY. Ackroyd *et al.*[40] reported comparable results for GBP and AGB, yielding ICERs of €2139 (£1517) and €2720 (£1929) per QALY respectively. Finally, Pollock and colleagues[47] demonstrated an ICER of €5079 (£3602) per QALY for AGB. ICERs in all three studies were well below the €28 200 (£20 000) per QALY threshold for cost-effectiveness used by NICE. The most recent analysis[30] was published as part of the Health Technology Assessment programme at the National Institute of Health Research. This analysis was based on individual patient-level data from the UK informed by a large number of electronic hospital records, which allowed a comprehensive model design and profound predictability. Over a lifetime, the analysis yielded an incremental cost of €21 514 (£15 258) in the operated cohort, 2·142 incremental QALYs per participant and an ICER of €10 052 (£7129) per QALY. Although the latter analysis arguably employed superior methodology to that used in previous studies and the present analysis, selection of data inputs to the analysis may have underestimated the value of surgery in England. In addition, the difference in results might be associated with the modelled distribution of surgical methods (which does not reflect current case mix), the cost of surgery (overestimated compared with current level as the cost has been decreasing over time), and lack of clarity about the cost of surgical complications and end-stage diseases.

The present UK decision analytic model incorporated a substantial number of health states and conditions that commonly occur in obese patients, which contributed to the accuracy and validity of the modelled outcomes. The model accounted for the most widely adopted surgical approaches, and the distribution of their utilization patterns was informed by the latest available source. Surgical methods and baseline patient characteristics were extracted from the national UK registry and are highly applicable for modelling of surgical outcomes in local patient cohorts. Furthermore, the model included monetary effects of short- and mid-term complications, both informed by well recognized national-level registries. Finally, the projection of cost-effectiveness outcomes for 10 years and the analysis of delay in the provision of surgery provided an opportunity to estimate the feasibility of bariatric surgery from another angle.

Decision analytic modelling has the inherent limitation of being a simplification of reality. Several empirical studies, performed in Swedish and US populations, did not demonstrate a cost-saving effect of bariatric surgery. However, they were all characterized by limitations such as a limited time period of modelling, reporting of discontinued surgical techniques and use of an open surgical approach[48,49]. Like other decision analytic models, the present analysis also has a number of limitations, as discussed previously[15]. In brief, the analysis did not account for all potential obesity-related complications and the cost benefits of surgery were potentially underestimated. The model did not predict various outcomes of surgery for different populations of diabetic patients, which could have an impact on the overall clinical effectiveness of the therapy. In addition, the model did not take into account the reduction in indirect medical costs seen after bariatric surgery[50]. Despite the lifetime period used in this model, the effect of bariatric surgery was assumed not to last beyond 15 years. This might lead to incorrect estimation of the true clinical and economic outcomes. This analysis is also limited by lack of complication data beyond 2 years, it being assumed that there would be no long-term complications, and by the approach to complication management being informed by a single surgeon. Furthermore, data on the management of patients after surgery or surgical candidates who do not undergo surgery were driven by assumptions based on clinical knowledge.

Despite increased rates of obesity in the UK, a recent analysis of bariatric surgery in seven European countries showed that England has one of the lowest utilization rates, 103 procedures per 1 million population, compared with a European average of 401 per million[51]. There is geographical variation in access to bariatric surgery in the UK. In some areas, commissioning groups have drawn up eligibility criteria that breach national guidelines and reduce the number of patients eligible for surgery. The present results emphasize the clinical benefit of bariatric surgery and associated monetary gains that result from avoidance of obesity-related illnesses. The findings justify non-limited access to surgery to all eligible categories of obese patients in the UK.

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Supporting information

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

Snapshot quiz

Snapshot quiz 18/12

Answer: At exploratory laparotomy there was a jelly-like collection within the peritoneal cavity – pseudomyxoma peritonei, also known as (jelly belly). This is a slow-growing cancer, which usually begins in the appendix, occasionally in the ovary or bowel. The mucin is usually not deposited on the small bowel or its mesentery because of its constant mobility. Extensive deposits in the whole abdomen make it difficult to excise completely. Cytoreductive surgery with or without hyperthermic intraperitoneal chemotherapy is often recommended.