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Assessing economic investment required to scale up bariatric surgery capacity in England: a health economic modelling analysis

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ABSTRACT

Objectives To quantify the economic investment required to increase bariatric surgery (BaS) capacity in National Health Service (NHS) England considering the growing obesity prevalence and low provision of BaS in England despite its high clinical effectiveness.

Design Data were included for the patients with obesity who were eligible for BaS. We used a decision-tree approach including four distinct steps of the patient pathway to capture all associated resource use. We estimated total costs according to the current capacity (current scenario) and three BaS scaling up strategies over a time horizon of 20 years (projected scenario): maximising NHS capacity (strategy 1), maximising NHS and private sector capacity (strategy 2) and adding infrastructure to NHS capacity to cover the entire prevalent and incident obesity populations (strategy 3).

Setting BaS centres based in NHS and private sector hospitals in England.

Main outcome measures Number of BaS procedures (including revision surgery), cost (GBP) and resource utilisation over 20 years.

Results At current capacity, the number of BaS procedures and the total cost over 20 years were estimated to be 140 220 and £1.4 billion, respectively. For strategy 1, these values were projected to increase to 157 760 and £1.7 billion, respectively. For strategy 2, the values were projected to increase to 232 760 and £2.5 billion, respectively. Strategy 3 showed the highest increase to 564 784 and £6.4 billion, respectively, with an additional 4081 personnel and 49 facilities required over 20 years.

Conclusions The expansion of BaS capacity in England beyond a small proportion of the eligible population will likely be challenging given the significant upfront economic investment and additional requirement of personnel and infrastructure.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study estimates the economic investment and resources required to scale up the capacity of bariatric surgery (BaS) in England.
⇒ The study used the inputs from bariatric surgeons and key decision-makers to provide a realistic perspective regarding scaling up BaS in England.
⇒ Sensitivity and scenario analysis were conducted to test the uncertainties around model inputs and assumptions.
⇒ A conservative approach was used in calculating cost inputs and several assumptions were made in cost estimates for scale-up scenarios, such as exclusion of costs related to supplementation, medication, outpatient follow-up, cosmetic surgery.
⇒ The study did not consider the potential change in National Institute for Health and Care Excellence guidelines and change in the landscape of antiobesity medications over a 20-year time horizon.

INTRODUCTION

Effective obesity treatment can not only improve the health of treated patients but also reduce the economic impact across health systems globally, including in the UK.[1–4] Obesity is associated with reduced life expectancy and multiple long-term complications.[5] The Health Survey of England 2019 indicated that 28% of adults had obesity (body mass index (BMI) ≥30 kg/m^2) and 3.3% had severe obesity (BMI≥40 kg/m^2).[6] By 2060, the projected prevalence of UK adults who are overweight or have obesity will be 84.8%.[7] The current cost of obesity and associated complications for the National Health Service (NHS) is £6.1 billion (around 4% of the total NHS spending on health services in 2022/2023[8]), and for society, £27 billion, which is projected to increase 4–5 fold by 2050.[1] The NHS has established policies that address the growing challenges to obesity treatment provision and access in England.[5]

The UK National Institute for Health and Care Excellence (NICE) recommend bariatric surgery (BaS) as the most effective treatment option for the management of severe obesity.[9] That includes people with BMI above 40 kg/m^2, or BMI above 35 kg/m^2 with obesity-related complications (ORCs), or BMI above 30 kg/m^2 with recent-onset type 2 diabetes mellitus (T2DM) in specific situations.[9] BaS results in significant sustained long-term weight loss beyond 7 years,[10–12] improved health[11] and decreased cardiovascular disease, cancer[13–16] and mortality.[9 15 17] It is the most clinically effective and cost-effective intervention for weight management when compared with no intervention or lifestyle interventions.[18–21]

The UK pathway to BaS starts with a general practitioner (GP) assessment, followed by a referral to the primary care specialist weight management clinic.[22] Prior to the referral patients must engage with a tier 3 clinic for weight management for at least 12 months.[22] The bariatric dietician at the primary care specialist weight management clinic would support the patient for lifestyle change over the next 6 months, before they refer the patient to bariatric surgeon.[22] The patient then attends a preassessment clinic with a bariatric nurse to follow a preoperative diet, leading to BaS.[22]

The immediate cost of BaS in the UK was estimated to be £9.16 million per 1000 operated population in 2008–2013, with an additional discounted lifetime healthcare cost of £15.26 million.[19] However, only an estimated 0.2% of the annual eligible population in England receive BaS, and the number also includes revision operations for complications, poor weight loss and weight regain.[23] Reasons for the low penetration of BaS in the NHS include factors related to the funding and physician preference or attitude towards BaS, or patient preference.[24–26] In those accepted for surgery, there remain prolonged waiting times[19 27 28] due to limited NHS capacity and prioritisation of other surgical procedures.[29]

There is a need to understand the feasibility of scaling up BaS, particularly with the increasing prevalence of obesity[6] and its complications. While there is awareness of the limited capacity of the NHS to address the need for BaS, data on the economic investment required to scale up BaS are sparse. In line with NHS expansion plans,[5] this study aims to estimate the investment and resources required to scale up NHS capacity for BaS capacity in England. These results will guide healthcare systems and health technology assessment bodies in making informed decisions on scaling up BaS and efficient management of resources to treat obesity.

METHODS

We used a landscape assessment and a pragmatic literature review to develop a stepwise patient pathway and construct the BaS scale-up model for NHS England. Three experienced bariatric surgeons working in the NHS validated the conceptual framework.

Model structure

We used a decision-tree approach including four distinct steps of the patient pathway (eligibility assessment, pre-BaS assessment, BaS procedure and post-BaS follow-up) to capture associated resource use (figure 1). These steps constitute the standard UK patient pathway and have been previously described by Tako *et al*.[30] We estimated the total costs at current capacity and also over a 20-year time horizon under each of the following BaS scale-up strategies: Strategy 1: maximising NHS capacity, which involved pushing the current capacity to its maximum potential given the current resources and personnel without additional infrastructure or personnel included during scale-up. The additional resource use in terms of personnel time was assumed to be proportional to the increase in capacity with the cost of each

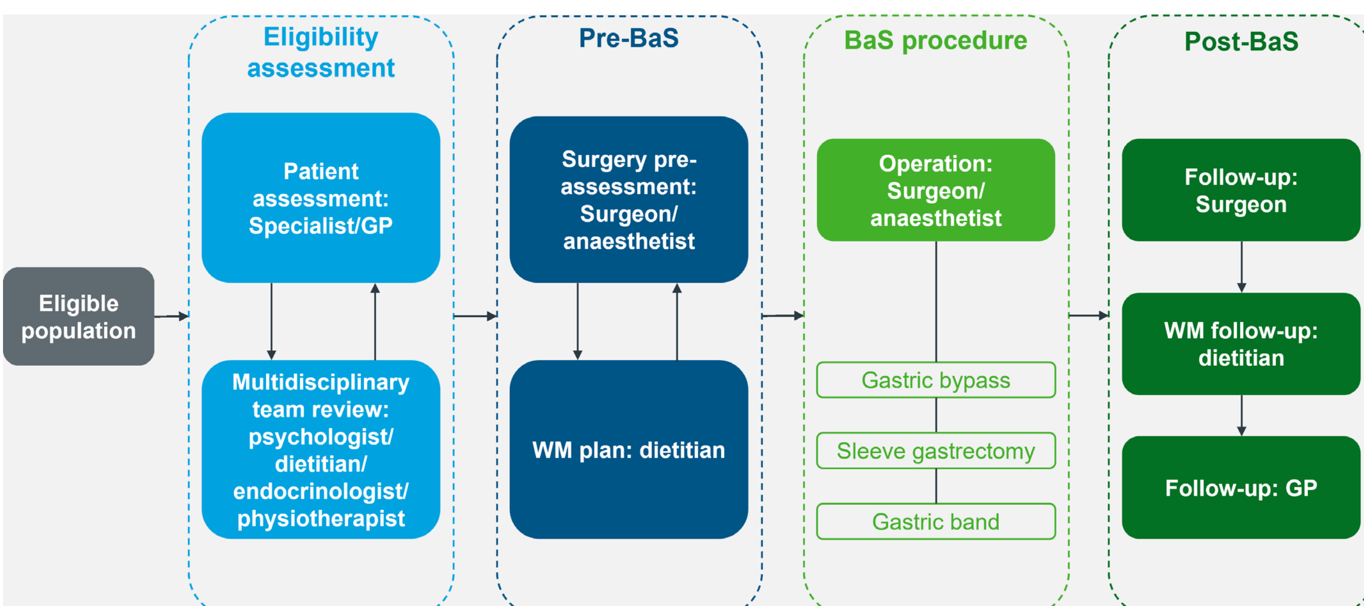

Figure 1 Patient pathway for BaS scale-up model. The figure represents the patient pathway applied in the analysis, comprising four distinct steps (shown in separate blocks): eligibility assessment, pre-BaS assessment, BaS procedure and post-BaS follow-up. BaS, bariatric surgery; GP, general practitioner; WM, weight management.

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additional operation being the same; strategy 2: maximising current NHS and private sector capacity: in addition to maximising NHS capacity, this strategy involved using a proportion of private sector capacity without additional infrastructure/personnel. The cost of surgery in the NHS and private sector was assumed to be equivalent (this is the total cost to society wherein patients are not charged or compensated) and the cost equivalence between NHS and private sector for BaS was assumed that is, NHS purchases private care at NHS prices; strategy 3: adding infrastructure to increase the current NHS capacity: in addition to maximising NHS capacity given current resources, this strategy involved building more facilities and adding personnel to increase the current capacity, both of which were assumed to be exclusively dedicated to BaS.

Key assumptions

Based on literature,[31] we assumed that all eligible patients required the multidisciplinary team review in the eligibility assessment stage and this was validated by bariatric surgeons. However, not all patients were required to visit all the personnel included in the multidisciplinary team review (eg, 100% of patients needed the consultation with GP and bariatric surgeons, but only 80% visited an endocrinologist). We considered no cost discounting or inflation. A fixed number of incident cases were added each year to the fixed prevalent patient population. Additionally, we assumed the cost of short-term complications (30 days) was included in the procedure costs, and no additional costs were considered, while long-term complications (occurring at years 1 and 2) were captured in the same year to account for the total costs incurred per patient, as they were expected to be continuous from the previous years. We assumed that 100% of new staff capacity would be focused on BaS in the scale-up strategy and gastric band surgery would be phased out at a constant rate over the next 10 years, as per input from the bariatric surgeons.[32]

Model inputs

We obtained all model inputs from published evidence and/or expert opinions from five NHS key decision-makers (KDMs). To gather data regarding infrastructure costs and resource utilisation, we held online interviews with the KDMs working in BaS with experience in the setup, management and expansion of new or current BaS clinics within NHS England. Three NHS bariatric surgeons validated the key model inputs (patient preferences, costs, capacity and resource use). Population, cost and capacity inputs are described in tables 1A–C and online supplemental table 1, respectively. Complication rates and healthcare resource utilisation are described in online supplemental tables 2 and 3, respectively. To estimate costs, resource use data were captured during each step of the patient pathway and combined with unit cost information, including all medical personnel involved and the time spent; revision surgery; hospitalisation; outpatient/inpatient visits (frequency and costs) and monitoring tests (frequency and costs).

Analyses

Base-case analysis

We selected the eligible population (incident and prevalent) as per the NICE guidelines' eligibility criteria. We assumed the proportion of the eligible population receiving BaS to be 10% (based on expert opinion and an Office of Health Economics study[33]) and we used this in the base case for all three scale-up strategies. We considered a 20-year time horizon appropriate for achieving the target BaS capacity and eligible population.

Scenario and sensitivity analysis

We only conducted scenario and sensitivity analyses for strategy 3 as it is more flexible to cover a greater proportion of the eligible patient population.

Scenario analysis

We performed scenario analyses and one-way sensitivity analysis (OWSA) to test the model robustness and identify model drivers. Scenario 1 included different proportions (5%, 25% and 100%) of the eligible population over a 20-year time horizon. Scenario 2 assessed the distribution of gastric bypass procedure. Scenario 3 evaluated the impact of change in the eligible population (population with BMI≥40 kg/m^2).

One-way sensitivity analysis

We adjusted input model parameters by 20% of their default value to evaluate the robustness of the results and the influence of individual parameters. The uncertainty in assumptions/inputs was captured as lower and upper bounds and displayed in a tornado diagram.

Patient and public involvement

None.

RESULTS

Base-case analysis

The prevalent and annual incident targeted eligible population sizes were estimated at 347 885 and 10 326, respectively. The total targeted eligible population size over 20 years was estimated at 554 405. With the current capacity in NHS England, a total number of BaS procedures (including revision surgery) were estimated to be 140 220 (revision surgeries: 2474) over 20 years, which is significantly smaller than the estimated total population size. The associated annual and overall costs were £70.6 million and £1.4 billion, respectively. We calculated the BaS backlog as the combination of 'current eligible population' and 'newly eligible population' added each year and it was estimated to be 424 143 over 20 years. The outcomes of the base-case analysis for all three strategies are described in table 2. Detailed results on the cost breakdown associated with the procedure and the complications are described in online supplemental materials, as well as the cost vs capacity over 20 years for the current and projected scenarios.

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Table 1 Population, cost and capacity inputs for BaS scale-up model

	Model input	Source
(A) Population inputs		
Total population (≥18 years age)	44715345	[44]
Proportion of population eligible for BaS (NICE guidelines)	7.78%	[45]
Obesity incidence rate (annual)	2.97%	[6]
Prevalent population (NICE guidelines eligibility criteria)	3478854	[6]
Incident population (annual) (NICE guidelines eligibility criteria)	103261	[6]
Proportion of eligible population that is estimated to receive BaS*	10.00%	Assumption
Estimated current eligible population size†	347885	Calculated
Estimated newly eligible population size (annual)‡	10326	
(B) Cost inputs		
Inputs	Source	
Cost per procedure for gastric band, sleeve gastrectomy and gastric bypass§	NHS reference costs[46]	
Complication treatment costs (cost per episode for cholecystectomy, abdominal wall hernia operations, banding operations, leakage and abscess, obstruction, stricture, gastric ulcer)		
Cosmetic surgery cost	Excluded from cost inputs	
Cost per episode for gastric ulcer (included 8-week antibiotics treatment, one GP visit and one diagnostic test)	NHS reference costs[46]	
Infrastructure costs for BaS scale-up (small-scale and large-scale facilities): ► Number of BaS procedures per year (facility capacity). ► Cost of setting up facility. ► Time required to set up the facility (in years). ► Time required for facility to be fully functional (in years).	PMR KDMs' interviews¶	
(C) Capacity inputs		
Inputs	Source	
Current annual capacity (number of BaS) for NHS and private sector**	PMR KDMs' interviews¶[47]	
Maximum potential annual capacity	PMR KDMs' interviews¶	
Current BaS distribution by procedure type (gastric band, sleeve gastrectomy and gastric bypass) for 2013–2018	[34]	
BaS distribution by procedure type (for scale-up strategy)††	Inputs from bariatric surgeons¶	

Among five KDMs, three were heads of the departments (gastroenterologist, two were the lead for BaS), one was C-level executives/board member of a hospital and one was the director of procurement.
*There are several reasons why a patient may not receive BaS despite being eligible; these include (but are not limited to) patient preference, physician preference/attitude towards BaS, along with costs and waiting lists.
†Calculated using prevalent population keeping proportion of eligible population who receive BaS as 10%.
‡Calculated using incident population keeping proportion of eligible population who receive BaS as 10%.
§All the resource costs incurred at every stage of the patient pathway were assumed to be included in the procedure for all eligible costs patients.
¶Data from PMR report are described in online supplemental table 1.
**2018–2019 data are included; 2020–2022 data are excluded since numbers were under-represented due to COVID-19 pandemic.
††Based on bariatric surgeons' opinion that the gastric band procedure is the least effective BaS and is assumed to be gradually phased out in next 10 years.
BaS, bariatric surgery; KDMs, key decision-makers; NHS, National Health Service; NICE, National Institute for Health and Care Excellence; PMR, primary market research.

Strategy 1: maximising current NHS capacity

Over a 20-year time horizon, the number of BaS procedures (including revision surgery) was projected to increase to 157760 (revision surgeries: 2867; incremental: 17540 BaS). This was calculated as the maximum potential NHS capacity (ie, the number of BaS completed annually) multiplied by the time horizon, that is, 20 years. The maximum potential capacity was taken as 12.5% more than the current capacity (KDMs' inputs). The projections estimated the largest increment for gastric bypass (22362), followed by sleeve gastrectomy (5758). The number of gastric band operations was projected to decrease from

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Table 2 Base-case analysis: incremental values over 20 years*

	Strategy 1: maximising current NHS capacity	Strategy 2: maximising current NHS and private sector capacity	Strategy 3: adding infrastructure to increase current NHS capacity
Number of BaS procedures (n)	17 147	90 784	416 742
Gastric band	−10 974	−8637	−3286
Sleeve gastrectomy	5758	43 176	207 528
Gastric bypass	22 362	56 245	212 499
BaS backlog (n)			
Current	424 143	424 143	424 143
Projected	407 023	332 023	0
Cost breakdown			
Infrastructure costs of BaS scale-up	**£0**	**£0**	**£362 500 000**
Number of additional facilities needed—small-scale facility	N/A	N/A	1
Number of additional facilities needed—large-scale facility	N/A	N/A	48
Procedure costs	**£238 217 988**	**£974 230 140**	**£4 261 177 612**
Gastric band	−£57 616 922	−£45 349 121	−£17 250 674
Sleeve gastrectomy	£55 291 672	£414 570 055	£1 992 636 562
Gastric bypass	£240 543 238	£605 009 206	£2 285 791 723
Revision surgery–gastric band	−£204 198	−£160 720	−£61 137
Revision surgery–sleeve gastrectomy	£237 606	£1 781 543	£8 563 008
Revision surgery–gastric bypass	£1 710 880	£4 303 170	£16 257 852
Personnel costs–post-BaS follow-up	**£3 385 898**	**£17 924 406**	**£81 597 599**
Complication costs	**£19 539 294**	**£60 590 462**	**£246 629 873**
Gastric band	−£2 991 137	−£2 354 264	−£895 555
Sleeve gastrectomy	£1 259 693	£9 445 023	£45 397 631
Gastric bypass	£21 270 737	£53 499 703	£202 127 798
Total–20 years	**£262 887 469**	**£1 058 669 001**	**£4 976 664 806**
Total–annual*	**£13 144 373**	**£52 933 450**	**£248 833 240**

Bolded values within the table represent summed total costs.
*All the incremental values are represented for 20 year time horizon, except the total annual cost.
BaS, bariatric surgery; N/A, not applicable; NHS, National Health Service.

15 889 to 4915 (incremental: −10 974). The total annual cost was projected to increase to £83.7 million, and the overall total cost was estimated to increase to £1.7 billion (online supplemental table 1). Online supplemental figure 1 illustrates the total costs compared with capacity in both current and projected scenarios. Scaling up with strategy 1 would reduce the backlog to 407 023 over 20 years (table 2 and online supplemental figure 2).

Strategy 2: maximising current private sector and NHS capacity

Over a 20-year time horizon, the number of BaS procedures (including revision surgery) was projected to increase to 232 760 (revision surgeries: 4229; incremental: 92 540 BaS). This was calculated as the maximum potential NHS capacity and the potential increase in private sector capacity utilised by the NHS multiplied by the time horizon. The maximum potential capacity was taken as 12.5% more than the current based on expert inputs, and the potential additional capacity from the private sector used by the public was assumed to be 25%. The projections estimated the largest increment for gastric bypass (56 245), followed by sleeve gastrectomy (43 176). The number of gastric band operations was projected to decrease from 15 889 to 7251 (incremental: −8637). The total annual cost was projected to increase to £123.5 million, and the overall total cost was estimated to increase to £2.5 billion over 20 years (online supplemental table 5). Scaling up would reduce the backlog to 332 023 (table 2).

Strategy 3: adding infrastructure to increase current NHS capacity

Over a 20-year time horizon, the number of BaS procedures (including revision surgery) was projected to increase to 564 784 (revision operations: 10 295; incremental: 424 563 BaS). In this strategy, this number was estimated after adding the infrastructure to cover the entire

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prevalent and incident population over 20 years. The projections estimated the largest increment for gastric bypass surgery (212 499), followed by sleeve gastrectomy (207 528). The number of gastric band operations was projected to decrease from 15 889 to 12 603 (incremental: −3286). Additionally, the number of revision operations was projected to increase from 2474 to 10 295 over the next 20 years, and the highest incremental component was represented by gastric bypass (5859). The total annual cost was projected to increase to £319.4 million. The overall total cost was projected to increase to £6.4 billion over 20 years. The incremental cost related to BaS procedure costs represented the largest component, amounting to 85.6% of the total cost (incremental value of £4.3 billion). This was followed by the infrastructure cost of the BaS scale-up, with an incremental value of £362.5 million. Incremental costs related to complications, personnel (post-BaS follow-up) and revision surgery represented only a small fraction of total costs, amounting to incremental values of £246.6 million, £81.6 million and £24.8 million, respectively (online supplemental table 6). Scaling up would reduce the backlog to zero over 20 years, considering the proportion of the eligible patient population estimated to receive BaS was 10% (table 2).

BaS scale-up over 20 years would require an additional 49 facilities and 4081 personnel, the majority of whom would be nurses, healthcare assistants/healthcare service workers, anaesthetists and surgeons.

Scenario analysis

In scenario 1, as the proportion of eligible population receiving BaS varied from 5% to 100%, the target population size, the number of BaS procedures and the total costs also varied significantly. For instance, at 100% coverage, the total number of BaS was estimated at 5 647 832, and the total 20 year costs were projected to increase to £65.2 billion. In scenario 2, achieving 100% distribution of gastric bypass over 10 years resulted in an increase in the number of BaS procedures to 569 693 and total 20 year costs to £6.8 billion. In scenario 3, with 10% of the eligible population with BMI≥40 kg/m^2 receiving BaS, the overall total cost was projected to increase from £1.4 billion to £2.4 billion over 20 years, which is considerably lower than the base case value.

Table 3 presents summary results of the scenarios, and detailed results for these scenarios are described in online supplemental text 1.

One-way sensitivity analysis

The OWSA results indicate that the model was most sensitive to patient preference for BaS, the proportion of the population eligible for BaS (NICE guidelines), and the cost per procedure for gastric bypass and sleeve gastrectomy (online supplemental figure 3). The OWSA demonstrated the robustness of the model even with ±20% variation in the majority of input parameter values.

DISCUSSION

To our knowledge, this is the first study to evaluate the required investment of scaling up BaS to address the unmet needs in the NHS. This study demonstrated that scaling up BaS to treat obesity will be challenging due to the need for further investment; even within the context of only 5%–10% of the eligible population modelled to receive BaS. Based on the model estimates, the economic investment required to scale up BaS capacity by 12.5% to maximise the current NHS England capacity, without scaling up the infrastructure and personnel was estimated to require an incremental cost of £13.7 million/year, with a capacity to conduct an additional 17K operations over 20 years, reducing the backlog to approximately 407K over a 20-year time horizon. Another strategy to maximise BaS use in NHS and private sectors, increased the capacity by an additional 91K operations over 20 years and increased the total annual cost by £52.9 million, which reduced the backlog to 332K operations. The third strategy, maximising NHS capacity, along with the addition of

Table 3 Scenario analysis

Base case/scenarios	Number of BaS (including revision surgery)	Total 20-year costs for current scenario (in billions)	Total 20-year costs for projected scenario (in billions)	Incremental (in billions)
Base case: strategy 3	564 784	£1.4	£6.4	£5.0
Proportion of eligible population who would receive BaS: 5%	282 371	£1.4	£3.1	£1.7
Proportion of eligible population who would receive BaS: 25%	1 411 958	£1.4	£16.2	£14.8
Proportion of eligible population who would receive BaS: 100%	5 647 832	£1.4	£65.2	£63.8
Distribution of BaS by type of procedure: Gastric bypass surgery: 100%	569 693	£1.4	£6.8	£5.4
Eligible population with BMI≥40 kg/m^2	234 474	£1.4	£2.4	£1.0

BaS, bariatric surgery; BMI, body mass index.

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infrastructure and personnel, aimed to provide BaS to the whole target population and resolve the backlog, which supported an additional 417K surgeries over 20 years with an additional budget of £248.8 million/year. The total 20-year incremental costs to NHS England were estimated at £5 billion, including £4.3 billion for procedures, £363 million for infrastructure and £247 million for 4081 additional personnel.

All these strategies require significant investment, especially if BaS was to be used as the sole treatment strategy to address the needs for the eligible population. However, there is no single treatment strategy that will address all the demands of the high prevalence of obesity and its impact on health and economics.

To reduce obesity prevalence and its health consequences will require expansion of all treatment strategies combined with a system-wide, holistic and multifaceted approach to obesity, combining prevention with treatment strategies.[9]

Although scaling up the capacity of BaS to cover 10% of those eligible may be unrealistic from an investment perspective, base-case strategy 1 appears more achievable in terms of economic investment, despite the reduction in backlog being relatively minimal. The data suggest that strategy 3 is most beneficial in covering the eligible population that opts for BaS, considering an estimated 10% of the population will receive BaS out of a total eligible population of 5.5 million. However, the feasibility of such substantial economic investment cannot be predicted (estimation of £5 billion) over a 20-year time horizon, despite the well-established cost-effectiveness of BaS.[33] The required investment for strategy 3 is likely to be significantly offset by the economic benefits achieved by the reduction in incidence/severity of ORCs in these patients. The economic benefits associated with BaS have been estimated at £1.25 billion over a 3-year period for 25% of the eligible population opting for BaS.[33] These benefits were primarily related to additional paid work generated after BaS and a potential reduction in disability benefits.[33] In addition, strategy 3, which involves the addition of personnel, may considerably reduce waiting times, as indicated by a simulation study, where the addition of three surgeons and two physicians to a UK healthcare centre reduced waiting times by 5 weeks.[30]

In the scenario analysis, varying the proportion of the eligible population receiving BaS from 10% to 5%, 25% and 100% proportionally increased the budget from £1.4 billion to £3.1 billion, £16.2 billion and £65.2 billion, respectively. This is in line with a prior study which suggested that the economic impact increased in tandem with the proportion of the eligible population that would undergo surgery.[33] Our study also assessed the impact on model results with an increasing incidence rate of obesity. This further corroborates the need for the NHS to evaluate the significance of BaS in the management of severe and complex obesity. Additionally, the economic estimate of this study is based on 10% of the eligible population receiving BaS, therefore, at least 90% of the eligible population will require alternative intervention.

Our model suggests that a preference for performing only gastric bypass will require a larger investment than performing sleeve gastrectomy over the course of 20 years (£6.8 billion vs £6.0 billion, respectively). This could be partially explained by its association with higher complication rates[34] and no increase in patients' return to work.[35] However, our study only takes a limited economic and resource perspective on the selection of the most appropriate operation type; any NHS prioritisation should also account for surgery efficacy, complication rates and cost-effectiveness. This study will also assist other healthcare systems around the world facing similar challenges.

It is important to acknowledge the limitations of our study. First, several assumptions were made in the cost estimates for scale-up scenarios, and the model took a conservative approach with respect to costs; certain elements such as training costs, nutritional supplements and medication costs, outpatient hospitalisation during follow-up and additional follow-up costs in special population such as pregnant women, diabetes, etc were not included. Second, the model did not include cost offsets associated with long-term benefits of BaS to the overall NHS budget, for example, reduction in diabetes and other obesity related comorbidities, maternal BaS-related reduction in obesity in offspring, etc.[36] Third, the model assumed long-term complications only up to 2 years due to limited data availability.[37] Although a wide range of prevalence data related to long-term complications is available, data related to their associated costs to the healthcare system is limited. This is in line with similar assumptions made by previous studies evaluating cost-effectiveness of BaS.[31 38–40] In addition, the model did not include the cost of cosmetic/plastic surgery. Although, cosmetic surgery can have a significant impact on the patients' well-being with respect to psychosocial recovery and improved maintenance of weight loss, funding for this in the NHS is extremely rare.[41 42] Furthermore, a conservative approach was used in calculating cost inputs (eg, a cost-minimisation approach was used to calculate the number of new facilities required); of note, full efficiency was assumed for personnel in the projected scenario while no delays in setting up new facilities and becoming fully functional were included in the model. This conservative estimate suggests that the required investment could be much higher than the current estimate. This could be further corroborated by additional eligibility criteria for BaS as per the new NICE guidelines 2023,[9] including patients agreeing to long-term follow-up after surgery and the inclusion of other ethnicities (South Asian, Chinese, etc) with a lower BMI threshold.[9] It is also important to consider that over a 20-year time horizon, there could be further changes in the current NICE guidelines to lower the BMI eligibility criteria to include populations with a BMI>35 kg/m^2 without comorbidities, according to the recent updates in International Federation for the Surgery of Obesity and Metabolic Disorders

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(IFSO) and American Society for Metabolic and Bariatric Surgery guidelines.[43] This would further increase the size of the eligible population, thereby impacting economic investment and the backlog. In addition, there is uncertainty regarding the future landscape of antiobesity medications (AOMs) over the next 20 years, which could offer an effective way of managing obesity. Although the AOM prices could fall beyond a certain period, they could still be more expensive than BaS over long term. Hence, it is too complex to capture AOMs costs in this study and considering the model base case assumes only 10% of eligible patients receive BaS, the remaining patients would still require other interventions to manage obesity. Additionally, this modelling-based study should also be supported by the real-time measurement of investment by NHS and resource use in future.

Our study has several strengths including being one of the first in the UK to estimate the economic investment and resources required to scale up the capacity of BaS in England. We used inputs from bariatric surgeons and KDMs regarding scaling up BaS in England to provide a realistic perspective. Additionally, inputs and patient pathway design/assumptions were validated to reflect the real-world scenario. We also conducted sensitivity and scenario analysis to test the uncertainties in model inputs and assumptions.

CONCLUSION

We have presented several approaches to expand BaS capacity in NHS England based on available investment funding. Realistically, expansion beyond a small proportion of the eligible cohort will be challenging given the significant upfront economic investment and additional requirements of infrastructure and personnel. Therefore, in order to meet the demands of the increasing prevalence of obesity and its complications, multiple treatment approaches will be needed in addition to BaS, and scalable treatment options will be required.

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Data availability statement Data are available on reasonable request. Most of data inputs were obtained directly from previously published studies or NHS reports. Inputs around infrastructure investment and facility setup time were generated from a primary market research study conducted by IQVIA, and the data are not publicly available.No dataset were generated or analysed from any data repositories for this study.

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REFERENCES

1 Health matters: obesity and the food environment 2017, Available: https://www.gov.uk/government/publications/health-matters-obesity-and-the-food-environment/health-matters-obesity-and-the-food-environment--2
2 Boutari C, Mantzoros CS. A 2022 update on the epidemiology of obesity and a call to action: as its twin COVID-19 pandemic appears to be receding, the obesity and Dysmetabolism pandemic continues to rage on. *Metab Clin Exp* 2022;133:155217.
3 Haase CL, Eriksen KT, Lopes S, *et al*. Body mass index and risk of Obesity-Related conditions in a cohort of 2.9 million people: evidence from a UK primary care database. *Obesity Science & Practice* 2021;7:137–47.
4 Hughes CA, Ahern AL, Kasetty H, *et al*. Changing the narrative around obesity in the UK: a survey of people with obesity and healthcare professionals from the ACTION-IO study. *BMJ Open* 2021;11:e045616.
5 Tackling obesity: empowering adults and children to live healthier lives, 2020. Available: https://www.gov.uk/government/publications/tackling-obesity-government-strategy/tackling-obesity-empowering-adults-and-children-to-live-healthier-lives#fn:5
6 Health Survey for England 2019: Overweight and obesity in adults and children 2019, Available: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2019
7 Okunogbe A, Nugent R, Spencer G, *et al*. Economic impacts of overweight and obesity: current and future estimates for 161 countries. *BMJ Glob Health* 2022;7:e009773.
8 The NHS budget and how it has changed, 2023. Available: https://www.kingsfund.org.uk/projects/nhs-in-a-nutshell/nhs-budget#:~:text=What%20is%20the%20NHS%20budget,as%20staff%20salaries%20and%20medicines
9 National Institute for Health and Care Excellence. Obesity: identification, assessment and management: guidelines. London, 2023.
10 Courcoulas AP, Patti ME, Hu B, *et al*. Long-term outcomes of medical management vs Bariatric surgery in type 2 diabetes. *JAMA* 2024;331:654–64.
11 Gloy VL, Briel M, Bhatt DL, *et al*. Bariatric surgery versus non-surgical treatment for obesity: a systematic review and meta-analysis of randomised controlled trials. *BMJ* 2013;347:f5934.
12 Alfadda AA, Al-Naami MY, Masood A, *et al*. Long-term weight outcomes after Bariatric surgery: A single center Saudi Arabian cohort experience. *J Clin Med* 2021;10:4922.
13 Booth H, Khan O, Prevost T, *et al*. Incidence of type 2 diabetes after Bariatric surgery: population-based matched cohort study. *Lancet Diabetes Endocrinol* 2014;2:963–8.
14 Carlsson LMS, Peltonen M, Ahlin S, *et al*. Bariatric surgery and prevention of type 2 diabetes in Swedish obese subjects. *N Engl J Med* 2012;367:695–704.

BMJ Open: first published as 10.1136/bmjopen-2024-084356 on 31 July 2024. Downloaded from http://bmjopen.bmj.com/ on June 8, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

15 Kassem MAM, Durda MA, Stoicea N, *et al*. The impact of Bariatric surgery on type 2 diabetes mellitus and the management of Hypoglycemic events. *Front Endocrinol (Lausanne)* 2017;8:37.
16 van Veldhuisen SL, Gorter TM, van Woerden G, *et al*. Bariatric surgery and cardiovascular disease: a systematic review and meta-analysis. *Eur Heart J* 2022;43:1955–69.
17 Sjöström L, Narbro K, Sjöström CD, *et al*. Effects of Bariatric surgery on mortality in Swedish obese subjects. *N Engl J Med* 2007;357:741–52.
18 Boyers D, Retat L, Jacobsen E, *et al*. Cost-effectiveness of Bariatric surgery and non-surgical weight management programmes for adults with severe obesity: a decision analysis model. *Int J Obes (Lond)* 2021;45:2179–90.
19 Gulliford MC, Charlton J, Prevost T, *et al*. Costs and outcomes of increasing access to Bariatric surgery: cohort study and cost-effectiveness analysis using electronic health records. *Value Health* 2017;20:85–92.
20 Aguiar M, Frew E, Mollan SP, *et al*. n.d. The health economic evaluation of Bariatric surgery versus a community weight management intervention analysis from the idiopathic intracranial hypertension. *Life*11:409.
21 Picot J, Jones J, Colquitt JL, *et al*. The clinical effectiveness and cost-effectiveness of Bariatric (weight loss) surgery for obesity: a systematic review and economic evaluation. *Health Technol Assess* 2009;13:1–190, .
22 Pathway for management of severe obesity and/or Bariatric Surgery In Primary Care, Available: https://www.lnds.nhs.uk/Library/Pathwayformanagementofsevereobesity.pdf
23 NHS England: Guidance for Clinical Commissioning Groups (CCGs). Clinical guidance: revision surgery for complex obesity (appendix 8), 2016. Available: https://www.england.nhs.uk/wp-content/uploads/2016/05/appndx-8-revision-surgery-ccg-guid.pdf
24 Weight-loss surgery in England: many who need it aren’t getting it 2019, Available: https://theconversation.com/weight-loss-surgery-in-england-many-who-need-it-arent-getting-it-118204
25 Ahmad A, Laverty AA, Aasheim E, *et al*. Eligibility for Bariatric surgery among adults in England: analysis of a national cross-sectional survey. *JRSM Open* 2014;5:2042533313512479.
26 Fehervari M, Fadel MG, Reddy M, *et al*. Medicolegal cases in Bariatric surgery in the United Kingdom. *Curr Obes Rep* 2023;12:355–64.
27 Guide to NHS waiting times in England, Available: https://www.nhs.uk/nhs-services/hospitals/guide-to-nhs-waiting-times-in-england
28 The Operating Framework: for the NHS in England 2011/12, 2010. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/216187/dh_122736.pdf
29 Gasoyan H, Tajeu G, Halpern MT, *et al*. Reasons for Underutilization of Bariatric surgery: the role of insurance benefit design. *Surg Obes Relat Dis* 2019;15:146–51.
30 Tako AA, Kotiadis K, Vasilakis C, *et al*. Improving patient waiting times: a simulation study of an obesity care service. *BMJ Qual Saf* 2014;23:373–81.
31 Borisenko O, Lukyanov V, Ahmed AR. Cost-utility analysis of Bariatric surgery. *Br J Surg* 2018;105:1328–37.
32 Bolckmans R, Askari A, Currie A, *et al*. Clinical characteristics of patients undergoing primary Bariatric surgery in the United Kingdom based on the National Bariatric surgery Registry. *Clin Obes* 2023;13:e12585.
33 Shedding the pounds: obesity management, nice guidance and bariatric surgery in England 2010, Available: https://www.ohe.org/publications/shedding-pounds-obesity-management-nice-guidance-and-bariatric-surgery-england
34 The United Kingdom National Bariatric Surgery Registry. Third Registry report 2020. n.d. Available: https://e-dendrite.com/Publishing/Reports/Bariatric/NBSR2020.pdf
35 Tishler CL, Reiss NS. Roux-en-Y gastric bypass may not increase patients' return to work. *Arch Surg* 2008;143:1024–5.
36 Berglind D, Müller P, Willmer M, *et al*. Differential methylation in inflammation and type 2 diabetes genes in siblings born before and after maternal Bariatric surgery. *Obesity (Silver Spring)* 2016;24:250–61.
37 Sheehan A, Patti ME. Hypoglycemia after upper gastrointestinal surgery: clinical approach to assessment, diagnosis, and treatment. *Diabetes Metab Syndr Obes* 2020;13:4469–82.
38 NICE guidelines: Obesity: identification, assessment and management, 2014. Available: https://www.nice.org.uk/guidance/cg189
39 Lucchese M, Borisenko O, Mantovani LG, *et al*. Cost-utility analysis of Bariatric surgery in Italy: results of decision-analytic Modelling. *Obes Facts* 2017;10:261–72.
40 Gounder ST, Wijayanayaka DR, Murphy R, *et al*. Costs of Bariatric surgery in a randomised control trial (RCT) comparing Roux en Y gastric bypass vs sleeve Gastrectomy in Morbidly obese diabetic patients. *N Z Med J* 2016;129:43–52.
41 Sadeghi P, Duarte-Bateman D, Ma W, *et al*. Post-Bariatric plastic surgery: Abdominoplasty, the state of the art in body contouring. *J Clin Med* 2022;11:4315.
42 Tummy tuck (Abdominoplasty). n.d. Available: https://www.nhs.uk/conditions/cosmetic-procedures/cosmetic-surgery/tummy-tuck
43 Eisenberg D, Shikora SA, Aarts E, *et al*. American society for metabolic and Bariatric surgery (ASMBS) and international Federation for the surgery of obesity and metabolic disorders (IFSO): indications for metabolic and Bariatric surgery. *Surg Obes Relat Dis* 2022;18:1345–56.
44 UK Office for National Statistics 2021 census data for England 2021, Available: https://www.ethnicity-facts-figures.service.gov.uk/uk-population-by-ethnicity/demographics/age-groups/latest#main-facts-and-figures
45 Desogus D, Menon V, Singhal R, *et al*. An examination of who is eligible and who is receiving Bariatric surgery in England: secondary analysis of the health survey for England Dataset. *Obes Surg* 2019;29:3246–51.
46 2020/21 national cost collection data publication. 2022. Available: https://www.england.nhs.uk/publication/2020-21-national-cost-collection-data-publication
47 Statistics on Obesity, Physical Activity and Diet, England 2021, Available: https://digital.nhs.uk/data-and-information/publications/statistical/statistics-on-obesity-physical-activity-and-diet/england-2021

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