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Original article

Cost-effectiveness of bariatric and metabolic surgery, and implications of COVID-19 in the United Kingdom

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Abstract

Background: People living with obesity have been among those most disproportionately impacted by the COVID-19 pandemic, highlighting the urgent need for increased provision of bariatric and metabolic surgery (BMS).

Objectives: To evaluate the possible clinical and economic benefits of BMS compared with nonsurgical treatment options in the UK, considering the broader impact that COVID-19 has on people living with obesity.

Setting: Single-payer healthcare system (National Health Service, England).

Methods: A Markov model compared lifetime costs and outcomes of BMS and conventional treatment among patients with body mass index (BMI) $\geq$ 40 kg/m^2, BMI $\geq$ 35 kg/m^2 with obesity-related co-morbidities (Group A), or BMI $\geq$ 35 kg/m^2 with type 2 diabetes (T2D; Group B). Inputs were sourced from clinical audit data and literature sources; direct and indirect costs were considered. Model outputs included costs and quality-adjusted life years (QALYs). Scenario analyses whereby patients experienced COVID-19 infection, BMS was delayed by five years, and BMS patients underwent endoscopy were conducted.

Results: In both groups, BMS was dominant versus conventional treatment, at a willingness-to-pay threshold of £25,000/QALY. When COVID-19 infections were considered, BMS remained dominant and, across 1000 patients, prevented 117 deaths, 124 hospitalizations, and 161 intensive care unit admissions in Group A, and 64 deaths, 65 hospitalizations, and 90 intensive care unit admissions in Group B. Delaying BMS by 5 years resulted in higher costs and lower QALYs in both groups compared with not delaying treatment.

Conclusion: Increased provision of BMS would be expected to reduce COVID-19-related morbidity and mortality, as well as obesity-related co-morbidities, ultimately reducing the clinical and economic burden of obesity. (Surg Obes Relat Dis 2021;17:1897–1904.) © 2021 American Society for Bariatric Surgery. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Key words: COVID-19; Infection; Pandemic; Obesity; Bariatric surgery; Metabolic surgery; Cost-effectiveness analysis; Surveillance endoscopy

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There is a paucity of effective interventions for obesity, except for bariatric and metabolic surgery (BMS) [1–3]. However, despite positive Diabetes Surgery Summit's (DSS) and UK National Institute for Health and Care Excellence's (NICE) recommendations [4,5], the provision of BMS is particularly limited in the UK relative to other European countries [6,7]. As a result, many patients living with obesity in the UK do not have access to the most effective treatment [7].

People living with obesity have been among those most disproportionately impacted by the COVID-19 pandemic, owing to high rates of hospitalization, intensive care unit (ICU) admission, and mortality [8–10], with increasing body mass index (BMI) linked to more severe COVID-19 [10]. This highlights an urgent need to improve access to interventions shown to address known risk factors for COVID-19. The pandemic has also led to the delay or cancellation of many elective procedures, including BMS [11]. Delayed surgical treatment for obesity has been shown to impair postoperative outcomes, including the likelihood of achieving diabetes remission [11]. Delays as short as 1 year have also been shown to increase the cost of care versus prompt surgery [12]. There is, therefore, a need to better understand the potential impact of the COVID-19 pandemic, including delays to BMS, on patients living with obesity and healthcare systems.

The objective of this study was to evaluate the potential clinical and economic benefits of BMS compared with conventional, nonsurgical treatment options from a healthcare payer and a societal perspective in the UK, considering the broader impact that COVID-19 has on patients living with obesity.

Methods

A cost-effectiveness analysis (CEA) was performed using a Markov model with a lifetime horizon, as with previously published analyses [13,14], to evaluate the economic impact of BMS from a UK healthcare payer and a societal perspective.

In alignment with the 2nd Diabetes Surgery Summit (DSS-II) and NICE guidelines [4,5], the following 2 populations were considered in the CEA: patients with BMI $\geq$ 40 kg/m^2, or BMI $\geq$ 35 kg/m^2 with obesity-related co-morbidities (Group A); and patients with BMI $\geq$ 35 kg/m^2 with type 2 diabetes (T2D; Group B).

The base case analysis compared the 2 most common types of BMS—laparoscopic gastric bypass and laparoscopic sleeve gastrectomy—with conventional treatment, defined as supervised diet and exercise programs with or without pharmacotherapy. Distinct, procedure-specific inputs were used for the 2 different types of BMS. Outputs were calculated as an average of the 2 and weighted according to their relative utilization in UK clinical practice.

A scenario analysis was conducted to quantify the impact of BMS relative to conventional treatment among patients living with obesity and infected with COVID-19. In this scenario, all patients experienced infection once during 1 cycle 1 year after treatment. Infections could lead to hospitalization, ICU admission, and/or death. These events were adjusted according to patients' BMI levels [8,15,16]. The results were compared with the base case analysis (no consideration of COVID-19 infection).

An additional scenario analysis was conducted wherein BMS treatment and effects thereof were delayed for 5 years, in line with waiting times reported in the literature [17]. Prior to BMS, all patients received conventional treatment and experienced the effects thereof. The potential impact of endoscopy screening being required for all patients undergoing BMS and postoperative surveillance endoscopy being required for sleeve gastrectomy patients, in line with recent International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) statements [18,19], was also investigated.

Extended details of the study methodology can be found in the supplementary material.

Model structure

The model (Fig. 1) was used to capture the complex nature of obesity and its associated co-morbidities over time. Patients could occupy a diabetes health state (either with T2D, without T2D, or in T2D remission), and transition between T2D and remission on an ongoing basis. Patients could simultaneously occupy and transition between mutually exclusive health states (stroke, myocardial infarction [MI], cancer) as they progressed through the model. Prior to entering the Markov model structure, complication, reoperation, and 30-day mortality rates due to surgery were allocated to the BMS cohort alongside associated costs and utilities. BMS and conventional treatment led to changes in BMI, blood pressure (BP), lipid ratio (LR), and rate of T2D remission accordingly. BMI affected the probability of transitioning to T2D. Age, sex, BP, LR, and T2D status affected the risk of stroke and MI, based on Framingham risk equations [20]. Patients could also experience knee pain and sleep apnea.

Model inputs

Model baseline characteristics (mean age, mean BMI, proportion of females, and proportion with T2D) were obtained from audit data on patients that underwent BMS in the Bristol, UK, area. All other clinical inputs, including the efficacy and safety of BMS and conventional treatment, were sourced from the literature. Comprehensive and targeted searches were conducted to identify relevant publications. Model inputs were selected in consideration of the hierarchy of evidence in the scientific literature, as well as

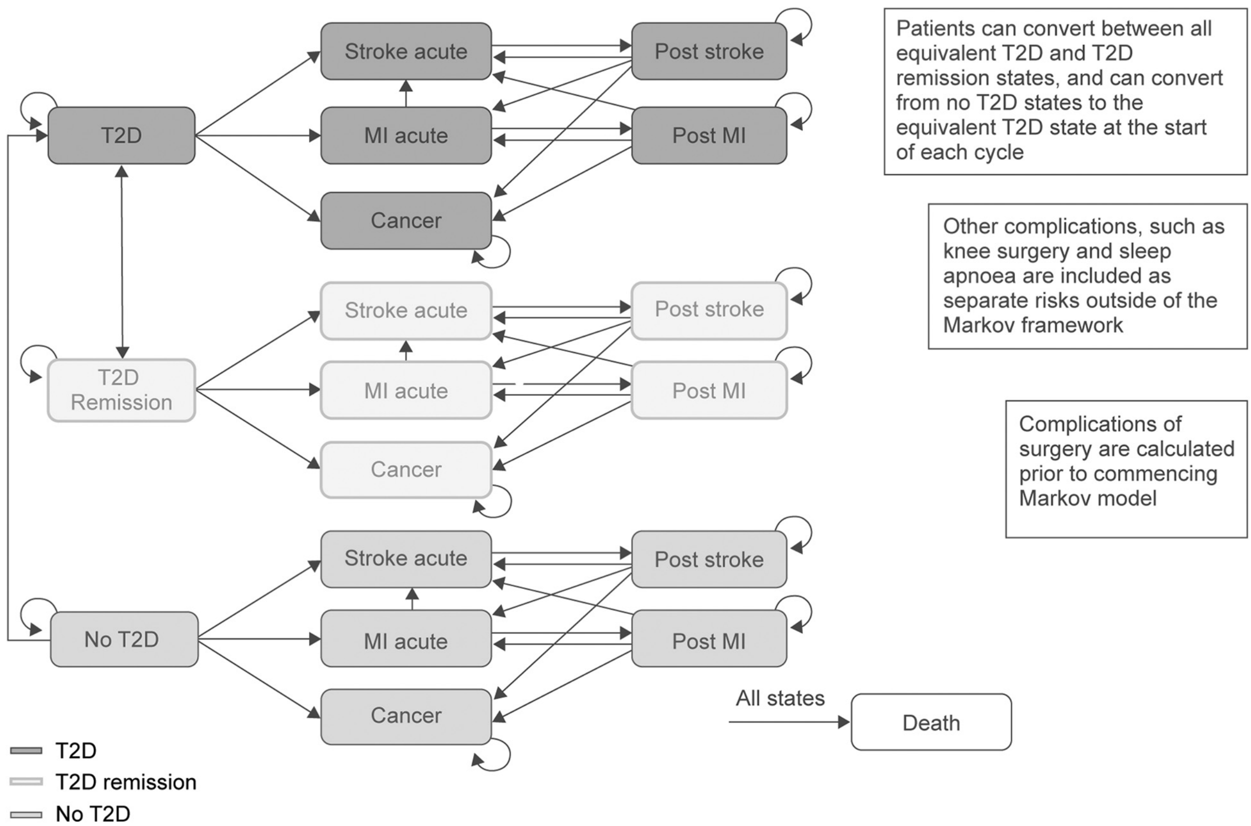

Fig. 1. Model structure. MI = myocardial infarction; T2D = type 2 diabetes.

their validity and generalizability to UK clinical practice. Clinical inputs are summarized in Supplementary Table 3, with those specific to the COVID-19 scenario analysis summarized in Supplementary Table 4 and those specific to the endoscopy scenario analysis in Supplementary Table 5.

All patients in the model were assigned a starting utility value—a valuation of health-related quality of life (HRQoL)—ranging from 1 (equivalent to full health) to 0 (equivalent to death). Changes in BMI, and other clinical conditions, resulted in utility changes. These valuations were then multiplied by the duration of time that the patient spent in these clinical conditions, which accumulated over time until death, resulting in the final clinical output of the model: quality-adjusted life years (QALYs). Utility inputs are summarized in Supplementary Table 6.

Costs included the cost of treatment and the costs associated with each co-morbidity. Where possible, unit costs were derived from NHS reference costs (inflated to 2019 GBP values); all costs were UK-specific. Cost inputs are summarized in Supplementary Table 7.

Societal impact was measured by incorporating productivity losses/gains, based on employment rate, and work impairment, into the model, which were dependent on BMI.

An annual discount rate of 3.5% was chosen for both costs and utilities, as per the NICE reference case [21].

Model outputs

Model outputs included costs and QALYs. These were used to calculate the cost-effectiveness of BMS versus conventional treatment, represented as incremental cost-effectiveness ratios (ICER; the difference in cost between 2 interventions, divided by the difference in their effect [QALYs]). The net monetary benefit (NMB; calculated as the benefit [QALYs] of an intervention multiplied by a willingness-to-pay [WTP] threshold, minus the cost of the intervention) was used as a measure of the value of each treatment in monetary terms. The WTP threshold, corresponding to the maximum cost per health outcome (QALYs) that a health system is willing to pay, was set at £25,000/QALY as per the NICE reference case [21].

Sensitivity analyses

Probabilistic and deterministic sensitivity analyses (PSA and DSA, respectively) were conducted to test the robustness of model results.

Results

Base case analysis

The mean age (standard deviation [SD]) was 46.45 (10.68) years and 51.74 (8.37) years for Group A and B, respectively. The mean BMI (SD) was 48.90 (7.37) kg/m^2 and 49.15 (8.48) kg/m^2 for Group A and B, respectively.

Within these populations, BMS was found to be the dominant strategy (lower costs and higher QALYs) over conventional treatment, in both Group A and Group B, from the healthcare payer perspective (Table 1). BMS also had lower rates of T2D, stroke, MI, cancer, knee pain, and sleep apnea, and lower costs associated with these co-morbidities (Supplementary Table 9). BMS resulted in an incremental NMB of £110,024 in Group A, and £64,495 in Group B, at a WTP threshold of £25,000/QALY gained (Supplementary Table 9).

BMS was cost saving for an NHS service after 12 years in Group A and 5 years in Group B. Considering a societal perspective, the total costs per patient following BMS were lower than those for conventional treatment, in both populations; it took 2 and 4 years of running an NHS service for BMS to be cost saving in Group A and B, respectively.

Sensitivity analyses demonstrated that model outcomes were robust across a broad range of input parameters. Within the DSA, outcomes were most sensitive to BMI-related inputs, such as disutility per unit increase in BMI (Supplementary Fig. 1). In the PSA, BMS was associated with cost savings in all simulations for both groups and generated higher QALYs in 99.9% and 100% of simulations in Group A and Group B, respectively (Supplementary Fig. 2).

Impact of COVID-19

Across 1000 patients with COVID-19 in Group A, the model predicted that BMS would prevent 117 deaths, 124 hospital admissions, and 161 ICU admissions due to COVID-19, compared with if they received conventional therapy. In Group B, the model predicted that 64 deaths, 65 hospital admissions, and 90 ICU admissions due to COVID-19 would be prevented. The number needed to treat to avoid 1 death was 9 patients in Group A and 16 patients in Group B.

When COVID-19 infections were considered, BMS remained dominant, resulting in an increase in both survival years and QALYs and a reduction in total costs versus conventional treatment (Table 2).

Compared with the base case (no consideration of COVID-19 infection), BMS was associated with a per-patient increase in incremental survival years (+2.12 and +1.04 in Group A and Group B, respectively), QALYs (+.37 and +.08, respectively) and incremental costs (+£3,889 and +£4,082, respectively; Table 2). Compared with the base case, NMB remained positive, increasing by £5,298 to £115,322 in Group A and decreasing by £2,027 to £62,468 in Group B.

The results of the COVID-19 scenario analyses were most sensitive to variation in the risk of COVID-19–related death per BMI unit (Supplementary Fig. 3).

Impact of delayed surgery

In Group A and Group B, delaying BMS by 5 years was associated with less cost savings (−4.2% and −12.3%, respectively), fewer QALYs gained (−10.2% and −4.5%, respectively) and a reduction in survival years (−8.6% and −5.7%, respectively) compared with not delaying the treatment (Table 3).

Compared with the base case, NMB remained positive, decreasing by £11,381 to £98,643 in Group A, and by £3,284 to £61,211 in Group B. BMS was dominant versus conventional treatment in both groups.

Impact of endoscopy

When preoperative endoscopy for all patients and postoperative endoscopy for sleeve gastrectomy patients every 3 years were considered, BMS was associated with higher costs relative to the base case analysis, but remained cost saving compared with conventional treatment, in both groups (Supplementary Table 10).

Table 1
Base case results (per patient)

Treatment	Total costs	Total survival years	Total QALYs	Incremental costs	Incremental QALYs	ICER
Group A*						
Conventional treatment†	£51,519	20.21	7.81	–	–	–
Surgery	£46,691	20.56	12.02	−£4,828	4.21	Dominant
Group B‡						
Conventional treatment†	£67,085	18.73	7.03	–	–	–
Surgery	£59,258	19.07	9.30	−£7,827	2.27	Dominant

QALY = quality-adjusted life year; ICER = incremental cost-effectiveness ratio.
* Patients with body mass index (BMI) $\geq$ 40 kg/m^2 or BMI $\geq$ 35 kg/m^2 with obesity-related co-morbidities.
† Conventional treatment comprised behavior change strategies to increase patients' physical activity or decrease inactivity, improve eating behavior and the quality of the person's diet, and reduce energy intake.
‡ Patients with BMI $\geq$ 35 kg/m^2 with type 2 diabetes.

Table 2
COVID-19 scenario analysis (per patient)

		Total costs	Survival years	QALYs	NMB at £25k/QALY	ICER
Group A*						
COVID-19	Conventional treatment†	£45,351	15.84	6.13	£107,937	
	Surgery	£44,413	18.31	10.71	£223,260	
	Difference	−£939	+2.47	+4.58	£115,322	Dominant
Without COVID-19	Conventional treatment†	£51,519	20.21	7.81	£143,690	
	Surgery	£46,691	20.56	12.02	£253,715	
	Difference	−£4,828	+.35	+4.21	£110,024	Dominant
Group B‡						
COVID-19	Conventional treatment†	£58,262	14.89	5.59	£81,553	
	Surgery	£54,516	16.28	7.94	£144,020	
	Difference	−£3,745	+1.39	+2.35	£62,468	Dominant
Without COVID-19	Conventional treatment†	£67,085	18.73	7.03	£108,722	
	Surgery	£59,258	19.07	9.30	£173,217	
	Difference	−£7,827	+.35	+2.27	£64,495	Dominant

QALY = quality-adjusted life year; NMB = net monetary benefit; ICER = incremental cost-effectiveness ratio.
* Patients with body mass index (BMI) $\geq$ 40 kg/m^2 or BMI $\geq$ 35 kg/m^2 with obesity-related co-morbidities.
† Conventional treatment comprised behavior change strategies to increase patients' physical activity or decrease inactivity, improve eating behavior and the quality of the person's diet, and reduce energy intake.
‡ Patients with BMI $\geq$ 35 kg/m^2 with type 2 diabetes.

Discussion

The results of this study show that BMS is expected to lead to a reduction in costs and an increase in HRQoL, yielding substantial NMB over a lifetime horizon. Further, from a societal perspective, BMS was shown to be cost saving within a maximum of 4 years for the UK NHS.

These results agree with multiple prior studies showing that BMS offers significant health benefits to patients living with obesity and T2D, including a reduction in mortality and co-morbidities [22,23], and is a cost-effective treatment option for healthcare providers [14,24,25]. Despite this, patient access to BMS is severely limited. For example, in the UK, the number of NHS BMS procedures are falling; between 2011–2012 and 2014–2015, the number of procedures fell by 31%, from 8794 to just 6032 [7]. This is the case even though the prevalence of obesity is increasing [26]. Increasing equitable access to BMS will be a critical step toward alleviating the clinical and economic burden associated with obesity.

People living with overweight or obesity are at increased risk of hospitalization, ICU admission, and mortality in the presence of COVID-19 infection [8–10]. The pandemic has

Table 3
Delayed surgery scenario analysis (per patient)

		Total costs	Survival years	QALYs	NMB at £25,000/QALY	ICER
Group A*						
Delayed surgery	Conventional treatment†	£51,519	20.21	7.81	£143,690	
	Surgery	£47,255	20.53	11.58	£242,333	
	Difference	−£4,624	+.32	+3.78	£98,643	Dominant
Not delayed	Conventional treatment†	£51,519	20.21	7.81	£143,690	
	Surgery	£46,691	20.56	12.02	£253,715	
	Difference	−£4,828	+.35	+4.21	£110,024	Dominant
Group B‡						
Delayed surgery	Conventional treatment†	£67,085	18.73	7.03	£108,722	
	Surgery	£60,222	19.06	9.21	£169,933	
	Difference	−£6,864	+.33	+2.17	£61,211	Dominant
Not delayed	Conventional treatment†	£67,085	18.73	7.03	£108,722	
	Surgery	£59,258	19.07	9.30	£173,217	
	Difference	−£7,827	+.35	+2.27	£64,495	Dominant

QALY = quality-adjusted life year; NMB = net monetary benefit; ICER = incremental cost-effectiveness ratio.
* Patients with body mass index (BMI) $\geq$ 40 kg/m^2 or BMI $\geq$ 35 kg/m^2 with obesity-related co-morbidities.
† Conventional treatment comprised behavior change strategies to increase patients' physical activity or decrease inactivity, improve eating behavior and the quality of the person's diet, and reduce energy intake.
‡ Patients with BMI $\geq$ 35 kg/m^2 with type 2 diabetes.

therefore put people living with obesity at further increased risk of complications and mortality, imparting additional pressure on healthcare systems. In the modelled scenario analysis wherein all patients experienced COVID-19 infection, after just 1 year, BMS reduced the number of deaths, hospitalizations, and ICU admissions versus conventional treatment in both populations studied. These results suggest that BMS, in addition to the already established health benefits for patients living with obesity and T2D [1–3], may reduce complications and mortality associated with COVID-19 infection. These findings are consistent with prior research which revealed low rates of ICU admissions among BMS patients with COVID-19 [27]. Considering the large backlog of non–COVID-19 care in the UK [28], due to many elective operations being cancelled to cope with the influx of COVID-19 patients, such reductions in ICU admissions would be expected to help alleviate the strain of the current and future pandemics on healthcare resources.

Given the prevalence of obesity, delays in access to BMS may contribute to deteriorating population health and higher expenditures. BMS delays of 5 years, indicative of a growing backlog of elective procedures [29], were found to reduce QALYs and cost savings associated with BMS. At the start of the pandemic, it was thought that performing elective procedures would put patients at unnecessary risk of infection with COVID-19 and so many procedures were postponed or cancelled. However, recent data suggest that the risk of COVID-19 infection during surgical procedures is lower than expected [27,30]. In an international cohort study of adult patients who underwent primary BMS, only 10 of 2001 (.5%) patients were diagnosed with symptomatic COVID-19 at 30 days postoperatively [30]. Moreover, a recent study in the US showed that prior metabolic surgery with subsequent weight loss was associated with lower rates of hospital and ICU admission in patients with obesity who became infected with COVID-19 [31]. These studies suggest that the benefit of continuing BMS far outweighs that of delaying such procedures and, in line with this, clinical organizations such as the American Society for Metabolic and Bariatric Surgery have called for their resumption [32].

Recent IFSO statements recommended endoscopy screening for all BMS procedures and postsurgical endoscopy surveillance every 2–3 years for patients that underwent sleeve gastrectomy [18,19]. Despite the additional cost associated with endoscopy, when considered in the model, BMS remained cost saving versus conventional treatment.

Though the uptake of BMS is not solely dependent on its provision, these results emphasize the urgency with which the provision of BMS should be improved, with such changes expected to result in reductions in morbidity and mortality and improvements in quality of life for patients living with obesity. In addition, reductions in healthcare resource use resulting from obesity-related co-morbidities, and improvements in productivity, would reduce the economic burden of obesity on healthcare systems and society.

Limitations

This study considered multiple populations in line with those most strongly recommended by DSS-II and NICE and a broad range of co-morbidities [4,5], and utilized a lifetime horizon, helping to understand the potential long-term impact of BMS. It is important to note that, although the highest level of evidence was prioritized, the sourcing of data occurred via targeted reviews, as opposed to systematic literature searching, which possibly resulted in relevant data being missed. In addition, given the absence of studies able to evaluate causal inference, data informing the COVID-19 scenario analysis were based on observational studies alone. However, the latest evidence on BMS was utilized, with longer follow-up times than evidence used in previously published CEAs [13,14].

Owing to a lack of complete data across all populations, the clinical data do not universally match each patient group in the model (further details are provided in the Supplementary material). Similarly, data specific to the UK were used when possible, and supplemented with data from the EU, US, and Australia where necessary, though the applicability of the non-UK population data was validated by clinical expert opinion. Conversely, as some of the clinical inputs utilized in the model are specific to Bristol hospitals, this may limit their generalizability to healthcare systems outside the UK. In addition, T2D remission was not defined consistently between the utilized studies. Despite these limitations, sensitivity analyses suggested that the results would remain similar to the base case analysis regardless of variations in clinical parameters.

Finally, this study was based on a simulation model and, therefore, comparative studies, prospective or retrospective, and possibly using registry data, should be conducted to validate these results.

Conclusion

Increased provision of BMS would be expected to reduce morbidity and mortality, as well as obesity-related co-morbidities, compared with conventional treatment, ultimately reducing the economic burden of obesity on healthcare systems. The cost-effectiveness of BMS was higher when COVID-19 infections were considered or access to surgery was delayed, due to increased morbidity and mortality.

Disclosures

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.soard.2021.07.009.

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