

■ ARTHROPLASTY

The impact of an enhanced recovery programme on length of stay and post-discharge resource usage following hip and knee arthroplasty

A SERVICE EVALUATION AND COST ANALYSIS



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Aims

The aim of this study is to assess the impact of a pilot enhanced recovery after surgery (ERAS) programme on length of stay (LOS) and post-discharge resource usage via service evaluation and cost analysis.

Methods

Between May and December 2019, 100 patients requiring hip or knee arthroplasty were enrolled with the intention that each would have a preadmission discharge plan, a preoperative education class with nominated helper, a day of surgery admission and mobilization, a day one discharge, and access to a 24/7 dedicated helpline. Each was matched with a patient under the pre-existing pathway from the previous year.

Results

Mean LOS for ERAS patients was 1.59 days (95% confidence interval (CI) 1.14 to 2.04), significantly less than that of the matched cohort (3.01 days; 95% CI 2.56 to 3.46). There were no significant differences in readmission rates for ERAS patients at both 30 and 90 days (six vs four readmissions at 30 days, and nine vs four at 90 days). Despite matching, there were significantly more American Society of Anesthesiologists (ASA) grade 3 patients in the ERAS cohort. There was a mean cost saving of £757.26 (95% CI £-1,200.96 to £-313.56) per patient. This is despite small increases in postoperative resource usage in the ERAS patients.

Conclusion

ERAS represents a safe and effective means of reducing LOS in primary joint arthroplasty patients. Implementation of ERAS principles has potential financial savings and could increase patient throughput without compromising care. In elective care, a preadmission discharge plan is key.

Cite this article: *Bone Jt Open* 2021;2-11:966–973.

Keywords: Arthroplasty, Hip, Knee, Enhanced recovery, Outcomes, Service evaluation, Quality improvement, Length of stay, Rehabilitation

Introduction

Primary arthroplasty is a successful treatment for osteoarthritis of the hip and knee and confers significant functional benefit and satisfaction to patients. Increasing demands on healthcare systems worldwide, in addition to the need for continuous improvement in patient outcome, has led to the development of strategies to optimize treatment pathways.

The Danish surgeon Professor Henrik Kehlet introduced the concept of enhanced recovery after surgery (ERAS) and applied it successfully in the setting of gastrointestinal surgery in the 1990 s.¹ His team introduced a multimodal approach to patients undergoing colonic resection for neoplasm, and through aggressive and proactive perioperative care, achieved excellent early postoperative outcomes. Enhanced recovery protocols

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doi: 10.1302/2633-1462.211.BJO-2021-0125.R1

Bone Jt Open 2021;2-11:966–973.

are based on three main pillars of treatment: evidence-based perioperative care, a multimodal and multidisciplinary team approach, and continuous audit.

Implementation of the ERAS concept has reliably led to improvements in length of stay (LOS) and readmission rate in the early postoperative period across numerous surgical subspecialties, including orthopaedic surgery.²⁻⁴ ERAS is becoming an increasingly crucial part of a successful arthroplasty programme, with early mobilization leading to improved early outcome measures, reduced mortality,⁵ and reduced LOS.⁶

Previous research within our unit (Primary Joint Unit, Musgrave Park Hospital, Northern Ireland)⁷ investigated the reasons for prolonged LOS following primary arthroplasty. Four key areas were identified, which together contributed 74.1% of excess bed days, with the first two contributing 60.6%:

1. Postoperative referral to social services (49.2%).
2. Patient admission prior to day of surgery (11.4%).
3. Patients who were slow to mobilize postoperatively (10.5%).
4. Provision of occupational therapy equipment for discharge (3.0%).

The aim of this service evaluation was to determine whether a pilot ERAS programme could significantly reduce LOS and cost without a significant increase in the rate of emergency department (ED) attendances or readmissions within 90 days. This paper presents, to our knowledge, the first formal cost analysis of an ERAS programme in arthroplasty patients.

Methods. Between 21 May and 9 December 2019, a pilot ERAS programme was introduced as part of a service evaluation within our institution (Primary Joint Unit, Musgrave Park Hospital, Northern Ireland). Its primary aim was to reduce LOS by introducing six key changes in the clinical pathway for primary joint arthroplasty patients:

1. Preadmission phone call and discharge plan with emphasis on patient responsibility.
2. Day of surgery admission.
3. Mobilization within four hours post-surgery.
4. Routine day one discharge.
5. Post-discharge phone call one day after discharge.
6. Patient access to a 24/7 dedicated helpline.

A flowchart detailing the pathway for each patient during the perioperative period is provided in Figure 1. Prior to the commencement of the pilot programme, all hospital staff in direct patient contact were invited to information sessions to explain the rationale and concepts behind the ERAS approach. Two to four weeks prior to the intended admission date, patients received a phone call from an orthopaedic nurse. This call gave the patient a clear

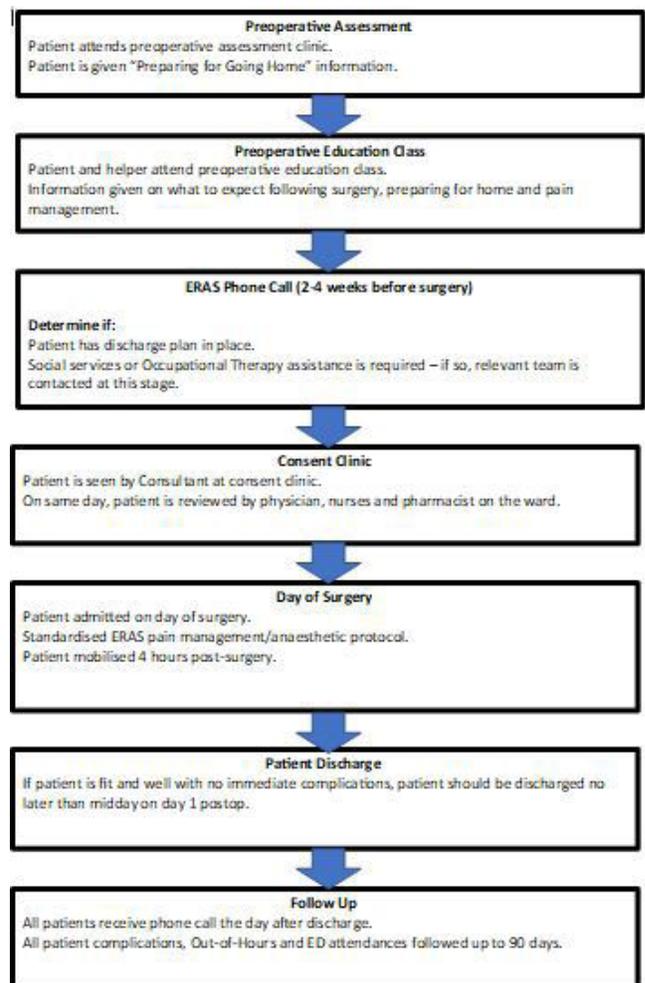


Fig. 1
ERAS patient pathway.

overview of the ERAS programme, discussed the support that may be required following discharge from hospital, and included a conversation with a patient-nominated helper to discuss their responsibilities following the patient's discharge from hospital. In order for patients to be eligible for ERAS, they were required to attend a preoperative education class and be suitable for admission on the day of surgery.

Following this phone call and prior to admission, each patient was required to:

1. Attend a consent clinic with their surgeon;
2. Attend a preoperative physiotherapist led education class;
3. Undergo the admission process with both the ward physician and ward nurse; and
4. Be interviewed by the ward pharmacist.

Consent clinics were not part of routine practice at the time of the ERAS pilot. Only a small number of patients in the matched cohort attended a preoperative

Table I. Unit costs of health service use.

Resource items	Unit cost, £	Details
Hip arthroplasty*	5,338	Average cost per episode for very major hip procedure based on average LOS of three days
Hip arthroplasty excess 613 bed day*		
Knee arthroplasty*	5,532	Average cost per episode for very major knee procedure based on average los of three days
Knee arthroplasty excess day bed*	613	
Ward bed day (general medicine)*	550	
ED attendance*	210	
Doppler ultrasound*	80	Direct access
Calculated tomography pulmonary angiogram*	170	Direct access
GP consultation out-of-hours†	91	Based on face-to-face consultation (9.22 minutes) plus 20 minutes travel time (indirect, £156 per hour)

*Source: Belfast Health and Social Care Trust Finance Department.

†Unit Cost of Health and Social Care.⁸

ED, emergency department; LOS, length of stay.

physiotherapist led education class. Patients in the ERAS cohort who were identified as requiring occupational therapy (OT) were referred preoperatively for assessment.

The ERAS patients were matched 1:1 with a cohort of retrospective control patients from the previous year (January 2018 to December 2018) for comparison. This was to avoid any halo effect that would occur if we chose contemporaneous patients. They were matched on the following variables: day of surgery admission, operating consultant, affected joint (hip/knee), sex, age (± 2.5 years), American Society of Anesthesiologists (ASA) classification (± 1 grade), and month of surgery (best possible match). These variables were matched in the order stated. In all cases, patients were matched for day of surgery admission, consultant, affected joint, and sex. Matched controls were identified without arthroplasty. It was not possible to identify more than one match for every ERAS patient, and so when multiple matches were identified for a single ERAS patient, the closest match (based on the variables above) was selected. No formal sample calculation was performed. The sample reflected the number of participants that were eligible for the ERAS programme during the pilot period (May 2019 to December 2019).

The cost analysis was undertaken from the perspective of the health service, but limited to hospital resources and out-of-hours general practitioner attendances. This included attendances to ED, outpatient clinics, GP out-of-hours, radiological investigations, and hospital readmissions. These were considered to be the services which were most likely to be impacted on by the introduction of

Table II. Reasons for exclusion from enhanced recovery after surgery protocol.

Reason	Patients, n
Refused or unable to attend preoperative education class	13
Surgery cancelled*	10
Decided against surgery at present	5
Complex case	2
Unable to attend consent clinic	1
Patient refused proposed date for surgery	1
Did not attend for surgery	1
Day of surgery brought forward (therefore unable to be seen at consent or preoperative education class)	1
Total	34

*Reasons for surgery cancellation were urinary tract infection ($n = 1$), cardiology assessment required ($n = 2$), myocardial infarction ($n = 1$), stroke ($n = 1$), found lump under arm ($n = 1$), new diagnosis chronic obstructive pulmonary disease ($n = 1$), and active lower respiratory tract infection ($n = 1$). Two further patients subsequently underwent surgery but outside the ERAS study window.

ERAS. Health service use and associated costs were based on the 30-day and 90-day period post-surgery. As the time period of the study was less than one year, discounting of costs was not necessary. Data on helpline usage was gathered prospectively to allow future improvements in the service. However, this data was not included in the cost analysis due to a lack of comparable data for the matched control arm. Prior to the ERAS protocol, patients had telephone access to the orthopaedic ward, but this was not formalized in the same way as the ERAS pilot.

Data relating to both the ERAS and control patients' primary hospital admission for hip or knee arthroplasty were obtained from patient notes, the Belfast Orthopaedic Information System (BOIS), Northern Ireland Electronic Care Record (NIECR), and the Northern Ireland Picture Archiving and Communications System (NIPACS). This work evaluates a service improvement programme, so therefore ethical approval was not required.

Statistical analysis. Patient-level data were combined with unit costs (Table I) to estimate costs for each patient. Unit costs were obtained directly from our institutions' finance department or the publicly available Unit Costs of Health and Social Care. The price year was set at 2018/2019.⁸ Number (percentage) of patients using each service, mean number of times service used (95% confidence intervals (CIs)), and the associated mean costs of each service type (95% CI) were reported for each group. The difference in total costs between groups was estimated using regression methods adjusted for the matching variables. All statistical analysis was carried out using Stata/IC 15.1 (StataCorp, USA). Significance was judged where the CI of differential means excluded zero or $p < 0.05$.

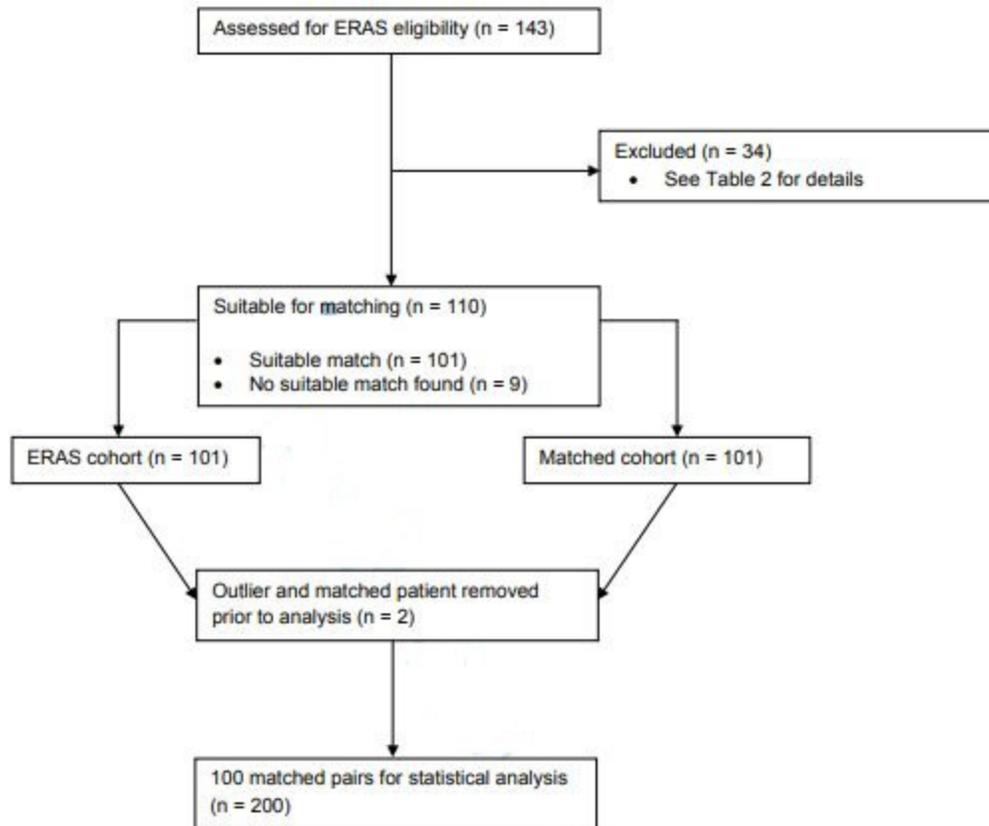


Fig. 2
CONSORT diagram.

Results

Of the 143 potential patients, 34 were unable to continue on the ERAS pathway for reasons documented below (Table II). This left 109 patients (110 joints) who adhered to the ERAS protocol.

The pilot programme ran from May 2019 to December 2019, and during this time one patient in the ERAS group was identified as a significant outlier; this patient experienced two prolonged inpatient admissions in the follow-up period, lasting a total of 64 days. This patient was removed from statistical analysis, along with the matched control, leaving 100 matched pairs for statistical analysis. The patient matching process is summarised below (Figure 2).

The baseline characteristics of the two matched cohorts are summarized in Table III. The mean ages of patients in the ERAS and matched cohorts were 65.75 years (standard deviation (SD) 10.98) and 65.98 years (SD 10.22), respectively, with equal numbers of females in each group (63 patients; 63%). However, 15 (15%) of the ERAS cohort were ASA grade 3 compared to just four (4%) in the matched cohort. A post hoc two-sample test of proportions confirmed this difference was statistically significant

Table III. Patient demographics.

Variable	ERAS (n = 100)	Matched control (n = 100)
Sex, n		
Female	63	63
Male	37	37
Age, yrs, mean (SD; range)	65.75 (10.98; 31.46 to 86.35)	65.98 (10.22; 31.95 to 85.23)
ASA grade, n		
1	8	1
2	77	95
3	15	4
Joint, n		
Primary hip	40	40
Primary knee	60	60

ASA, American Society of Anesthesiologists; ERAS, enhanced recovery after surgery; SD, standard deviation.

($p = 0.008$). In each cohort, 40 patients (40%) underwent primary total hip arthroplasty, and 60 patients (60%) underwent primary total knee arthroplasty.

At the time of the preadmission phone call, an orthopaedic nurse explained to the patients what to expect postoperatively and the level of care that was available

Table IV. Health service use over 30 days.

Service	ERAS (n = 100)			Matched control (n = 100)			Mean difference (95% CI)
	Patients, n	Events, n	Mean (95% CI)	Patients, n	Events, n	Mean (95% CI)	
LOS primary admission, days	100	159	1.59 (1.14 to 2.04)	100	301	3.01 (2.56 to 3.46)	-1.42 (-2.06 to -0.78)
Readmissions	6	6	0.06 (0.02 to 0.10)	4	4	0.04 (-0.00 to 0.08)	0.02 (-0.04 to 0.08)
Readmission, days	6	20	0.2 (0.04 to 0.36)	4	7	0.07 (-0.09 to 0.23)	0.13 (-0.09 to 0.35)
ED attendances	11	15	0.15 (0.04 to 0.26)	11	19	0.19 (0.08 to 0.30)	-0.04 (-0.19 to 0.11)
Doppler	7	8	0.08 (0.02 to 0.14)	6	7	0.07 (0.01 to 0.13)	0.01 (-0.07 to 0.09)
CTPA	1	1	0.01 (-0.02 to 0.04)	5	5	0.05 (0.02 to 0.08)	-0.04 (-0.09 to 0.01)
GP out-of-hours	9	11	0.11 (0.03 to 0.19)	7	10	0.1 (0.02 to 0.18)	0.01 (-0.10 to 0.12)

CI, confidence interval; ED, emergency department; ERAS, enhanced recovery after surgery; LOS, length of stay.

Table V. Health service use over 90 days.

Service	ERAS (n = 100)			Matched control (n = 100)			Mean difference (95% CI)
	Patients, n	Events, n	Mean (95% CI)	Patients, n	Events, n	Mean (95% CI)	
Readmissions	8	9	0.09 (0.04 to 0.14)	4	4	0.04 (-0.01 to 0.09)	0.05 (-0.02 to 0.12)
Readmissions, days	8	28	0.28 (0.10 to 0.46)	4	7	0.07 (-0.11 to 0.25)	0.21 (-0.05 to 0.47)
ED attendances	21	35	0.35 (0.18 to 0.52)	17	36	0.36 (0.19 to 0.53)	-0.01 (-0.24 to 0.22)
Doppler	12	17	0.17 (0.08 to 0.26)	9	13	0.13 (0.04 to 0.22)	0.04 (-0.09 to 0.17)
CTPA	3	3	0.03 (-0.01 to 0.07)	5	5	0.05 (0.01 to 0.09)	-0.02 (-0.07 to 0.03)
GP out-of-hours	12	14	0.14 (0.05 to 0.23)	10	14	0.14 (0.05 to 0.23)	-0.00 (-0.12 to 0.12)

CI, confidence interval; ED, emergency department; ERAS, enhanced recovery after surgery; LOS, length of stay.

from social services. None of the ERAS patients considered they would need additional care following discharge. In the matched control, eight patients (8%) requested a discussion with a social worker after their surgery. In all, six of the eight patients (75%) that requested social services had their discharge delayed, awaiting social services input. Only one patient received additional care from social services following discharge.

Hospital use for patients in the inpatient and 30-day and 90 -day postoperative periods is presented in Tables IV and V. Mean LOS for the ERAS patients was 1.59 days (1.14 to 2.04). This was a significant reduction when compared with the matched cohort (mean LOS 3.01 days; 95% CI 2.56 to 3.46). At the 30 -day postoperative time point, there was no significant increase in the number of readmissions for the ERAS patients when compared with the matched control (six readmissions vs four readmissions). Of the six readmissions in the ERAS cohort, one patient was ASA grade 3, and the rest were ASA grade 2. All readmitted patients in the matched cohort were ASA 2. There were 15 ED attendances for the ERAS cohort (11 patients), and 19 for the matched cohort (11 patients), at the 30 -day point. Of the 11 ERAS patients, nine were ASA grade 2 and two were ASA grade 3. In the matched cohort, all patients were ASA grade 2. Patients in the matched control group underwent five calculated tomography pulmonary angiograms (CTPAs) in the early postoperative period, compared with one in the ERAS cohort.

At 90 days following the index procedure, there was again a statistically non-significant increase in the number of readmissions in the ERAS group compared with the matched cohort. There were nine readmissions (eight patients) in the ERAS cohort, compared with still four readmissions in the matched cohort. Of the readmitted ERAS patients, one was ASA grade 3, and the rest were ASA grade 2. All readmitted patients in the matched cohort were ASA grade 2. In addition, although there were similar numbers of ED attendances in both groups (35 vs 36); this consisted of 21 patients in the ERAS group, compared to 17 in the matched cohort. Of the 21 ERAS patients, three were ASA grade 3, 17 were ASA grade 2, and one was ASA grade 1. By comparison, for the 17 in the matched group, 16 were ASA grade 2, and one was ASA grade 3.

Of the 21 ERAS patients attending ED within the 90 -day period, three (14%) had negative CTPA scans for suspected pulmonary embolus, and 12 (57%) negative Doppler scans for suspected deep vein thrombosis (DVT). In the matched cohort, five patients (29%) had CTPA in the 90 -day postoperative period (four negative, one positive), and nine (53%) had negative Doppler scans.

Reasons for all readmissions up to 90 days were varied and have been summarized below by groups, along with the associated LOS (Table VI).

In total, 109 preoperative phone calls were made to the patients in the ERAS cohort. The mean duration of call was 37.6 minutes (SD 9.7). Postoperatively, 73 patients

Table VI. Reasons for readmissions and associated length of stay by group.

Diagnosis for readmission	ERAS	Matched control
	Length of stay, days	
Chest pain	1	N/A
Suspected thrombosis	1	N/A
Multifactorial delirium and LRTI	4	N/A
Anaemia of chronic disease	1	N/A
Pleurisy secondary to LRTI	3	N/A
PR bleeding secondary to enoxaparin	1	N/A
AKI secondary to obstructive uropathy	8	N/A
Hospital-acquired pneumonia	5	N/A
Unresolved LRTI	4	N/A
Localized swelling, mass, and lump, lower limb	N/A	1
Leg pain and urinary tract infection	N/A	4
Pulmonary embolism	N/A	1
Mechanical fall	N/A	1

AKI, acute kidney injury; ERAS, enhanced recovery after surgery; LRTI, lower respiratory tract infection; N/A, not applicable; PR, per rectum.

Table VII. Costs (£) of health service use over 90 days for hip and knee patients.

Service	ERAS (n = 100), mean (95% CI)	Matched control (n = 100), mean (95% CI)	Mean difference (95% CI)
Primary admission including joint arthroplasty, days	4,590.07 (4,314.33 to 4,865.81)	5,460.53 (5,184.79 to 5,736.27)	-870.46 (-1,260.41 to -480.51)
Readmission, days	154.00 (53.89 to 254.11)	38.50 (-61.61 to 138.61)	115.50 (-26.0 to 257.07)
ED attendances	73.50 (38.70 to 108.30)	75.60 (40.80 to 110.40)	-2.10 (-51.31 to 47.11)
Doppler	13.60 (6.21 to 20.99)	10.40 (3.01 to 17.79)	3.20 (-7.25 to 13.65)
CTPA	5.10 (-1.50 to 11.69)	8.50 (1.91 to 15.09)	-3.40 (-12.73 to 5.93)
GP out-of-hours	12.74 (4.87 to 20.61)	12.74 (4.87 to 20.61)	-0.00 (-11.13 to 11.13)
Total cost	4,849.01 (4,535.27 to 5,162.75)	5,606.27 (5,292.53 to 5,920.01)	-757.26 (-1,200.96 to -313.56)
Total cost adjusted for sex, consultant, joint, and age	4,852.52 (4,541.23 to 5,163.81)	5,602.76 (5,291.47 to 5,914.05)	-750.25 (-1,190.49 to -310.00)

CI, confidence interval; CTPA, calculated tomography pulmonary angiogram; ERAS, enhanced recovery after surgery.

made a total of 181 phone calls to the ERAS helpline. These calls had a mean of 8.2 minutes (SD 3.3) in duration. Of these phone calls, 89.5% were made within three months of surgery.

The primary inpatient cost was, on average, £870.46 (£-1,260.41 to -£480.5) less for the ERAS patients than the matched control (Table VII). The initial cost saving was offset by the slightly higher propensity for postoperative readmission, and increased LOS for readmissions in the ERAS group. The mean total cost of total joint arthroplasty, including readmission and complications, in the ERAS cohort was £4,849.01 (95% CI £4,535.27 to £5,162.75). The corresponding cost per joint arthroplasty in the matched control was £5,606.27 (95% CI £5,292.53 to £5,920.01). This gives an overall cost saving per joint arthroplasty of £757.26 (95% CI £-1,200.96 to £-313.56). When figures were adjusted for baseline characteristics, the total cost saving per patient was £750.25 (95% CI £-1,190.49 to £-310.00).

Discussion

With an increasing focus on efficiency within the UK NHS, the ERAS pathway represents an important strategy for the future of primary joint arthroplasty. Our results show a reduction in LOS postoperatively from three days to 1.6 days, a mean improvement of 1.4 bed days (-2.06 to -0.78) per patient. The median length of admission was one day for the ERAS cohort (interquartile range (IQR) 1 to 2), and two days for the matched cohort (IQR 1 to 3). Prior to the pilot, we had no preadmission discharge planning. In the ERAS cohort, none of the patients requested or received additional care. In comparison, eight patients in the matched group requested social services, only one of which received additional care following discharge. Referral to social services as an inpatient frequently results in a discharge delay. In a previous publication,⁷ we demonstrated that postoperative involvement of social services accounted for 49.2% of our excess bed days. We

conclude that absence of preadmission discharge planning has a major impact on prolonged LOS. This must be addressed in any successful ERAS programme.

Within 90 days of surgery, there were similar numbers of ED attendances in both cohorts (35 vs 36), but unexpectedly there were more patients in the ERAS cohort (21 vs 17). Of the 21 ERAS patients, three had negative CTPA scans for suspected pulmonary embolus and 12 had negative Doppler scans for suspected DVT. This was roughly equivalent to the matched cohort, in which five patients underwent CTPA and nine patients underwent Doppler scans. Although we had a helpline for the patients at the time of the ERAS pilot, critically we failed to create guidelines for the staff taking the calls. Thus, patients with leg swelling were often advised to attend ED, where, based on the commonly used Well's score,⁹ patients must have a Doppler scan to exclude DVT. Furthermore, according to NICE guidance,¹⁰ anyone with a negative scan should have it repeated and five of the 12 ERAS patients with a negative scan had a repeat negative Doppler scan. Subsequently, local guidelines have changed, such that if

unilateral leg swelling improves after a four-hour period of elevation, a Doppler scan is not indicated and also a negative Doppler scan does not need to be repeated.

Previous studies have shown that ERAS protocols can reduce the rate of medical complications in the early postoperative period.¹¹ While a shorter inpatient stay is indicative of fewer inpatient complications, there was no significant impact on ED attendances or readmissions in the early postoperative period, which is largely similar to previous studies in our unit.¹²

Prior to the ERAS pilot, local practice was to admit 50% of patients the day before surgery. Local obstacles to change included custom and practice, as well as the absence of routine preadmission consent clinics. Such clinics have been associated with significant reductions in medicolegal claims.¹³ For this pilot, these clinics were also timed to coincide with nursing, physician, and pharmacist consultations, which were all completed prior to admission. Going forward in the post-COVID-19 era, the local plan is to make these consultations virtual, which will be more convenient for the patient and will abolish logistical issues around scheduling.

Limitations. There are limitations to this service evaluation. The patients involved in the ERAS pathway were selected according to the inclusion criteria detailed earlier and were matched systemically in order to reduce bias and allow comparison between groups. Prior to the introduction of the ERAS protocol, very few ASA grade 3 patients were admitted on the day of surgery. A potential bias was only including day of surgery admissions in the matched cohort; this necessitated the matching of ASA grade 3 ERAS patients with less comorbid matched patients. Therefore, there were significantly more ASA grade 3 patients in the ERAS cohort. However, the proportion of ASA grade 3 patients in the ERAS cohort is more consistent with that reported in the UK National Joint Registry (NJR),¹⁴ and is therefore representative of a typical arthroplasty population. Also, elderly and frail patients have been shown to benefit the most from ERAS protocols.²

It is important to note that effective implementation of ERAS is not without cost. Patient education and communication in the perioperative period are critical to successful outcomes. These services need to be adequately resourced to be effective. Helplines are labour and time intensive, and having learned from our ERAS pilot, staff require appropriate guidelines. Staffing costs associated with the ERAS helpline have not been included in the cost analysis. Inside and outside normal working hours, the helpline was run by the ward staff and advanced clinical practitioners, respectively, with no additional resource required because of the small pilot numbers. This does represent a real expense that should be taken into account when designing an effective ERAS pathway. However, we anticipate that these costs should be offset by savings elsewhere in the ERAS

pathway. Potentially, ERAS protocols could lead to both increased patient throughput and reduced costs through bed closures. The latter would allow ward staff to provide care in a more virtual environment post-COVID-19.

In summary, this ERAS pilot resulted in cost savings by reducing LOS without compromising on patient safety. The cost savings applied to a population of arthroplasty patients who were similar demographically to the UK arthroplasty population as a whole, as evidenced in the NJR. Therefore, these findings should be generalizable to arthroplasty populations in other units. However, to be effective, we need to invest in quality preparation prior to admission and have appropriate guidelines post discharge to reduce an unnecessary burden on ED. Pre-admission discharge planning should be mandatory in an elective care setting.



Take home message

- Enhanced recovery programmes can reduce length of stay and costs without compromising patient safety.
- Pre-admission discharge planning should be mandatory in an elective care setting.

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- J. C. Hill: Conceptualization, Methodology, Resources, Writing - review and editing.
- A. Agus: Data curation, Formal analysis, Writing - review and editing.
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- D. Beverland: Conceptualization, Methodology, Supervision, Writing - review and editing.

Funding statement:

- Although none of the authors has received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article, benefits have been or will be received but will be directed solely to a

research fund, foundation, educational institution, or other non-profit organization with which one or more of the authors are associated.

ICMJE COI statement:

- A. Agus declares that the Northern Ireland Clinical Trials Unit received funds from the Trauma & Orthopaedics Research Charity (TORC) for involvement in the design and analysis of the study, which is related to this work. D. Beverland reports consultancy, payment for lectures (including service on speakers bureaus) and payment for development of educational presentations from DePuy International, all of which is unrelated to this article.

Open access funding:

- The authors report that they received open access funding for this manuscript from Trauma and Orthopaedics Research Charity (www.torcni.org).

Acknowledgements:

- The authors would like to thank the Belfast Arthroplasty Research Trust (BART) and the staff of Musgrave Park Hospital, Belfast, Northern Ireland, for their help and support.

Ethical review statement:

- This work evaluates a service improvement programme; therefore, formal ethical approval was not required.

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