



RATeS (Re-Admissions in Trauma and Orthopaedic Surgery): a prospective regional service evaluation of complications and readmissions

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Abstract

Introduction All the surgeries carry risks, which may lead to readmission at a later date. At present, there is limited Trauma and Orthopaedic (T&O) specific data in the literature. As a result, a prospective regional service evaluation aimed to discover the current complication and readmission rates across all T&O procedures and identify any factors associated with these outcomes.

Methods Data were collected at six sites across Yorkshire and Humber for all T&O procedures during October 2016. Patient demographics and procedure-specific data were collected. Post-operative complications and length of stay were recorded. All the patients were then followed up for 30 days post-discharge to determine if they experienced complications which resulted in readmission and further surgical intervention.

Results 1411 patients having a total of 64 operations were recorded with 1391 completing follow-up (98.5%). Overall in-patient complication rate was 8.4% with the readmission rate being 4.4%. An ASA grade of three or more was found to be associated with readmission. Procedure-related factors such as the use of VTE prophylaxis and prophylactic antibiotics, as well as the elective nature of certain operations were negatively associated with readmission. The largest subgroup of patients was those undergoing total hip (THR) or knee replacements (TKR). For these 234 patients, the readmission rate for TKR and THR being 3.77% and 3.13%, respectively.

Conclusions This large, multi-centre project describes readmission rates following trauma and orthopaedic surgery. In the presented study, the elective nature of the procedure was associated with a reduced risk of readmission.

Keywords Trauma and orthopaedics · Readmission · Outcome · Morbidity · Mortality

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Introduction

Surgery is not risk free; there are inevitably complications, and some of these may lead to unplanned readmission to hospital. Complications may be unexpected, but some are expected outcomes in a proportion of patients undergoing a particular procedure [1].

Readmission after surgical procedures presents a challenge both for surgical units and patients. Readmission might entail further investigation, re-operation or other forms of treatment. The detriment to the patient is clear. There is also additional burden to the treating hospital. In the United Kingdom (UK), the trust receives no remuneration from commissioners for a readmission within 30 days of discharge [2]. This has a small impact where the patient can be discharged the same day, but the financial penalty will be relatively greater where the patient requires admission,

diagnostics or further intervention. In addition to this, readmissions consume resources such as beds and diagnostic facilities. Methods for avoiding readmission include written information and the use of open appointments [3]; however post-operative problems are inevitable and in an ideal world the majority would be managed on an outpatient basis with the minority requiring in-patient management.

Department of Health statistics show that the emergency readmission rates for all the specialties within 30 days of discharge in 2010–2011 were 11.6% [4]. The literature contains studies which have identified some factors associated with readmission following surgical procedures. These include urgent procedures, and patient factors including deprivation. Previous studies have been based in single centres, single operations or used retrospective data. The predictive value of readmission models derived from a single centre has recognised limitation as it is difficult to untangle institutional factors from factors related to the disease. It is also difficult to accurately assess which readmissions are avoidable as subjective criteria are frequently used, which may be unreliable [5].

The rationale for this service evaluation is that there is no prospective work on readmissions within trauma and orthopaedic (T&O) surgery within the UK which is generalisable. This is a clear gap in the literature as T&O covers approximately 25% of all the surgical interventions, and according to the National Joint Registry there were over 80,000 total hip replacements (THR) or revisions and over 90,000 total knee replacements (TKR) or revisions in the UK in 2012/13 [6]. This evaluation was based on six centres across Yorkshire and the Humber. Data were collected on all the patients undergoing emergency or elective T&O surgery within a month identified from operating theatre management systems, excluding those involved in polytrauma. The range of participating centres allows for comparison of readmission rates across a region and establishment of a standard against which to compare unit performance.

The aim of this study was to identify the rates of readmissions and complications following T&O procedures.

Methods

This study is reported in line with STROBE guidance [7]. As this was a multi-centre service evaluation, patient consent was not required. Clinical and information governance approvals were obtained for each participating site. Hospitals across the Yorkshire and Humber region were invited to participate. Teams were formed at each site consisting of medical students, junior doctors and a supervising consultant.

Patients eligible for inclusion were identified by the site teams on a daily basis from T&O operating theatre systems, including those patients attending for day surgery and

excluding polytrauma patients. To reduce risk of selection bias, all the eligible patients were included. Information about initial admission was then recorded within a standardised spreadsheet provided by the steering committee.

The study was conducted in two phases: identification and follow-up. The identification phase ran through October 2016; it highlighted those who underwent elective and emergency T&O procedures. The procedures were defined as operations undertaken by T&O surgeons, including (but not limited to) trauma, arthroplasty, osteotomy and arthroscopy. Data recorded included date of operation, gender, age, and post-code [allowing collection of English Index of Multiple Deprivation Score (IMD)] [8]. This score indicates level of deprivation based on geographical area, with lower decile numbers indicating a higher level of socioeconomic deprivation. The presence of medical conditions such as diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD) and ischaemic heart disease (IHD) was also noted. Admission-specific data were documented, including National Confidential Enquiries into Perioperative Deaths (NCEPOD) classification of procedure, High Dependency Unit (HDU)/Intensive Treatment Unit (ITU) length of stay, complications and overall length of stay. The follow-up phase consisted of following the patients for 30 days post-discharge via electronic patient record systems, identifying complications (defined as “any deviation from the normal post-operative course [9]”) and readmissions after their initial hospital stay. Planned admissions for two-stage procedures were not captured.

Outcomes

The primary outcome of this study was readmission. These were identified via the 30-day post-discharge follow-up; of these, unavoidable unplanned readmissions were identified. Secondary outcomes were complications, length of stay, higher care admissions and further intervention(s). Data collection continued at each site until at least 95% of the cases had been followed up to 30 days post-discharge.

Data collection

Data were pseudoanonymised, with the key held at the participating unit and were returned through a secure online REDCap server hosted at the University of Sheffield [10].

Analysis

Demographics were analysed using basic descriptive statistics to enable comparison with similar studies. Univariate analysis identified patient and operative factors associated with readmission. Significance was set at $p=0.05$ a priori.

Results

Sites

Six sites participated in data collection. These were spread across Yorkshire and the Humber region and included four district general hospitals (DGHs) and two major trauma centres (MTCs), with the numbers of beds at each unit ranging from 500 to 1900. Of these sites, one of the MTCs and one of the DGHs had specialists in orthopaedic spinal surgery.

Demographics

A total of 1411 patients were identified during the initial study period. Follow-up data were available for 1391 patients (98.5%). Of these, 31 (2.2%) patients underwent more than one operation in the study period. The baseline characteristics of the total study population are shown in Table 1. In total, 64 types of operation were performed (Fig. 1; Table 2). The full list of operations can be seen in online Appendix. Admission, injury and procedure-specific data were collected. This included the use of intraoperative antibiotics and in-patient VTE prophylaxis such as low-molecular weight heparin according to each trust's protocol.

All patient complications and readmissions

Readmission and complication rates are summarised in Figs. 2 and 3 (full data in Online appendix). Across all the patients within this study, the overall in-hospital

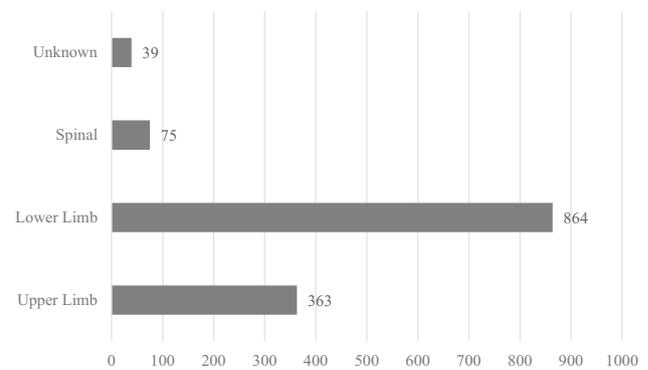


Fig. 1 Operation frequency by anatomy

complication rate was identified as 8.4%. Complications were observed in 117; of these, 45 were complications commonly discussed and documented during the operation consent process (e.g., infection).

During their stay, 30 patients returned to theatre for further unplanned procedures (2.2%). Fourteen patients died during their initial admission; the most common cause of death was sepsis secondary to hospital acquired pneumonia (1.0%).

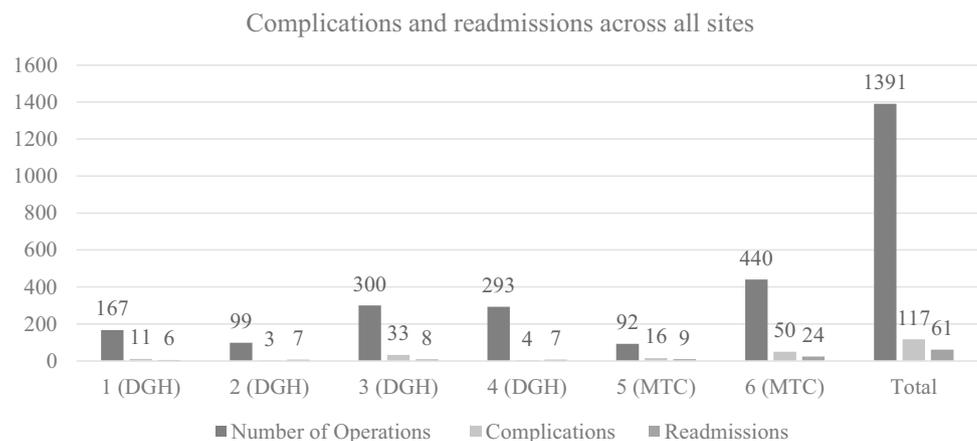
Following discharge, 61 patients were readmitted (4.4%), and 58 were unplanned, e.g., infection (4.2%).

Table 1 Baseline characteristics of the study population. Categorised by trauma and elective procedures

			Trauma	Elective	Total
Total (%)			483 (34.7)	908 (65.3)	1391 (100)
Age	Mean and SD		59.88 ± 22.5	57.7 ± 16.9	58.5 ± 19.0
Male	Number (%)		244 (50.5)	435 (47.9)	687 (48.7)
IMD	1–2	Mean	1.3	1.3	1.3
	3–5	Mean	3.8	3.9	3.9
	6–8	Mean	6.9	6.9	6.9
	9–10	Mean	9.4	9.3	9.3
	Overall	Mean ± SD	4.45 ± 2.8	4.5 ± 2.9	1.9 ± 0.8
ASA grade	≤ 2	Number (%)	309 (72.0)	649 (71.4)	958 (68.1)
	≥ 3	Number (%)	120 (24.8)	133 (14.7)	253 (18.0)
	Unknown	Number (%)	54 (11.2)	126 (13.9)	196 (13.9)
DM	Number diagnosed (%)		51 (11.8)	112 (12.3)	143 (10.2)
COPD	Number diagnosed (%)		35 (7.2)	49 (5.4)	84 (6.0)
IHD	Number diagnosed (%)		77 (15.9)	137 (15.1)	214 (15.2)
Smoking status	Current	Number (%)	44 (9.1)	77 (8.5)	121 (8.6)
	Ex-smoker	Number (%)	15 (3.1)	61 (6.7)	76 (5.4)
	Non-smoker	Number (%)	197 (40.8)	315 (34.7)	512 (36.4)
	Unknown	Number (%)	225 (46.6)	449 (49.4)	674 (47.9)

Table 2 Summary of all the complications and readmissions across all the procedure subgroup

	Number of procedures (% of all the procedures)	Number of complications in subgroup (% of all the complications)	Number of readmissions in subgroup (% of the readmissions)
Arthroscopy	174 (12.5%)	1 (0.9%)	6 (9.8%)
Lower limb amputations	2 (0.1%)	0 (0.0%)	0 (0.0%)
Nerve decompression	68 (4.9%)	1 (0.9%)	0 (0.0%)
Oncology/infection	77 (5.5%)	11 (9.4%)	4 (6.65)
Other	176 (12.7%)	1 (0.9%)	2 (2.2%)
Primary partial arthroplasty	24 (1.73%)	2 (1.7%)	0 (0.0%)
Primary total arthroplasty	259 (18.6%)	23 (19.7%)	8 (13.1%)
Secondary or tertiary partial arthroplasty	7 (0.5%)	0 (0.0%)	0 (0.0%)
Secondary or tertiary total arthroplasty	50 (3.6%)	10 (8.5%)	4 (6.65)
Spinal	65 (4.7%)	2 (1.7%)	1 (1.6%)
Trauma	487 (35.0%)	66 (56.4%)	34 (55.7%)
Upper limb amputations	2 (0.1%)	0 (0.0%)	0 (0.0%)
Total	1391 (100%)	117 (100%)	61 (100%)

Fig. 2 Complications and readmissions across all the sites (DGH district general hospital, MTC major trauma centre)

Factors associated with readmission across all the patients

Patient factors

Table 3 shows the patient demographics for those with readmissions. Readmissions were significantly associated with an ASA of three or more.

Operative factors

In this study, the use of antibiotic and VTE prophylaxis was associated with an increased rate of readmission. This is likely due to operation-specific confounding factors, such as the individuals receiving them already having a high risk of post-operative VTE and infection, e.g., previous VTE or contaminated wounds. The elective nature of the procedure was found to be associated with statistically significant

reduced risk of readmission. Table 4 shows the operative factors for those with readmissions.

Total hip and knee replacements

In this dataset, the greatest proportion of operations was elective THR or TKR, 7.6% and 9.2%, respectively. The demographics of this population can be seen in Table 5. General anaesthesia was used for 96 (41%) patients and spinal anaesthesia for 138 (59%). The mean (SD) length of stay was 6.14 (5.28) days.

Complications

In the post-operative period, there were 26 different complications in total across both THR and TKR (Fig. 4). For patients undergoing THR, four had post-operative

Fig. 3 Demonstration of complications and readmissions for all procedures

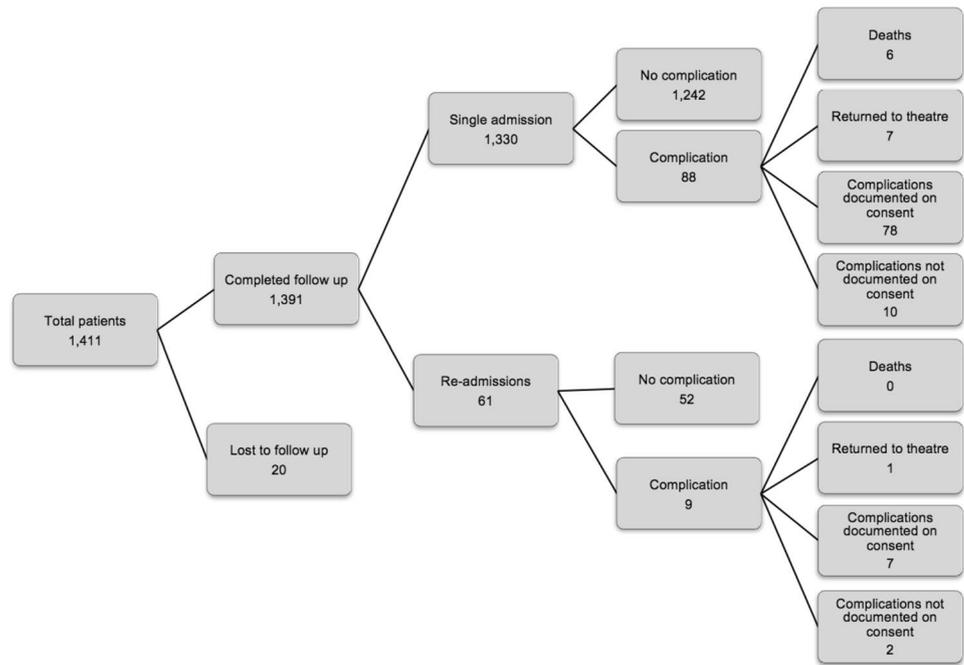


Table 3 Patient factors and relationship to readmission, significance assessed using Chi-square

Baseline factor	Proportion of patients with factor readmitted	Proportion of patients without factor readmitted	Odds ratio (95% CI)	P value
Male	32 (52.5%)	29 (47.7%)	1.16 (0.6968–1.9474)	0.56
ASA > 3	19 (31.1%)	26 (42.6%)	2.91 (1.5836–5.3496)	<0.05
COPD	6 (9.8%)	54 (88.5%)	1.75 (0.7294–4.1885)	0.21
DM	6 (9.8%)	54 (88.5%)	0.95 (0.4001–2.2427)	0.90
IHD	7 (11.5%)	53 (86.9%)	0.69 (0.3138–1.5610)	0.38

Table 4 Operative factors and relationship to readmission, significance assessed using Chi-square

Operative factor	Proportion of patients with factor readmitted	Proportion of patients without factor readmitted	Odds ratio (95% CI)	P value
Elective	27 (44.3%)	34 (55.7%)	0.40 (0.2403–0.6771)	<0.05
During daytime	61 (100%)	0 (0%)	1.64 (0.0974–27.569)	0.73
Blood transfusion use	3 (4.9%)	58 (95.1%)	2.03 (0.6057–6.8231)	0.25
VTE prophylaxis used	49 (80.3%)	12 (19.7%)	3.10 (1.6389–5.9010)	<0.05
Prophylactic antibiotics used	48 (78.7%)	13 (21.3%)	2.03 (1.0871–3.7793)	<0.05

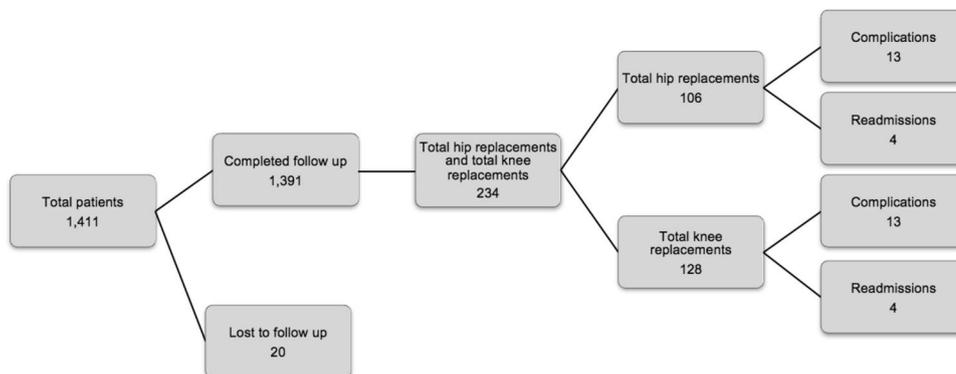
bleeding, three suffered acute kidney injury (AKI), three had infections such as pneumonia, one had a cardiac event and two had other complications such as electrolyte disturbances. For patients undergoing TKR, one had post-operative bleeding, six suffered AKI, two had infections, one had a cardiac event, two had neurological complications, and one had pain uncontrolled by analgesia. The demographics of these patients are summarised in Table 6.

Readmission

Following discharge, eight THR/TKR patients were readmitted, with four from each subgroup (Fig. 4). Of the eight readmissions, five were deemed to be avoidable and three unavoidable (reasons unrelated to initial admission, e.g., other medical conditions). Of the four THR patients, three were readmitted due to infection and one for unrelated medical conditions. For those who had had a TKR, two readmissions

Table 5 Baseline characteristics of all the patients undergoing elective hip and knee surgery

			Total hip replacement	Total knee replacement	Total
Total (%)			106 (45.3)	128 (54.7)	234 (100.0)
Age	Mean and SD		67.47 ± 12.7	68.47 ± 8.7	67.97 ± 10.7
Male	Number (%)		45 (42.5)	49 (38.7)	95 (40.6)
IMD	1–2	Number (%)	37 (34.9)	37 (28.9)	74 (32.1)
	3–5	Number (%)	21 (19.8)	28 (21.9)	49 (21.0)
	6–8	Number (%)	34 (32.1)	41 (32.0)	75 (32.0)
	9–10	Number (%)	13 (12.3)	19 (14.8)	32 (13.9)
	Overall	Mean ± SD	4.58 ± 2.8	4.97 ± 2.9	4.79 ± 2.85
ASA grade	≤ 2	Number (%)	72 (66.7)	78 (71.6)	150 (64.1)
	≥ 3	Number (%)	21 (22.6)	31 (24.2)	52 (22.22)
	Unknown	Number (%)	13 (12.3)	19 (14.8)	32 (13.68)
Diabetes	Number diagnosed (%)		9 (8.4)	16 (12.7)	25 (10.7)
COPD	Number diagnosed (%)		6 (5.7)	7 (5.6)	13 (5.5)
IHD	Number diagnosed (%)		20 (18.9)	25 (19.7)	45 (19.2)
Smoking status	Current	Number (%)	11 (10.4)	7 (5.5)	18 (7.7)
	Ex-smoker	Number (%)	10 (9.4)	12 (9.4)	22 (9.8)
	Non-smoker	Number (%)	43 (40.6)	52 (40.6)	95 (40.2)
	Unknown	Number (%)	42 (39.6)	57 (44.5)	99 (42.3)

Fig. 4 Demonstration of complications and readmissions for elective THR and TKR

were due to VTE and two were because of unrelated medical conditions. The demographics of these readmitted patients can be seen in Table 7. There were no deaths in patients undergoing TKR and THR. Of the patients readmitted, two required further surgical intervention, and the hospital stay for the readmissions ranged from 1 to 55 days.

Discussion

This paper reports the rates of in-hospital complications and readmissions within 30 days of discharge for patients undergoing T&O procedures at six centres across a Yorkshire and Humber region. The complication rate across all the procedures was 8.4% and the readmission rate was 4.4%. This is similar to the 4% readmission rate reported in a recent American study across all the orthopaedic procedures [11].

The only patient factor associated with overall readmission was an ASA grade of 3 or higher. The elective nature of certain operations was negatively associated with readmission. The use of VTE and antibiotic prophylaxis were found to be associated with an increased risk of readmission, but this is likely due to operation-specific confounding factors such as high risk of post-operative VTE and infection.

The largest subgroup of patients in this study underwent THR and TKR. The overall readmission rate for this population was 3.41% (3.77% and 3.13%, respectively). This compares with the UK readmission rates in the literature of 6.2% [12] and 5.9% [13] for THR alone. There is no individual TKR data in the UK literature at present. In comparison, US studies have shown a large variation in 30-day readmission rate, 1.8% [14] to 8.4% [15] for THR and 1.8% [16] to 6.6% [15] for TKR. In this subgroup, COPD was the only patient factor associated with readmission.

Table 6 Demographics of patients with complications

			Total hip replacement	Total knee replacement	Overall total
Total (%)			13 (12.3)	13 (10.2)	26 (11.1)
Age	Mean and SD		72 ± 14	67 ± 11	70 ± 13
Male	Number (%)		5 (38.5)	6 (46.2)	11 (42.3)
IMD	1–2	Number (%)	6 (46.1)	4 (30.8)	10 (38.5)
	3–5	Number (%)	2 (15.4)	0 (0.0)	2 (7.7)
	6–8	Number (%)	4 (30.8)	6 (46.1)	10 (38.5)
	9–10	Number (%)	1 (7.7)	3 (23.0)	4 (15.4)
	Overall	Mean ± SD	3.8 ± 2.7	6 ± 3.0	4.9 ± 3.04
ASA grade	≤ 2	Number (%)	8 (61.5)	7 (53.8)	15 (57.7)
	≥ 3	Number (%)	3 (23.1)	5 (38.5)	8 (30.8)
	Unknown	Number (%)	2 (15.4)	1 (7.7)	3 (11.7)
DM	Number diagnosed (%)		0 (0.0)	1 (7.7)	1 (3.9)
COPD	Number diagnosed (%)		2 (15.4)	1 (7.7)	3 (11.7)
IHD	Number diagnosed (%)		4 (30.8)	3 (23.1)	7 (26.9)
Smoking Status	Current	Number (%)	1 (7.7)	0 (0.0)	1 (3.9)
	Ex-smoker	Number (%)	1 (7.7)	2 (15.4)	3 (11.7)
	Non-smoker	Number (%)	10 (77.9)	5 (38.5)	15 (57.7)
	Unknown	Number (%)	1 (7.7)	6 (46.2)	7 (26.9)

Table 7 Demographics of readmitted patients

			Total hip replacement	Total knee replacement	Overall total
Total (%)			4 (1.70)	4 (1.70)	8 (3.41)
Age	Mean and SD		74.75 ± 4.44	76.25 ± 6.87	72.75 ± 6.51
Male	Number (%)		2 (50.0)	3 (75.0)	5 (62.5)
IMD	1–2	Number (%)	1	3	4
	3–5	Number (%)	0	0	0
	6–8	Number (%)	2	1	3
	9–10	Number (%)	1	0	1
	Overall	Mean (SD)	5.75 ± 2.49	2.75 ± 2.49	4.25 ± 2.09
ASA grade	≤ 2	Number (%)	1 (25.0)	3 (75.0)	4 (50.0)
	≥ 3	Number (%)	1 (25.0)	1 (25.0)	2 (25.0)
	Unknown	Number (%)	2 (50.0)	0 (0.0)	2 (25.0)
DM	Number diagnosed (%)		0 (0.0)	0 (0.0)	0 (0.0)
COPD	Number diagnosed (%)		0 (0.0)	2 (50.0)	2 (12.5)
IHD	Number diagnosed (%)		1 (25.0)	1 (25.0)	2 (25.0)
Smoking Status	Current	Number (%)	0 (0.0)	0 (0.0)	0 (0.0)
	Ex-smoker	Number (%)	0 (0.0)	1 (25.0)	1 (12.5)
	Non-smoker	Number (%)	2 (50.0)	1 (25.0)	3 (37.5)
	Unknown	Number (%)	2 (50.0)	2 (50.0)	4 (50.0)

Our results demonstrated that sex was not a factor associated with readmission and there is no consensus in current literature, with different studies finding readmission rates to be higher in males [17, 18], females [19, 20] and neither sex [11, 21]. We have reported that readmissions across all T&O surgery are associated with older patients and patients with ASA grades of 3 or higher, in

agreement with current literature [11, 13, 18, 20]. This study's reported results on smoking are inconclusive and this is likely due to the data collection quality surrounding patient smoking status. However, the literature recognises smoking to be an important factor associated with complications and readmission for patients undergoing both TKR and THR procedures [22].

Medical comorbidities including diabetes mellitus, COPD and IHD were not shown to be associated with readmissions within our dataset. These conditions have been shown to be recognised risk factors within the current literature, with some studies showing a greater [23–26] and lesser correlation with readmission [27].

In this study we have also shown that some procedure-related factors have an impact on overall readmission. Our results have demonstrated that operations scheduled as elective cases according to the NCEPOD Classification of Intervention were associated with a reduced the risk of readmission [28]. The use of VTE prophylaxis [29] and the use of prophylactic antibiotics [30] were factors associated with a potentially higher rate of readmission. This is likely due to the individuals receiving these being at a higher risk of adverse events, such as open contaminated fractures. This is in direct contrast to the literature.

Of the four THR surgeries which resulted in a complication, three were Surgical Site Infections (SSI); an SSI rate of 1.28% for the combined THR and TKR data set. This compares to a total SSI rate of 0.1% stated by Avram et al. [17]. However, a study in Bristol [31] found that in general surgical procedures SSI rates can be as high as 25%. Due to the nature of data collection in this study, it is likely that the true rates of SSI are lower than 1.28%, with RATEs capturing all patients with a clinical suspicion of infection, not only a confirmed diagnosis. As a result, RATEs represent an opportunity to evaluate specific hospital protocols for SSI reduction, and the findings have been reported to individual sites.

There is no published data exploring the relationship between deprivation, complication and readmission rates within T&O surgery in the NHS to date. The majority of studies investigating 30-day readmissions originate in the USA [32–34]; Martsof et al. [33] used ZIP codes to assess economic status and Keeney et al. [34] used the source of insurance payer (Medicaid vs Commercial carrier) as a deprivation measure. The RATEs authors used the patients' postcodes to determine individual IMD scores [8, 35]. This allowed the correlation between deprivation and increased risk of complications and readmissions to be investigated. However, the RATEs authors have not shown that deprivation quartile has a statistically significant effect on readmission or complication rates. This is contrary to American findings, which show that those of a lower socioeconomic class are at a higher risk of 30-day readmission [32–34].

Due to the small numbers of events, this study has limited generalisability. However, at present, there is some work within the literature to produce predictive tools and questionnaires which can then be used to negate modifiable risks [24, 26]. The use of these may reduce future readmissions rates, both in the UK and USA.

Limitations

Due to there being limited data on readmissions in T&O, we were unable to estimate the sample size required to provide accurate estimates of effect size. There were also limitations related to the follow-up databases, the quality of which varied across sites.

As this was a regional service evaluation, with a number of the sites being in close geographical proximity, there is the potential for patients to attend another site instead of being readmitted by their parent team. For example, within a recent US study, the rate of orthopaedic trauma patient being readmitted to other hospitals was reported as 27.3% [36]. Due to the ethical limitations of the project as a service evaluation, we were not able to confirm with individual patients if this had occurred. As a result, there is a potential for this study to under-report readmission rates.

Strengths

Due to the limited data for T&O procedures, this work not only describes complication, readmission and re-intervention rates, but is also clinically relevant for UK clinicians. It further demonstrates the potential for this method of trainee, collaborative-led retrospective, service evaluations to be transferable to specialties other than general surgery [37]. Despite this study's relative under-powering, the results provide signal of areas where interventions could be targeted to reduce readmissions, for example, higher anaesthetic risk or emergency patients.

Conclusion

RATEs are a step forward in providing low cost and large-scale data to benchmark NHS practice. It is a snapshot of the region's current T&O practice and will generate hypotheses for future research and quality improvement initiatives. RATEs have shown that readmission rates in the region are low, and causes of readmissions such as SSI may be an area for local quality improvement projects.

Recommendations

This study has provided a dataset that the centres involved can analyse for specific concerns, against which they can re-evaluate, specifically in the context of assessing SSI prevention procedures. The authors hope that this study will also encourage other directorates to perform further data

collections to compare to the existing set, and to expand the evidence further.

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