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Financial analysis of revision hip surgery at a tertiary referral centre as classified using the British Hip Society Revision Hip Complexity Classification

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Aims

The burden of revision total hip arthroplasty (rTHA) continues to grow. The surgery is complex and associated with significant costs. Regional rTHA networks have been proposed to improve outcomes and to reduce re-revisions, and therefore costs. The aim of this study was to accurately quantify the cost and reimbursement for a rTHA service, and to assess the financial impact of case complexity at a tertiary referral centre within the NHS.

Methods

A retrospective analysis of all revision hip procedures was performed at this centre over two consecutive financial years (2018 to 2020). Cases were classified according to the Revision Hip Complexity Classification (RHCC) and whether they were infected or non-infected. Patients with an American Society of Anesthesiologists (ASA) grade ≥ III or BMI ≥ 40 kg/m² are considered "high risk" by the RHCC. Costs were calculated using the Patient Level Information and Costing System (PLICS), and remuneration based on Healthcare Resource Groups (HRG) data. The primary outcome was the financial difference between tariff and cost per patient episode.

Results

In all, 199 revision episodes were identified in 168 patients: 25 (13%) least complex revisions (H1); 110 (55%) complex revisions (H2); and 64 (32%) most complex revisions (H3). Of the 199, 76 cases (38%) were due to infection, and 78 patients (39%) were "high risk". Median length of stay increased significantly with case complexity from four days to six to eight days ($p = 0.006$) and for revisions performed for infection (9 days vs 5 days; $p < 0.001$). Cost per episode increased significantly between complexity groups ($p < 0.001$) and for infected revisions ($p < 0.001$). All groups demonstrated a mean deficit but this significantly increased with revision complexity (£97, £1,050, and £2,887 per case; $p = 0.006$) and for infected failure (£2,629 vs £635; $p = 0.032$). The total deficit to the NHS Trust over two years was £512,202.

Conclusion

Current NHS reimbursement for rTHA is inadequate and should be more closely aligned to complexity. An increase in the most complex rTHAs at major revision centres will likely place a greater financial burden on these units.

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Introduction

Total hip arthroplasty (THA) continues to be one of the most common procedures performed in the NHS, with 109,624 procedures recorded in the National Joint Registry (NJR) in 2019 prior to the ongoing COVID-19 pandemic.[1] It is recognized to be one of the most clinically effective and

Table I. The British Hip Society Revision Hip Complexity Classification.[13]

	H1	H2	H3
Acetabular bone loss	Paprosky I or IIA	Paprosky IIB/C Cup retrieval – well-fixed socket (+ lysis)	Paprosky IIIA/B Pelvic discontinuity
Femoral bone loss	Paprosky I	Paprosky II, IIIA	Paprosky IIIB or IV Revision of metaphyseal filling stem
Periprosthetic fracture	UCS A	UCS B1, B2, C or D	UCS B3, E, F
Infection	Non-infected	DAIR or first-time revision	Re-revision Fungal, TB, multi-resistance
Soft-tissues	No abductor compromise	Abductor deficiency	Vascular or plastic reconstruction
Indication	First revision for aseptic loosening	Revision for dislocation	Re-revision for dislocation Revision of endoprosthesis
Patient factors	*suffix applied to denote BMI ≥ 40 kg/m^2 or ASA ≥ III		

ASA, American Society of Anesthesiologists; DAIR, debridement, antibiotics, and implant retention; TB, tuberculosis; UCS, Unified Classification System.

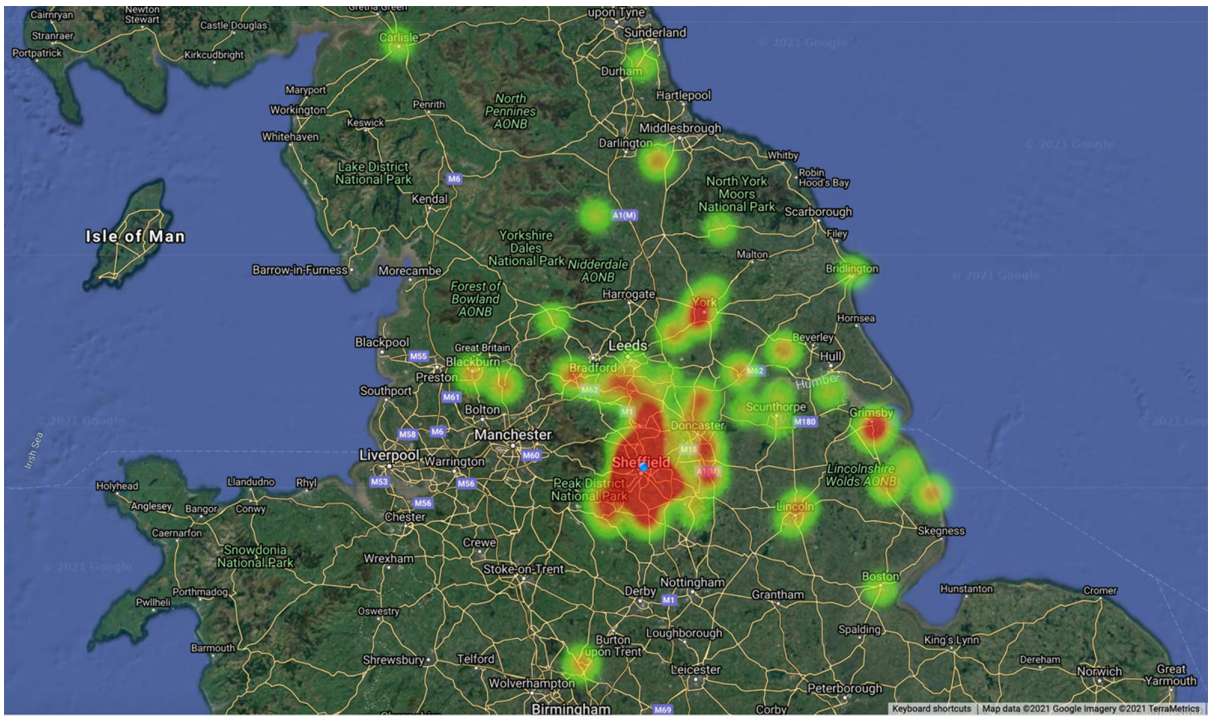

Fig. 1

Heat map depicting density of referrals to our unit.

cost-effective interventions performed based on the criteria set by the National Institute for Health and Care Excellence (NICE).[2]

As a result, revision total hip arthroplasty (rTHA) surgery continues to be a sizeable burden, consistently accounting for 8% of all hip arthroplasty procedures over the last few years.[1] In the USA, the burden of revision hip surgery is expected to double between 2007 and 2026.[3] It is a more complex, technically demanding, and time-consuming intervention,[4] with outcomes and survivorship well below that of the primary intervention.[1,5] Failure of the primary THA may be due to a wide variety of reasons, with the most common being aseptic loosening, infection, periprosthetic fracture, and dislocation. The cost of rTHA surgery is much greater than that of primary surgery owing to the increased theatre time, hospital length of stay (LOS), and implant costs. Additionally, the indication for rTHA also has a direct effect on cost, with infected revision being significantly more expensive than aseptic cases.[6,7] Remuneration in England is currently based on Healthcare Resource Groups (HRG) data, whereby the type of work, as well as the patient's comorbid state, is grossly grouped and assigned a value. From 2019 to 2020, the average remuneration for an elective, "very complex hip procedure for non-trauma" was £13,184 to £23,571, dependent upon comorbid state.[8] But patients requiring rTHA surgery are a very heterogeneous group, and thus categorization in this

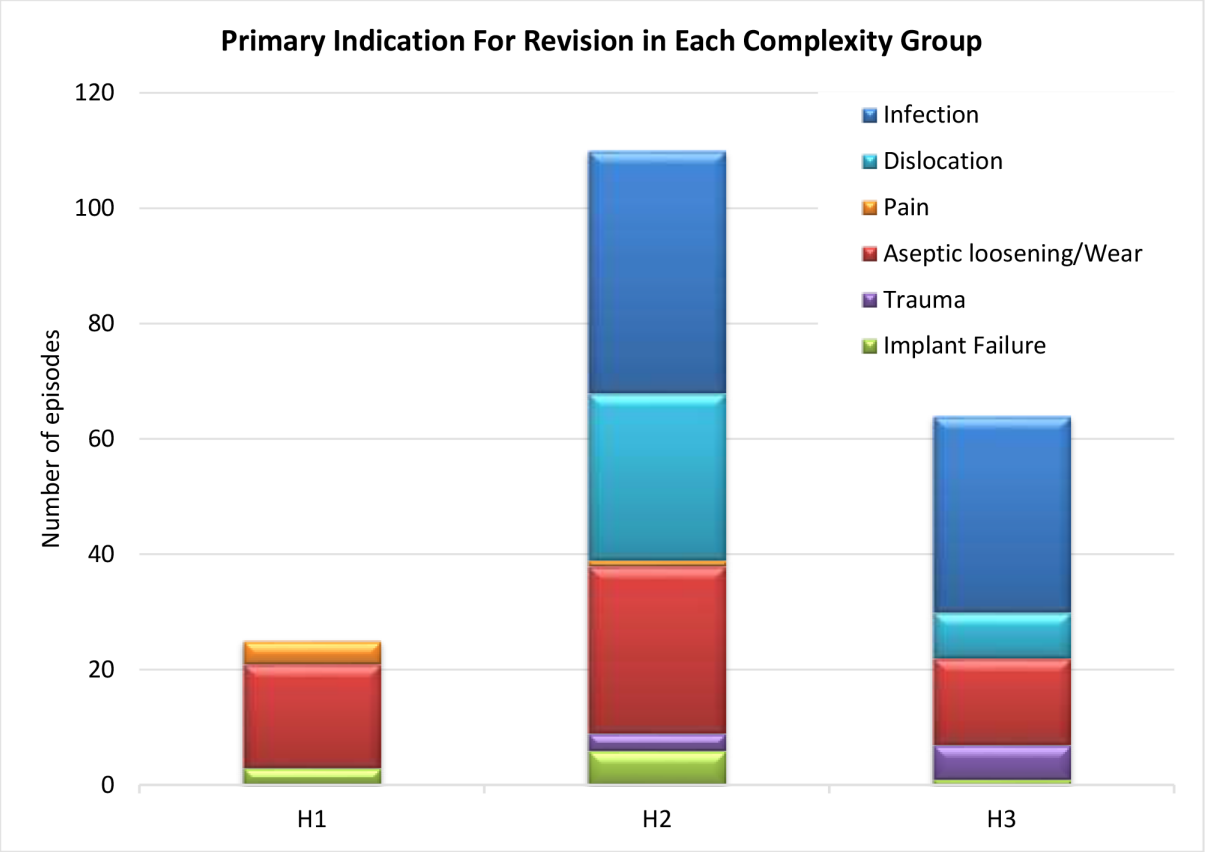

Fig. 2
Primary indication for revision by complexity group.

way is unlikely to truly reflect the cost of providing such specialized services.

In the UK, there is a drive to create regional network systems. Such networks are already well established in the UK in cancer and trauma care, demonstrating improved patient outcomes.[9-11] A three-tier system for revision arthroplasty has been proposed, with the Major Revision Centre (MRC) managing the multidisciplinary team (MDT) meeting, supported by Revision Units (RU) and Primary Arthroplasty Units (PAU). The aim is to ensure that the more complex or low-volume cases are performed by fewer specialist units in order to achieve excellent outcomes for patients, with low complication rates. The potential risk of such a system is that the burden of the more complex, high-risk, and consequently high-cost, work will be borne by the MRC without adequate remuneration. This has been reported previously for revision hip and knee surgery under previous iterations of NHS payment schemes.[6,12]

To help guide triage of patient care to the appropriate unit within the revision network, the British Hip Society (BHS) has proposed a classification system, the Revision Hip Complexity Classification (RHCC) (Table I).[13] This was developed using a modified Delphi method of consensus opinion among experts. The aim is to reflect complexity based upon mechanism of failure, bone loss on both the femoral and acetabular side of the joint (Paprosky Classification),[14,15] and patient factors such as BMI and American Society of Anesthesiologists (ASA) grade. The RHCC classifies patients into three groups of increasing complexity from the relatively simple aseptic loosening (H1), through to the highly complex (H3) situations of the multiply revised patient for infection, dislocation, or complex bone loss. Within each category there is the provision to denote high-risk patients on the basis of BMI ≥ 40 kg/m^2 or ASA grade ≥ III with an asterisk appended (e.g. H3*). The validation work on the RHCC has been completed, demonstrating that the RHCC is reliable in predicting complexity of hip revision.[13]

Methods

A retrospective analysis was performed of all revision hip arthroplasty cases carried out between 5 April 2018 and 5 April 2020, constituting two consecutive financial years. All episodes were identified from prospectively collected data in the unit's comprehensive arthroplasty database. This is a tertiary referral centre for the region and therefore sees a high volume of patients, representing the full

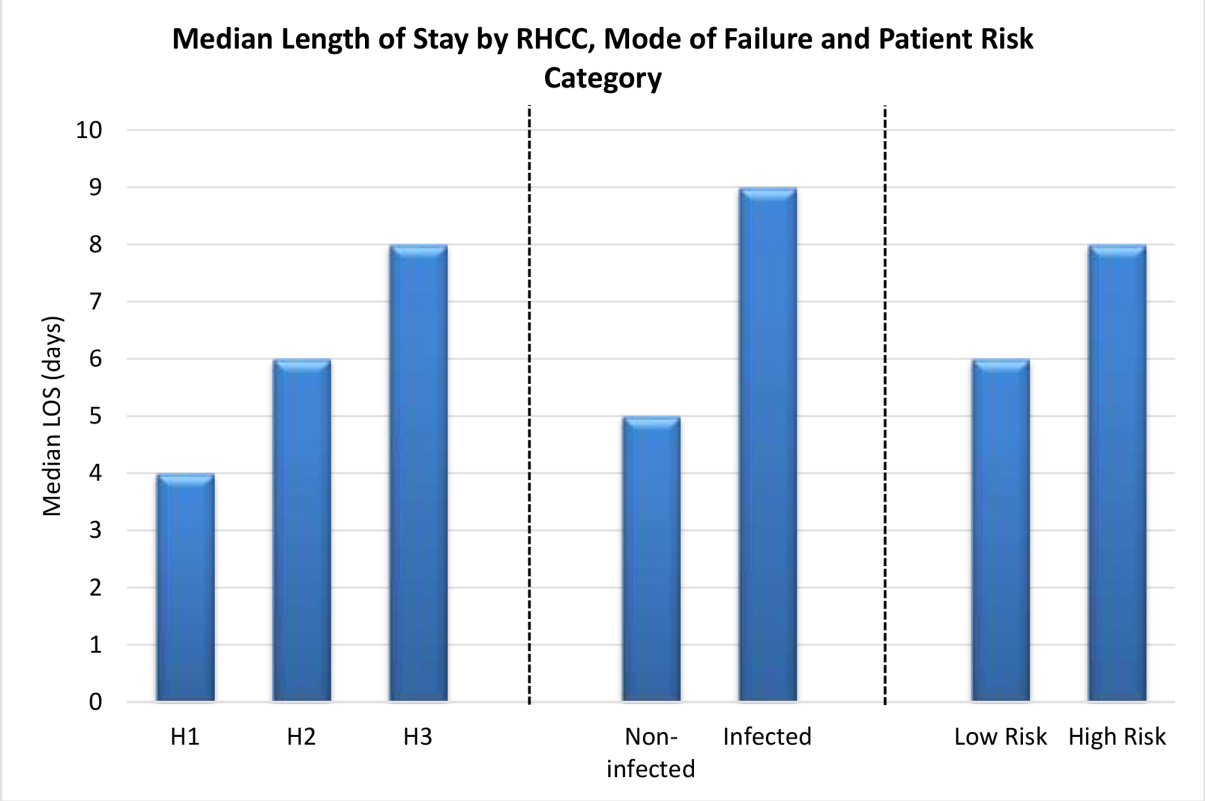

Fig. 3

Median length of stay (days) by Revision Hip Complexity Classification (RHCC), mode of failure, and patient risk category. LOS, length of stay.

spectrum of revision cases from the least to the most complex. As such, the unit also reflects any likely future proposal for a MRC.

Each episode was individually reviewed by the lead authors (DIH, MJP) to ensure that they fit the inclusion criteria of revision hip procedure performed in the reference timeframe, either debridement, antibiotics, and implant retention (DAIR), single-, first-, or second-stage. Exclusions included fixation only of periprosthetic fractures and staged procedures for septic arthritis of native joints. During the review process, the clinical notes were obtained from the electronic patient record (EPR) (Lorenzo EPR Solutions; DXC Technology, USA) to identify basic patient demographics, BMI, comorbidities, ASA grading, and the mode of failure (infected or non-infected). The radiological imaging from the hospital picture archiving and communication system (PACS) was obtained in order to determine the Paprosky Classification of acetabular and femoral bone loss.[14,15] Theatre use data were collected from the Operating Room Management Information System (ORMIS) (DXC Technology).

The complexity of each case was classified using the BHS RHCC (Table I). The RHCC classification takes into account the indication for revision (i.e. aseptic loosening, trauma, infection), as well as the previous history (re-revision), and the complexity of the reconstruction (Paprosky Classification), categorizing the case into one of three groups (H1 to H3) based upon increasing complexity. Further denotation can be applied within each group with an asterisk suffix to reflect the risk profile of the patient themselves based upon BMI ≥ 40 kg/m^2 and ASA grade ≥ III.

The hospital finance department provided the costs based on the Patient Level Information and Costing System (PLICS) and remuneration figures for each of the inpatient episodes based on the HRG codes. These were then analyzed to compare the relative costs between the RHCC groups, infected versus non-infected revisions, and low- versus high-risk patient groups (BMI ≥ 40 kg/m^2 and ASA grade ≥ III). The primary outcome measure was the difference between the cost of provision of the service and the remuneration to the hospital (profit/loss) per patient per inpatient episode.

Statistical analysis. All data were recorded in Excel 365 (Microsoft, USA) and statistical analysis performed using Prism 9.3.1 (GraphPad Software, USA). Non-parametric data are reported as a median with interquartile range (IQR). Statistical significance of differences between the groups was analyzed using Kruskal-Wallis analysis and two-tailed Mann-Whitney U tests. Significance was accepted at a p-value < 0.05.

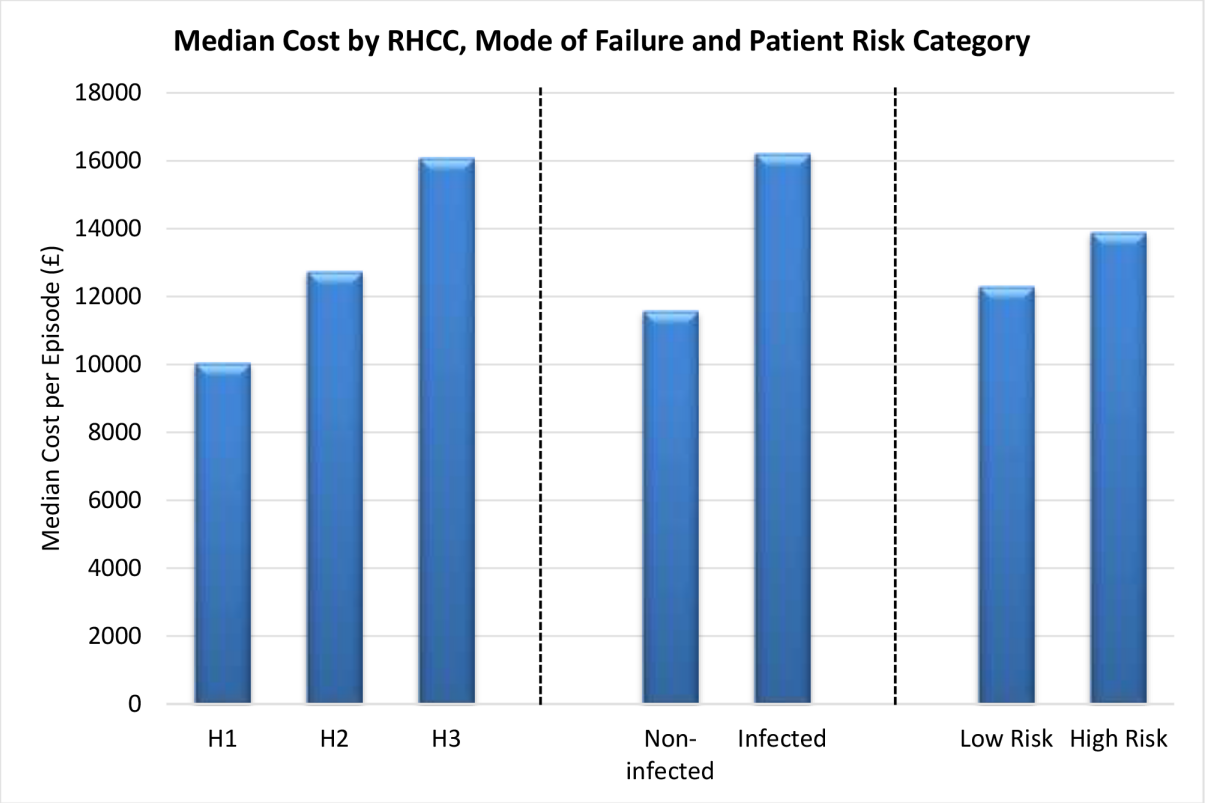

Fig. 4

Median cost based on the Revision Hip Complexity Classification (RHCC), mode of failure, and patient risk category.

Results

Complete demographic, clinical, and financial data were identified for 199 rTHA episodes in 168 patients, during the two consecutive financial years from 2018 to 2020, that met our defined inclusion criteria. There were 95 females (56.5%). The mean age at the time of surgery was 69.7 years (28 to 98). Of the 199 rTHA episodes, 47% had previously undergone primary or revision surgery within this unit. A heat map which depicts our current referral network is shown in Figure 1.

There were a total of 25 episodes (13%) in the H1 group, 110 (55%) in the H2 group, and 64 (32%) in the most complex H3 group. High-risk patients accounted for 78 episodes (39%). Infection was the primary diagnosis in 76 episodes (38%), of which 27 (36%) were second-stage procedures. For the infection group, 42 (55%) were H2 and 34 (45%) were H3 complexity groups. The remaining 123 episodes (61.8%) were non-infected due to all other causes including wear and aseptic loosening (n = 62, 50%), dislocation (n = 37, 30.1%), implant failure (n = 10, 8.1%), trauma (n = 9, 7.3%), and pain (n = 5, 4.1%). The indications for revision in each group are presented in Figure 2.

The median LOS demonstrated a significant increase between complexity groups: H1 (4 days, IQR 3 to 9); H2 (6 days, IQR 4 to 11); and H3 (8 days, IQR 4 to 17) ($p = 0.006$). The LOS also significantly increased in the infected group compared with the non-infected group (9 (IQR 6 to 15) vs 5 days (IQR 3 to 11), respectively, $p < 0.001$) and low- versus high-risk patient groups (6 (IQR 3 to 11) vs 8 (IQR 4 to 15), respectively, $p = 0.044$) (Figure 3).

The median total cost per episode of all rTHAs over the two financial years was £13,222 (IQR £9,676 to £19,203). Moreover, for the least complex H1 group the median cost was £10,057 (IQR £7,312 to £13,558), H2 £12,756 (IQR £9,188 to £17,854), and H3 £16,105 (IQR £11,982 to £25,704), demonstrating a significant increase in cost to the unit as case complexity rises according to the RHCC ($p < 0.001$). Costs were significantly increased between the non-infected group (£11,594, IQR £8,926 to £16,366) and infected group (£16,234, IQR £12,620 to £21,591), ($p < 0.001$), which is demonstrated in Figure 4. Remuneration did increase significantly ($p = 0.019$) with the RHCC complexity from the H1 group (£9,868, IQR £7,560 to £12,297) to the H2 group (£11,912, IQR £8,852 to £16,219) and the H3 group (£12,557, IQR £9,450 to £22,100), as it did between non-infected (£11,135, IQR £8,609 to £16,322) and infected groups (£14,070, IQR £9,767 to £17,360) ($p = 0.012$). A median deficit was demonstrated in all groups but rose significantly with complexity from £97 deficit (IQR £1,224 deficit to £1,308 profit) for H1, £1,050 deficit (IQR £3,189 deficit to £1,382

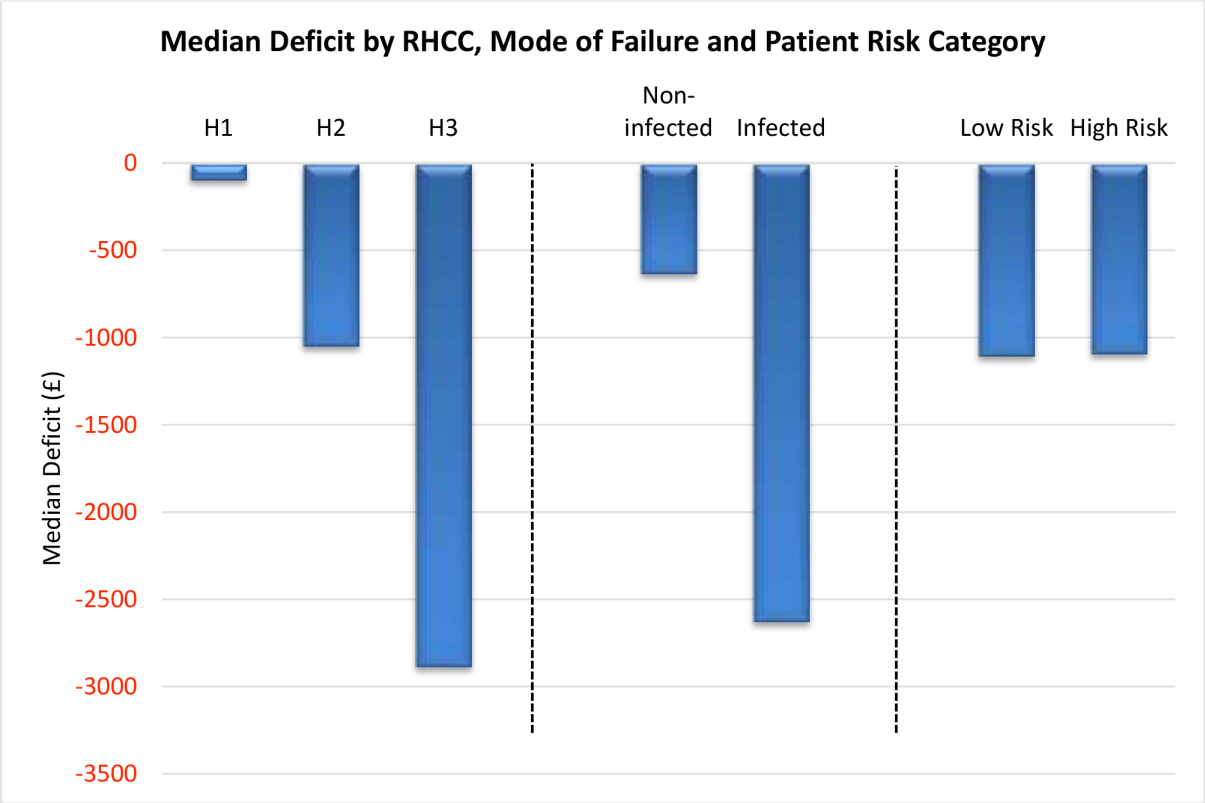

Fig. 5

Median deficit based on the Revision Hip Complexity Classification (RHCC), mode of failure, and patient risk category.

profit) for H2, and £2,887 deficit (IQR £5,947 deficit to £676 profit) for H3 (p = 0.006). The deficit for non-infected cases was £635 (IQR £2,749 deficit to £1,021 profit), rising to £2,629 (IQR £5,837 deficit to £1,438 profit) for infected cases (p = 0.032) (Figure 5). There was no statistically significant difference in the cost, remuneration, or final profit/deficit between the high- and low-risk groups.

Over the course of the two financial years, the rTHA service generated a deficit to the unit of £512,202.

Discussion

Remuneration of secondary care services in the NHS is based upon the National Tariff with a complex system of HRG codes, which aim to group together similar activities and assign them a value.[16] These HRGs have a basic descriptor such as "Very Major Hip Procedures for Non-Trauma" (HN12) or, "Very Complex Hip or Knee Procedures for Non-Trauma" (HN80), suffixed with a letter (A to F) to further denote complexity based on comorbid status. Additionally, there is then a degree of uplift to account for a prolonged LOS and the market forces factor (MFF), which accounts for the differing costs of services geographically. The National Tariff is adjusted to take into account inflationary costs, but this is done by way of a three-year cycle of cost data returns by hospital trusts on the true costs of treatments which are then averaged out nationally. As such, remuneration payments on the National Tariff are always likely to lag behind. In addition to this, as demonstrated in this paper, rTHA is a very heterogeneous group of procedures in which no two cases are the same and the costs vary wildly. To try and use such a blunt tool as HRGs, applied by non-clinical staff relying on limited information, to generalize a group of procedures as complex as rTHA, is extremely challenging and unlikely to give accurate results.

Our institution is a tertiary referral centre for revision hip and knee arthroplasty. It has a busy local referral pattern as well as a wide-reaching and long-established tertiary referral catchment area. The unit undertook 199 revision procedures in 168 patients over the two financial years of 2018 to 2020. Of these, more than 38% were for infection (DAIR, single-stage, first-, or second-stage), significantly higher than the average of 14.4% reported by the NJR. We have shown that revision procedures for infection carry the greatest cost and deficit to the treating unit and therefore account for much of the financial burden.

Median LOS varied widely, from one to 122 days. There was a statistically significant difference between all complexity groups, infected versus non-infected cohorts, and the high- versus low-risk cohorts. This is

likely to account, in part, for some of the higher costs in these groups. However, in the high-risk group (ASA ≥ III and BMI ≥ 40 kg/m^2), there was a trend towards higher costs and remuneration as would be expected, without reaching statistical significance ($p = 0.129$ and $p = 0.072$, respectively). There was no suggestion of a difference in the profit/deficit ($p = 0.572$), which would imply that the comorbidity element of the National Tariff and HRG coding system is working well to account for any true increase in costs that these patients represent.

The routine practice within our unit is to limit the length of time patients are treated with parenteral antibiotics. Typically, for the first-stage procedure, the focus is on strict surgical technique of debridement and local delivery of high-dose antibiotics in the form of cement beads, with no further parenteral antibiotics unless there is significant soft-tissue infection. For single-stage procedures, a short two-week course of parenteral antibiotics is preferred.[17,18] For this reason, we would expect our unit to have a shorter average LOS (and therefore lower costs) for infected cases than most other units treating infection. Shortened courses of antibiotics are the subject of the Short or Long Antibiotic Regimes in Orthopaedics (SOLARIO) study,[19] a multicentre randomized controlled trial which is currently ongoing. By using this approach, there is the opportunity to control costs through both antibiotic stewardship and patient LOS.

The RHCC was designed by the British Hip Society to reflect the complexity of the revision surgery being undertaken. It was formulated by performing a Delphi method of consultation with a panel of experts in the field. The aim of the RHCC was to identify the complexity of a case, and triage which revision centre or unit within a network would be most appropriate to undertake a particular revision procedure. We demonstrate that there is a correlation between the RHCC group and the increasing cost of a rTHA episode. However, the range of costs to the trust still vary wildly within each of the three groups. This, in part, will be due to first-stage revision episodes that are more costly due to the antibiotic use and increased LOS in a relatively unwell, potentially septic patient. A second-stage procedure is more predictable in terms of LOS, surgical time, and costs. The RHCC is not designed to differentiate between the two.

There are limitations to this study. It is recognized that the RHCC is a new classification system that is not yet widely adopted. It has, however, been developed using the recognized Delphi method of consensus opinion and has good inter- and intraobserver reliability. It has also been demonstrated in this paper that it correlates with the patient LOS, as well as the cost to the trust via PLICS data and the remuneration via the National Tariff and HRG coding systems. This paper has used PLICS data to evaluate the cost of the admission but, although this is far more accurate than the HRG coding system, it is not possible to capture each individual consumable used on a single patient. Assumptions are made within the system of the average daily cost per patient to encompass these. This paper also does not capture readmissions, or complications such as ongoing wound discharge or return to theatre for minor procedures unless they led to another revision episode. It is therefore likely that the true costs of managing a revision hip service are even greater than we have reported.

This paper has demonstrated that the current system of remuneration for the complex rTHA is inadequate and leads to a significant financial deficit. With the impending development of revision networks for rTHA, there seems to be little incentive for hospitals to volunteer to offer services for the most complex cases, particularly those with infection. There needs to be further development of funding strategies to cope with the heterogeneity of rTHA, particularly related to case complexity, so that centres treating the bulk of the more complex cases are not financially disincentivized. A more appropriate mechanism of payment may be the centralized specialist commissioning system that funds specialized services such as cancer care and thrombectomy services for stroke patients.[20]

The current NHS reimbursement for revision hip surgery does not adequately reflect the true costs of undertaking this type of work, particularly the more complex revision cases and those associated with infection. This has the greatest impact on the tertiary referral centres that are likely to become the hubs of any future revision networks and is therefore a financial disincentive to the effective creation of networked care.

Take home message

- The financial loss to the trust to provide tertiary hip revision services was estimated to be in excess of £0.5 million over the two financial years.
- The higher the complexity of case, the greater the deficit to the treating unit.
- Revision networks are designed to improve care by centralizing the greater complexity cases into major revision centres – consequently, this will also push the greatest burden of cost centrally.
- Specialized revision services must come with alternative funding models to account for the discrepancies identified.

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- T. P. Harrison: Methodology, Supervision, Writing – review & editing.
- S. Salih: Methodology, Validation, Writing – review & editing.
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- R. M. Kerry reports receipt of payment for preparation of occasional medicolegal reports, unrelated to this study.

Data sharing:
- The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

Ethical review statement:
- This is a retrospective observational study and therefore no formal ethical approval was required.

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