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Clinical Investigation

QUALITY AND PATIENT SAFETY

The financial cost of postoperative complications: a prospective cohort study with linked health systems data

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Abstract

Background: Five million surgical procedures are performed annually in the UK NHS. One in five patients experience postoperative complications, causing longer admissions and additional treatments. However, the economic cost of complications is poorly understood.

Methods: This was a planned analysis of the International Surgical Outcomes Study linked to NHS England Hospital Episode Statistics data, focusing on Payment by Results (PbR), the predominant funding mechanism before COVID-19. The primary outcome was cost of postoperative complications. The secondary outcome was profit–loss, comparing PbR (income) with surgical cost accounting for complications (expenditure). We calculated expenditure of admission by multiplying length of stay by average daily ward or critical care unit costs. We defined income using the tariff linked to PbR.

Results: We included 5167 patients undergoing surgery in the NHS in England, of whom 848 (16.4%) experienced a complication. Patients were on average 58.9 yr old, with 58.1% female and 41.9% male. Median length of stay was 7 days for patients with complications and 2 days without complications. The average cost of admission for patients with complications was £3100 (95% confidence interval [95% CI]: £2921–3279) compared with £1038 (95% CI: £1006–1070) for patients without complications. Profit–loss analysis, accounting for procedure and length of stay, showed a loss for most surgeries, regardless of complications. Average loss without complications was £930 (95% CI: £866–995) and £850 (95% CI: £629–1071) with complications.

Conclusions: Postoperative complications increase expenditure by ~200%. For most procedures, expenditure exceeds income, independent of complications.

Keywords: financial cost; healthcare economics; National Health Service; payment by results; postoperative complications

Editor's key points

- The volume of surgical procedures continues to grow worldwide, with related increases in postoperative complications.
- In order to assess the economic costs of postoperative complications, this study describes a planned secondary analysis of the International Surgical Outcomes Study (ISOS) conducted in the UK.
- The average cost per admission for patients with complications was almost three-fold compared with patients without complications. Methods to reduce complications are needed to improve the cost-effectiveness of surgery.
- Profit–loss analysis, accounting for procedure and length of stay, showed a loss for most surgeries, regardless of complications.

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- Future payment systems should achieve a balance between improving efficiency and ensuring adequate payment to support the healthcare service delivery.

Each year, ~5.1 million people undergo surgical procedures within the UK NHS, constituting a substantial component of NHS activity.[1] In 2015, surgery cost the NHS £10.9 billion.[1,2] Before the COVID-19 pandemic, there was an annual 4% increase in the frequency of surgery.[1] However, in the context of a backlog for surgical elective care, surgery is expected to represent a growing proportion of the NHS budget.[1,3]

Postoperative complications are estimated to account for one-third of expenses associated with surgical care.[4] Complications affect ~17% of the surgical population.[5] Their frequency and severity vary, and costs are tied to severity.[6] Severe complications can necessitate invasive interventions including re-operation, re-admission, and intensive care leading to longer inpatient stays, which increase costs. As the volume of surgery increases, the burden of postoperative complications is expected to increase. However, the financial impact of complications on health services is poorly understood, which has implications for health policy.

The predominant form of reimbursement for NHS surgical activity before the COVID-19 pandemic was Payment by Results (PbR).[7] During the pandemic, the NHS increased the amount of block payments, which consists of fixed payment for a specified volume of activity. This provided additional funding supporting services during and after the pandemic. Currently, block payments remain a part of institutional income.[8] There is also additional income supporting increased elective procedure activity to combat the surgical backlog.[9] PbR uses Healthcare Resource Groups (HRGs) as a form of currency, which consist of diagnoses and interventions consuming similar levels of NHS resources.[10] A tariff sets the price for HRGs, which is based on the average cost of services reported by NHS England providers.[10] Individual providers are reimbursed on a per procedure basis by commissioners according to the tariff.[10] This forms the basis of payment for healthcare services and health economic analyses. However, how closely PbR approximates the economic cost of surgery is unclear.

The International Surgical Outcomes Study (ISOS) was a prospective observational cohort study of elective surgery in 27 countries,[5] which provided a detailed description of postoperative complications and outcomes. The aim of this analysis was to report the financial cost of postoperative complications in England using linked Hospital Episode Statistics (HES) data. We investigated how closely PbR approximates the real cost of surgery by comparing the cost of hospital admission with income via PbR.

Methods

Study design and participants

We performed a secondary analysis of ISOS describing the cost of surgical procedures and postoperative complications in the NHS in England.[5] ISOS was an international multicentre cohort study of perioperative morbidity and mortality in patients undergoing elective surgery. Data collection occurred during a 7-day period between April and August 2014 in 474 hospitals in 27 countries. All patients (aged ≥18 yr) admitted to participating centres for elective surgery with a planned overnight stay were eligible. Patients undergoing day-case surgery or radiological procedures were excluded because they followed a dedicated pathway of care. In our secondary analysis, only patients from England were included. A complete description of the ISOS methods has been published.[5]

Data collection

Data describing consecutive patients were collected until hospital discharge on paper case record forms. Patient data collected included that recorded as part of routine care. Patients were followed up for a maximum of 30 days after surgery for complications. Data were anonymised before entry onto a secure internet-based electric case record form designed for ISOS.

Data linkage and research ethics approval

We restricted analysis to data from participants in England who consented to their personal information being linked to national databases. We used unique identifiers to link ISOS data to national HES data. This included HRG and Office of Population Census and Surveys Version 4 (OPCS-4) codes. In the UK, ISOS was approved by the Yorkshire and Humber Research Ethics Committee reference (13/YH/0371) (ISOS confidentiality advisory group [CAG] approval: 18/CAG/0205 and Data Access Request Service (DARS): DARS-NIC-68740-X7R2N-v3.3).

Outcome measures

Our primary outcome measure was income hospitals received via PbR and expenditure of postoperative complications. Our secondary outcomes were to report the net profit/loss per surgical procedure, accounting for complications, by comparing the expenditure of each hospital admission for surgery with income received via PbR.

Statistical methods

We recognise NHS funding has multiple income sources. We address PbR as a funding source as this was the predominant income source before the pandemic and forms the basis of health economic analysis.

Calculation of income and expenditure

NHS England uses PbR to determine the price payable by NHS commissioners to providers (i.e. hospitals).[10] PbR is indexed using HRG codes, a currency for which payment is paid by a tariff. HRGs consist of diagnoses and interventions consuming similar levels of NHS resources; other factors including comorbidities, complications, age group, and length of stay are considered.[10] A tariff is applied to each HRG, which includes the cost of the procedure.[10] Patients are assigned HRG codes based on intervention or diagnoses received during a spell of care (period of admission to discharge within a single provider for a single patient).[10] HRGs have trim points, defined as the upper quartile length of stay multiplied by 1.5 times the interquartile range of stay.[11] Once patients pass the trim point, a long-stay daily rate is applied for each additional day.[11] PbR uses a market force factor (MFF), adjusting the tariff according to regional costs.[11] Figure 1 demonstrates how PbR works.

We defined income by the income the hospital receives via PbR. HRG codes were assigned to each patient through HES. For patients exceeding the HRG trim point, we applied long-stay daily rates. We did not apply the MFF. ISOS data were from 2014, so we applied the 2014/15 tariff. We repeated the

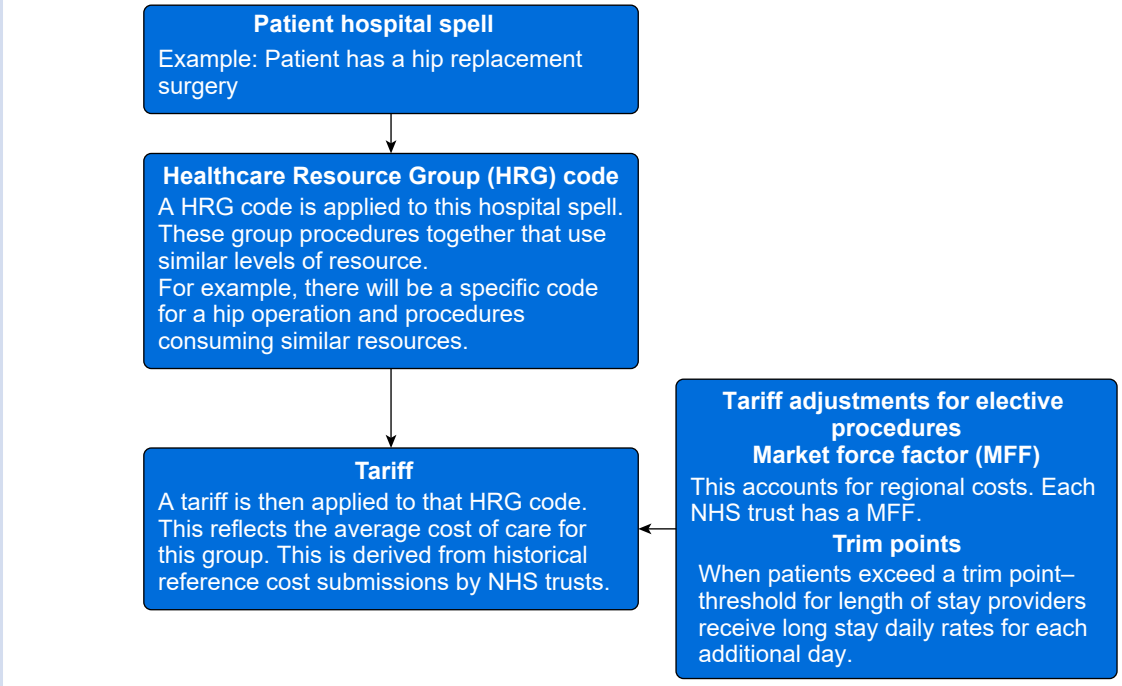

Fig 1. Flow diagram showing the calculation of cost of a patient episode for surgery. MFF, market force factor.

analysis adjusting for 2018/19 financial year inflation using the NHS cost inflation index, a measure of inflation specific to the NHS.[12] We could not apply the 2018/19 tariff, owing to the 2016/17 update introducing new HRG groupings and codes.[13]

We defined expenditure by length of hospital stay (LOS) in ward or ITU-based care or both and multiplied by cost. LOS was defined as the number of days spent on ward or ITU or both from completion of surgery to discharge or 30 days after surgery. We used the National Schedule of Reference Costs to calculate the cost of a daily stay on the ward and ITU. The daily cost of ward-based care was £359, and £1254 for ITU care based on the 2014/15 year.[14] We based the daily ITU figure on the average surgical specific ITU unit costs for an adult patient.[14] We repeated the analysis adjusting to 2018/19 inflation. This does not include costs specific to surgical procedure, for example, surgical staffing or equipment.

Statistical analysis

We prospectively planned the statistical analysis (Supplementary Appendix 1) before commencing analyses. We used STATA 13.1 (StataCorp, College Station, TX, USA) for all analyses. We excluded patients with missing data for post-operative complication status or LOS. Baseline characteristics are presented as mean (SD) and median (interquartile range [IQR]) if continuous and number (%) if categorical. We stratified baseline data by postoperative complication status. Data are presented in Great British Pound (GBP) and converted into euros using the average 2014/15 and 2018/19 exchange rates.

Primary analysis

We calculated income and expenditure for each hospital episode. This is summarised as a mean for the whole sample and grouped by surgical procedure category. We stratified the sample by the presence or absence of complications.

Secondary analysis

We conducted a profit–loss analysis by subtracting the income hospitals received by PbR from LOS expenditure. We repeated this for patients with and without complications.

Sensitivity analysis

Our primary analysis of expenditure is limited to estimates using LOS, but did not include surgery procedure costs. Our sensitivity analysis considers this. We calculated the cost of surgical procedure by multiplying mean total operating theatre time and theatre cost per minute using published data.[15] The running costs of NHS operating theatres are not widely reported; estimates from 2015 are between £14 min^{-1} and £20 min^{-1}.[16,17] There are no recent estimates or indication of what is included in these analyses. We used an average of £17 min^{-1} and repeated adjusting for inflation. Because of variation in operating theatre costs and timings, we repeated the analysis using internal data on theatre cost per minute, average operation timings, and average LOS from Bart's Health NHS trust from the 2022/23 financial year. The 2014/15 and 2018/19 years were not available. We paired HRG codes from the 2022/23 tariff and used the MFF for Bart's Health Trust to generate a profit–loss analysis.

Results

There were 5167 patients from the ISOS cohort included (Supplementary Fig. S1). We excluded 12 participants because of missing postoperative complications, 10 because of missing

LOS, one because of missing procedure category, and 97 because of missing HRG codes.

Baseline characteristics

Postoperative complications were present in 848 (16.4%) patients (Table 1). Patients experiencing a complication were 7.5 yr on average older. Of the 848 patients experiencing a complication, 50.5% were women and 49.5% men. Patients spent an additional 7 days in hospital when experiencing a complication. Orthopaedic operations had the highest proportion of postoperative complications at 24%.

Table 1 Baseline characteristics of included surgical patients, stratified according to postoperative complication. Data are presented as *n* (%) unless otherwise indicated. COPD, chronic obstructive pulmonary disease; IQR, interquartile range.

	No complications	Complications
Age, yr		
Mean (SD)	57.7 (17.4)	65.2 (15.7)
Median (IQR)	61 (45–71)	69 (56–77)
Sex		
Male	1745 (40.4)	420 (49.5)
Female	2574 (59.6)	428 (50.5)
Current smoker	571/665 (85.9)	94/665 (14.1)
ASA physical status	(*n*=4270)	(*n*=844)
1	1100 (25.8)	92 (10.9)
2	2235 (52.3)	359 (42.5)
3	902 (21.1)	367 (43.5)
4	33 (0.8)	26 (3.1)
Grade of surgery	(*n*=4310)	(*n*=846)
Minor	557 (12.9)	36 (4.3)
Intermediate	1893 (43.9)	260 (30.7)
Major	1860 (43.2)	550 (65)
Surgical speciality	(*n*=4319)	(*n*=848)
Orthopaedics	1198 (27.7)	209 (24.6)
Breast	162 (3.8)	18 (2.1)
Obstetrics and gynaecology	825 (19.1)	102 (12)
Urology and kidney	558 (12.9)	85 (10.0)
Upper gastrointestinal	165 (3.8)	45 (5.3)
Lower gastrointestinal	308 (7.1)	100 (11.8)
Hepatobiliary	102 (2.4)	25 (3)
Vascular	132 (3.1)	49 (5.8)
Head and neck	407 (9.4)	40 (4.7)
Plastic or cutaneous	102 (2.4)	21 (2.5)
Cardiac	99 (2.3)	108 (12.7)
Thoracic (lung)	73 (1.7)	24 (2.8)
Thoracic (gut)	8 (0.2)	0 (0.0)
Other	180 (4.2)	24 (2.8)
Laparoscopic surgery	703/4317 (16.3)	111/848 (13.1)
Hospital length of stay		
Mean (SD)	2.85 (3)	9.05 (7.5)
Median (IQR)	2 (1–4)	7 (4–11)
Critical care stay		
Mean (SD)	0.10 (0.5)	1.22 (3.4)
Median (IQR)	0 (0)	0 (0–1)
Comorbid disease		
Coronary artery disease	451/4306 (10.5)	179/847 (21.1)
Heart failure	92/4306 (2.1)	64/847 (7.6)
Diabetes mellitus	525/4306 (12.2)	141/847 (16.6)
Cirrhosis	20/4306 (0.5)	9/847 (1.1)
Metastatic cancer	119/4306 (2.8)	57/847 (6.7)
Stroke	123/4306 (2.9)	55/847 (6.5)
COPD or asthma	635/4306 (14.8)	169/847 (20)
Other	1575/4306 (36.6)	388/847 (45.8)

Expenditure

Average expenditure was £1420 (95% confidence interval [95% CI]: £1374–1467) (€1648 [95% CI: €1594–2371]). When adjusting for inflation, cost for patients with no postoperative complication was £1038 (95% CI: £1006–1070) (€1205 [95% CI: €1167–1242]) and £3100 (95% CI: £2921–3279) (€3597 [95% CI: €3389–3805]) for patients with complications. Plastics and cutaneous surgical procedures had the highest percentage increase in expenditure when patients experienced a complication, increasing by 305%, and thoracic (lung and other) surgical procedures had the lowest percentage increase in expenditure at 44%. Figure 2 and Table 2 show cost by surgical procedure for 2018/19. Expenditure for 2014/15 and expenditure in euros are presented in Supplementary Tables S1 and S2 and Supplementary Figure S2.

Pulmonary embolism was the complication with the largest expenditure at £5030 (€5837). Postoperative bleeding had the lowest expenditure at £3046 (€3534) (Supplementary Fig. S3).

Income

Average income was £4126 (95% CI: £4048–4204) (€4787 [95% CI: €4696–4878]). Patients with no postoperative complications had an average income of £3610 (95% CI: £3536–3685) (€4189 [95% CI: €4103–4275]), which rose to £5977 (95% CI: £5753–6202) (€6936 [95% CI: €6675–7196]) for patients with complications. Plastics and cutaneous surgical procedures had the highest percentage increase in income (111%) when patients experienced complications. Thoracic (lung and other) surgical procedures had the lowest percentage increase in income when patients had a complication (12%). Table 2 shows income by surgical procedure for 2018/19. Income for 2014/15 and income in euros are presented in Supplementary Tables S1 and S3 and Supplementary Figure S4.

Stroke was the complication requiring the highest income, £8699 (€10 094). Urinary tract infections required the lowest income at £5053 (€5863) (Supplementary Fig. S5).

Profit–loss analysis

Our profit–loss analysis showed income that hospitals receive via PbR was on average £2572 (€2984) more than ward/ITU expenditure in patients with no complications, and £2877 (€3339) more in patients with complications. This does not include the cost of the surgical procedure. All surgical categories showed a profit, with cardiac procedures having the highest, £6990 (€8111) (Supplementary Table S4). However, when cost of the surgical procedure was added into our profit–loss analysis, there was a loss for all surgical procedures except cardiac and thoracic (lung and other) surgery in patients with no complications, and only cardiac surgery in patients with complications (Table 3, Fig. 3). Plastics and cutaneous surgery produced the biggest loss of £2562 (€2973) in patients with complications. In patients without complications, head and neck surgery had the largest loss of £3185 (€3696). We repeated the analysis using internal data from Bart's Health Trust (Supplementary Table S5). All surgical procedures reported a loss, with cardiac surgery having the highest loss of £9545 (€11 048).

Sex and age disaggregated analyses are presented in the supplementary file. The average loss for women was £892 (95% CI: £816–967). For men, it was £953 (95% CI: £837–1068)

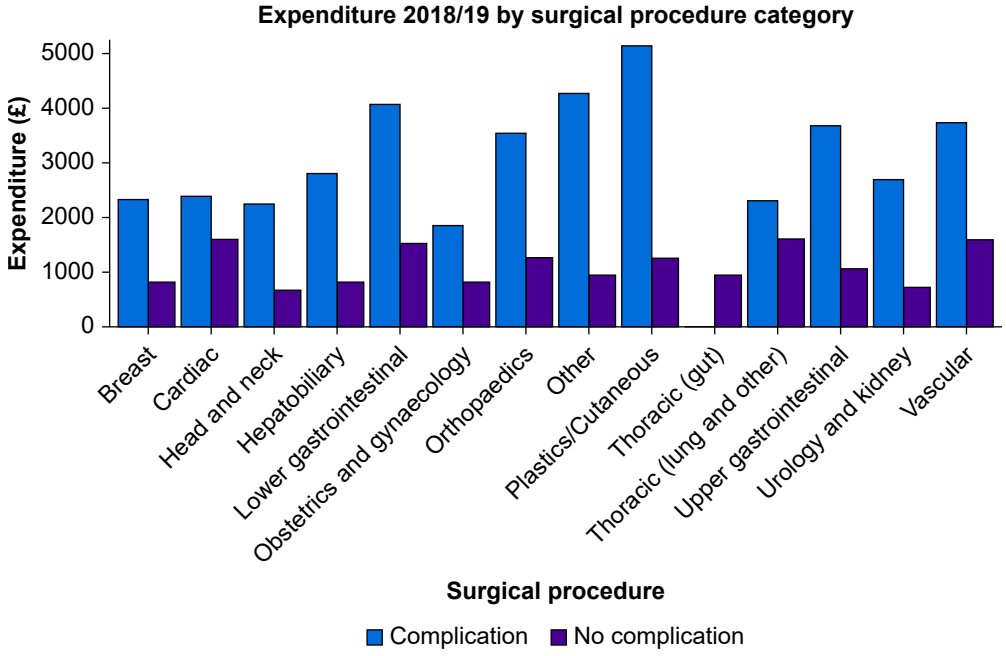

Fig 2. Average expenditure categorised by surgical procedure adjusted for 2018/19 inflation; data are not risk adjusted.

Table 2 Income and expenditure categorised by surgical procedure adjusted for 2018/19 inflation. 95% CI, 95% confidence interval; NA, not applicable.

Surgery category (*n*)	Average income 2018/19 no complication (£) (95% CI)	Average income 2018/19 with complication (£) (95% CI)	Average expenditure 2018/19 no complication (£) (95% CI)	Average expenditure 2018/19 with complication (£) (95% CI)
Orthopaedics (1405)	5162 (5028–5296)	7175 (6777–7574)	1262 (1196–1327)	3538 (3165–3911)
Breast (180)	2906 (2663–3149)	4119 (3206–5032)	819 (704–933)	2333 (1309–3357)
Obstetrics and gynaecology (927)	2302 (2236–2368)	3193 (2862–3525)	800 (764–836)	1841 (1456–2226)
Urology and kidney (643)	2235 (2086–2384)	3724 (3165–4284)	725 (663–786)	2701 (2185–3217)
Upper gastrointestinal (210)	3830 (3462–4199)	5832 (4843–6821)	1046 (878–1213)	3674 (2842–4507)
Lower gastrointestinal (408)	3664 (3416–3911)	5564 (5085–6043)	1516 (1369–1663)	4083 (3538–4628)
Hepatobiliary (127)	3169 (2693–3644)	5876 (4517–7236)	801 (643–960)	2818 (1706 –3930)
Vascular (181)	4844 (4405–5282)	5874 (5197–6550)	1584 (1270–1898)	3736 (2892–4580)
Head and neck (447)	2446 (2272–2620)	3969 (2808–5130)	652 (568–736)	2227 (1526–2928)
Plastics or cutaneous (123)	2732 (2341–3123)	5778 (4143–7413)	1269 (952–1585)	5139 (3685–6594)
Cardiac (207)	8577 (8018–9137)	9892 (9539–10 245)	1587 (1318–1856)	2370 (2030–2709)
Thoracic (lung and other) (97)	4873 (4346–10 245)	5438 (4319–6556)	1584 (1357–1812)	2284 (1557–3011)
Thoracic (gut) (8)	1601 (730–2471)	NA	942 (366–1517)	NA
Other (204)	3211 (2807–3614)	5606 (4446 –6765)	947 (754 –1140)	4261 (2835–5688)

(Supplementary Table S6, Supplementary Fig. S6). An upward trend in expenditure when patients experience a complication with age exists; age 95–100 yr had the highest expenditure of £7723 (€8961) (Supplementary Figs S7 and S8).

Discussion

We calculated the average cost of elective surgical admissions in a planned analysis of ISOS. We identified a 200% increase in average expenditure per surgical procedure after postoperative complications; this does not include the cost of surgical procedure. After accounting for the cost of surgical procedure, most operations made a loss, independent of the presence or absence of complications. This has important economic implications for the NHS as hospitals clear the backlog from the pandemic, which published figures suggest is more than 7 million cases.[18]

Postoperative complications occur in one-sixth of surgical patients; thus, expenditure increase is impactful. Previous investigations have quantified complication costs. A US study including 5120 episodes of surgical care reported a 119% increase in costs for patients with complications.[19] Other studies

Table 3 Profit–loss analysis categorised by surgical procedure for 2014/15 adjusted for inflation, including operating theatre cost. Positive numbers represent profit. Other and hepatobiliary categories are missing as data on operating time was not available. NA, not applicable.

	Profit–loss with surgery no complication (£)	Profit–loss with surgery with complication (£)	Profit–loss with surgery (adjusted for inflation) no complication (£)	Profit–loss with surgery (adjusted for inflation) with complication (£)
Orthopaedic	−161	−411	−169	−431
Breast	−194	−482	−203	−505
Obstetrics and gynaecology	−752	−894	−789	−938
Urology and kidney	−1178	−1642	−1236	−1723
Upper gastrointestinal	−1052	−1649	−1104	−1730
Lower gastrointestinal	−1659	−2294	−1740	−2407
Hepatobiliary	NA	NA	NA	NA
Vascular	−554	−1623	−581	−1703
Head and neck	−3036	−3085	−3185	−3237
Plastics or cutaneous	−2442	−3229	−2562	−3387
Cardiac	1849	2356	1939	2471
Thoracic (lung and other)	13	−115	13	−121
Thoracic (gut)	−2494	NA	809	NA
Other	NA	NA	NA	NA

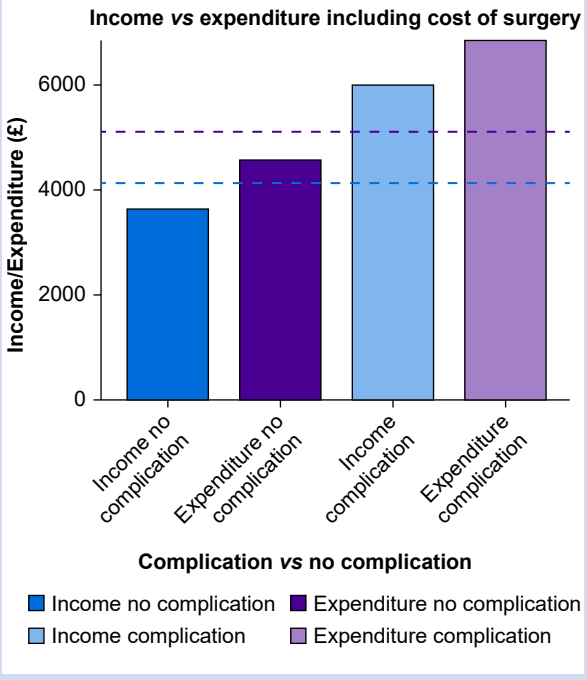

Fig 3. Our sensitivity analysis showing income received via Payment by Results *vs* expenditure including the cost of surgery itself. The purple line indicates average expenditure. The blue line indicates average income.

explored the costs of a single complication or a selection of complications, reporting an increase of 15–240%,[4,20–22] which aligns with our data.[20] These findings suggest methods identifying at-risk patients and reducing complications could have a substantial impact on the cost-effectiveness of surgery.[23,24]

We explored whether a difference between income hospitals receive via PbR and expenditure exists. We accounted for the cost of the surgical procedure and ward/ITU expenditure in a sensitivity analysis. Both methods calculating surgical cost showed a loss for most procedures, with a more significant loss for patients experiencing complications. This suggests PbR does not fully approximate the cost of hospital admission or complications. This is important as PbR in 2022/23 accounted for 60% of NHS hospital funding.[25] This might reflect the underlying purpose of PbR, to enhance financial efficiency.[26] If a hospital reduces procedure costs and maximises the number of procedures it conducts, it could generate a profit, which incentivises hospitals to perform certain procedures at higher volume and improve efficiency. However, if expenditure exceeds PbR income, this exacerbates loss.

In hospitals using PbR, LOS is reduced, thus improving efficiency.[26,27] However, some procedures remain unprofitable even when performed with optimal efficiency.[17,28] This is for several reasons. HRG groups are broad, containing multiple procedures for the same cost, thus overlooking differences. NHS providers report different units of costs for the same services affecting the tariff, potentially caused by differences in how institutions undertake costings.[29] This leads to underpayment in some trusts and exacerbates regional health inequality.[29] The MFF is designed to offset regional disparities. However, it is difficult to assess how much this impacts a hospital's profit–loss. In a sensitivity analysis, we applied the MFF for Barts Health NHS Trust to the profit–loss analysis. This showed a loss for all surgical procedures. Underpayment of healthcare systems worsens patient outcomes. Patients have longer waiting times because of lack of resources, which means they present later with more complex needs. Lack of resources results in lower care quality. The tariff is updated yearly, but it struggles to match changing guidelines and inflation, causing financial constraints.[30] Supplementary funding methods are used, including block contracts, which have the benefit of regular payments and increased spending control, but with the disadvantages of reduced flexibility to respond to demand, lack of transparency, and low incentives to increase efficiency.[31,32] There is limited evidence regarding which approach most closely represents the true cost of surgery or covers complica-

tion cost.[33] While PbR remains a key component of NHS provider reimbursement, it focuses on activity metrics (e.g. LOS) over patient outcomes. We contend greater adjustment is needed to reflect the economic cost of surgery, including postoperative complications and improved outcomes.[34]

This analysis has several strengths. It was a planned secondary analysis of a prospective cohort study with a statistical analysis plan. ISOS occurred in multiple institutions across England, thus increasing its external validity. We linked data reporting payments to hospitals for patients in the ISOS cohort using HRG coding. We used data on operating time from a hospital trust to calculate procedural cost and differentiated between ITU and ward-based care, improving granularity. There are also limitations. Our data are from 2014/15. Since the pandemic, the use of block payments has increased, which would cover part of the cost of surgery. PbR relies on accurate coding, and errors can cause underpayment or overpayment.[35] PbR does not break down the constituents of costings; thus, some procedure-specific costs are likely omitted, causing an underestimation of loss. We could not apply the 2018/19 tariff as the HRG codes changed; subsequently, we used the NHS cost inflation index. The tariff does consider this. However, it is not possible to approximate whether our income calculation is equal to the 2018/19 tariff. ISOS collected data to 30 days after surgery. For patients with a longer stay, the cost of care is truncated, causing an underestimation of income and expenditure. We excluded complication cost once patients were discharged, which included community care and readmissions, causing further underestimation.[36] Confounding variables mean we cannot fully attribute all LOS cost due to complications. For example, we used broad surgical categories; thus, LOS may be increased in categories unrelated to the complication itself. We did not carry out a risk adjustment; therefore, we cannot be sure the cost calculated is entirely attributable to complications. We only address financial cost, not quality of life or recovery.

Limitations exist with our cost of surgery calculation. Estimating theatre running costs is difficult; the latest data are from 2015 and do not explain how costs were derived.[16] We applied a single average cost for all surgical procedures, which did not consider operation expense variety. Only one study reported average operating time for the procedure categories used.[15] To improve this, we repeated the analysis using aggregate data from Barts Health NHS trust, stratified by procedure. We identified several differences; for example, cardiac procedures demonstrated a loss compared with the profit identified in our first method. This highlights fragility in the tariff system. Our analysis focused on the payment model used in the NHS in England which might have limited generalisability outside of this context. Lastly, we did not assess impact of complication severity on cost, which could lead to inaccurate resource allocation and reduce the ability to effectively prioritise quality improvement initiatives. This is an interesting further analysis to consider.

Conclusions

Postoperative complications increase income generated from PbR tariff by two-thirds, but increase the cost of ward and ITU accommodation by 200%, resulting in a loss for the majority of surgical procedures. Methods to improve postoperative outcomes and reduce complications are needed to improve the cost-effectiveness of surgery. Future payment systems should achieve a balance between improving efficiency and ensuring adequate payment to support the healthcare service delivery.

Authors' contributions

Study design: all authors
Analysis and interpretation of data: SLW, AJF
Writing the first draft of the manuscript: SLW, TEFA
Study concept: AJF, TEFA
Reviewing and approving the final draft of the manuscript: RMP
Study guarantor: TEFA
Critical revision of manuscript for important intellectual content, and approval of the final version of manuscript: all authors

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Declarations of interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2025.06.039.

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