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Chronic Subdural Haematoma: A UK Cost Description Analysis

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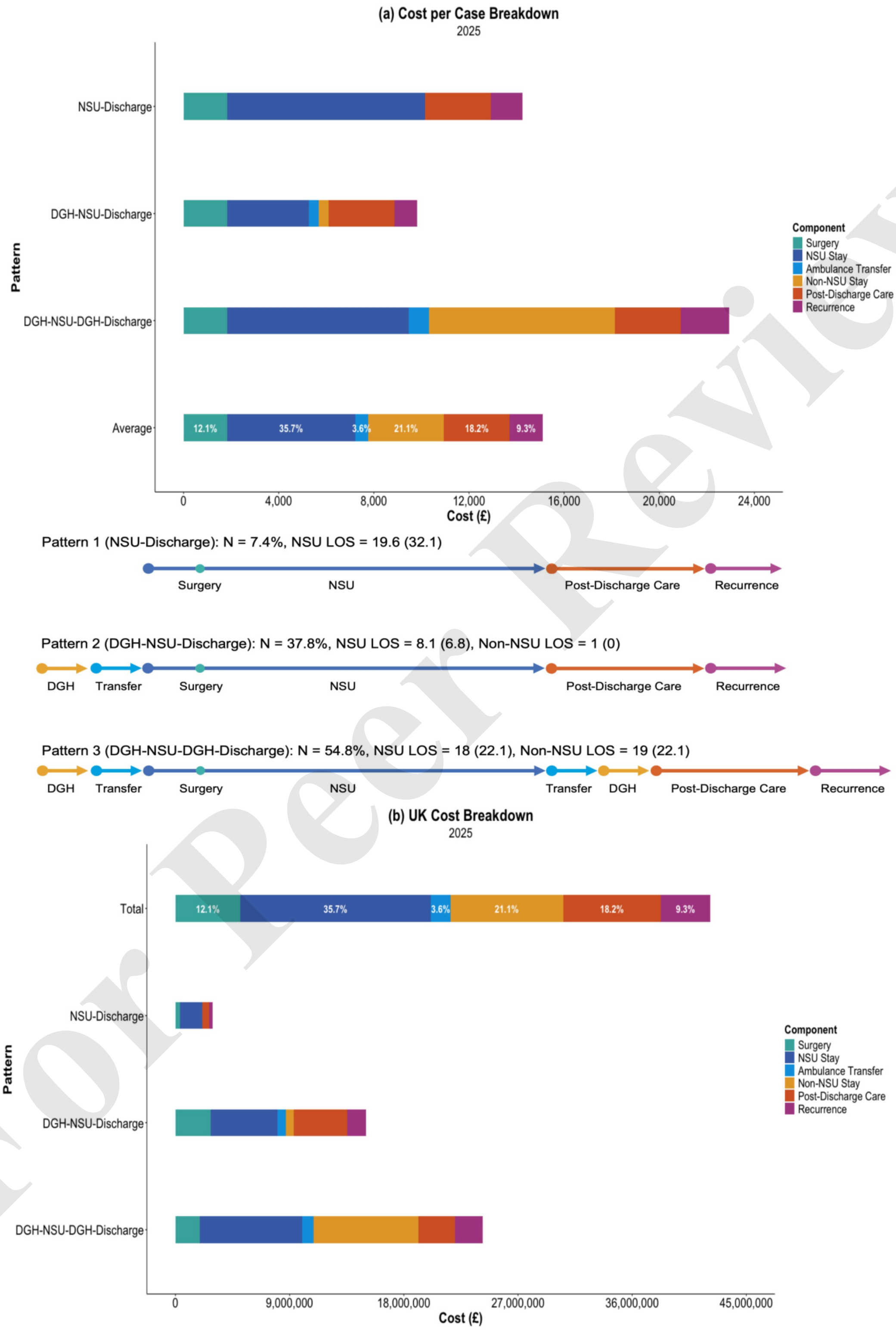
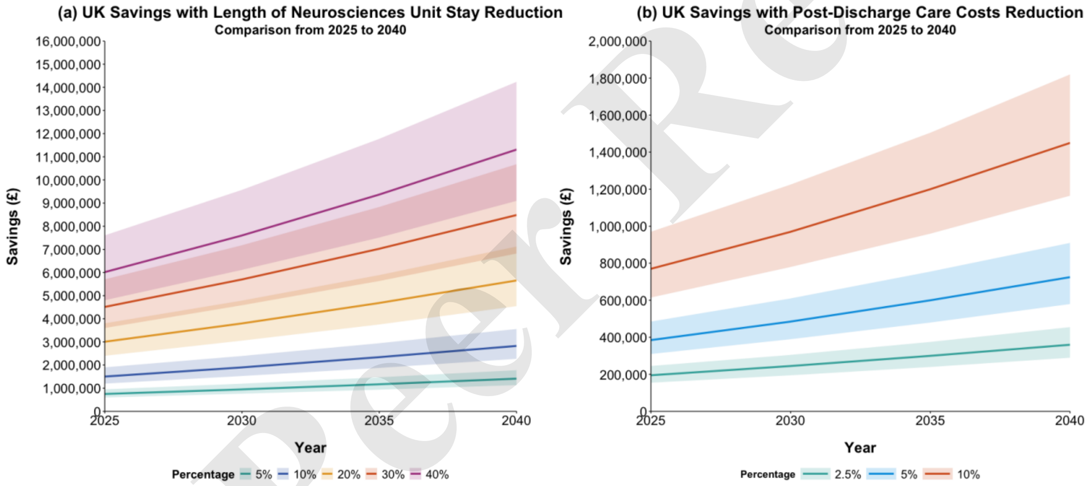
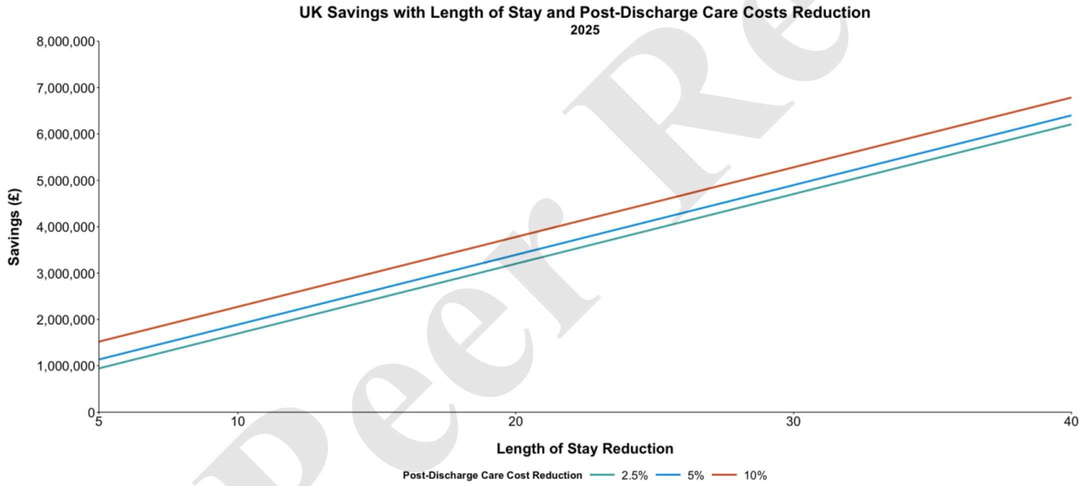
Table 1 – Estimated Cost per Case and UK Inpatient, Post-Discharge and Total Costs from 2025 – 2040. Data presented as mean, lower bound (LB) and upper bound (UB) in Great British Pounds (£).

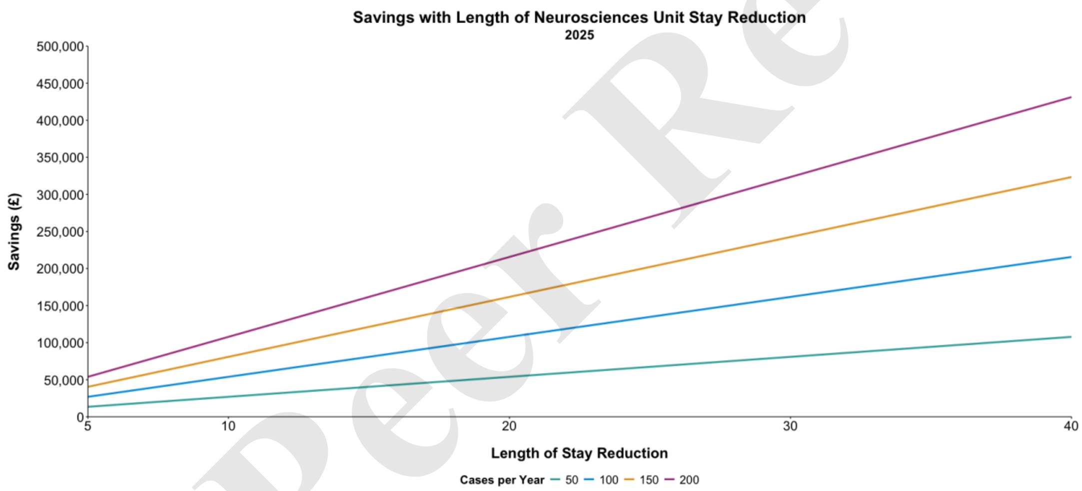
Year	**Cost**					
	Inpatient		**Post-Discharge**		**Total**	
	Per Case £	**UK £, (LB – UB)**	**Per Case £**	**UK £, (LB – UB)**	**Per Case £**	**UK £, (LB – UB)**
2025	12,300	33,460,000 (27,520,000 – 43,550,000)	2,800	7,690,000 (6,140,000 – 9,720,000)	15,100	42,150,000 (33,660,000 – 53,270,000)
2030	13,800	42,950,000 (34,565,000 – 54,080,000)	3,100	9,720,000 (7,820,000 – 12,240,000)	16,900	52,670,000 (42,385,000 – 66,320,000)
2035	15,600	52,940,000 (42,455,000 – 66,530,000)	3,500	11,980,000 (9,600,000 – 15,060,000)	19,100	64,920,000 (52,055,000 – 81,590,000)
2040	17,900	64,790,000 (52,105,000 – 81,540,000)	4,000	14,460,000 (11,630,000 – 18,210,000)	21,900	79,250,000 (63,735,000 – 99,750,000)



(a) Cost per Case Breakdown
2025
NSU-Discharge
DGH-NSU-Discharge
DGH-NSU-DGH-Discharge
Average
12.1%
35.7%
3.6%
21.1%
18.2%
9.3%
Pattern
0
4,000
8,000
12,000
16,000
20,000
24,000
Cost (£)
Component
Surgery
NSU Stay
Ambulance Transfer
Non-NSU Stay
Post-Discharge Care
Recurrence
Pattern 1 (NSU-Discharge): N = 7.4%, NSU LOS = 19.6 (32.1)
Surgery
NSU
Post-Discharge Care
Recurrence
Pattern 2 (DGH-NSU-Discharge): N = 37.8%, NSU LOS = 8.1 (6.8), Non-NSU LOS = 1 (0)
DGH
Transfer
Surgery
NSU
Post-Discharge Care
Recurrence
Pattern 3 (DGH-NSU-DGH-Discharge): N = 54.8%, NSU LOS = 18 (22.1), Non-NSU LOS = 19 (22.1)
DGH
Transfer
Surgery
NSU
Transfer
DGH
Post-Discharge Care
Recurrence
(b) UK Cost Breakdown
2025
Total
NSU-Discharge
DGH-NSU-Discharge
DGH-NSU-DGH-Discharge
12.1%
35.7%
3.6%
21.1%
18.2%
9.3%
Pattern
0
9,000,000
18,000,000
27,000,000
36,000,000
45,000,000
Cost (£)
Component
Surgery
NSU Stay
Ambulance Transfer
Non-NSU Stay
Post-Discharge Care
Recurrence


(a) UK Savings with Length of Neurosciences Unit Stay Reduction
Comparison from 2025 to 2040
Savings (£)
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
8,000,000
9,000,000
10,000,000
11,000,000
12,000,000
13,000,000
14,000,000
15,000,000
16,000,000
2025
2030
2035
2040
Year
Percentage 5% 10% 20% 30% 40%
(b) UK Savings with Post-Discharge Care Costs Reduction
Comparison from 2025 to 2040
Savings (£)
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
1,400,000
1,600,000
1,800,000
2,000,000
2025
2030
2035
2040
Year
Percentage 2.5% 5% 10%


UK Savings with Length of Stay and Post-Discharge Care Costs Reduction
2025
Savings (£)
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
5
10
20
30
40
Length of Stay Reduction
Post-Discharge Care Cost Reduction
2.5%
5%
10%


Savings with Length of Neurosciences Unit Stay Reduction
2025
Savings (£)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
5
10
20
30
40
Length of Stay Reduction
Cases per Year
50
100
150
200

Supplementary Table 1 – Unit Cost Estimates

Resource	2024/2025 Cost (£)	2029/2030 Cost (£)	2034/2035 Cost (£)	2039/2040 Cost (£)
Unilateral Surgical Procedure[1]	1,624.04	1,837.45	2,078.90	2,352.09
Bilateral Surgical Procedure[1]	2,436.05	2,756.17	3,118.35	3,528.13
Postoperative CT scan[1]	94.52	106.95	121.00	136.90
Bed Day in Ward[1]	412.04	466.18	527.44	596.76
Bed Day in Neurosciences Unit[1]	424.68	480.49	543.63	615.07
Ambulance Journey[2]	420.07	475.27	537.73	608.39
Post-Discharge Care[1]	2,756.83	3,119.10	3,528.98	3,992.72
CNS Band 6 (FT)[2]	98,369.65	111,296.23	125,921.47	142,468.59
Medical Consultant (1 PA)[2]	32,325.35	36,573.17	41,379.18	46,816.74
Operating Theatre per Hour[3]	1,107.83	1,253.41	1,418.12	1,604.47

Supplementary Table 2 – Compound Factor used to Estimate Costs

Year	Compound Factor
2012/2013 → 2021/2022	1.168
2017/2018 → 2021/2022	1.107
2021/2022 → 2024/2025	1.077
2021/2022 → 2029/2030	1.218
2021/2022 → 2034/2035	1.379
2021/2022 → 2039/2040	1.560

Supplementary Table 3 – Estimated Regional and UK Operative Case Numbers. Data presented as mean and 95% CI.

Year	Regional Operative Cases (n) (LB – UB)	UK Operative Cases (n) (LB – UB)
2025	135 (108 – 171)	2790 (2228 – 3526)
2030	150 (121 – 189)	3116 (2507 – 3923)
2035	163 (131 – 205)	3395 (2722 – 4266)
2040	174 (140 – 219)	3623 (2913 – 4560)

Supplementary Table 4 – Savings per Case with Various Combinations of Inpatient Stay Reduction and Post-Discharge Care Cost Reductions. Data presented for 2025 estimates in Great British Pounds.

2025		Savings Per Case with Inpatient Stay Reduction £					
		0%	**5%**	**10%**	**20%**	**30%**	**40%**
Savings per Case with Post-Discharge Care Cost Reduction £	**0%**	0	270	540	1,080	1,620	2,160
	2.5%	70	340	610	1,150	1,690	2,230
	5%	140	410	680	1,220	1,780	2,295
	10%	275	545	815	1,355	1,895	2,430

Supplementary Table 5 – Savings per case with various combinations of inpatient stay reduction and post-discharge care cost reductions. Data presented for 2040 estimates in Great British Pounds.

2040		Savings Per Case with Inpatient Stay Reduction £					
		0%	**5%**	**10%**	**20%**	**30%**	**40%**
Savings per Case with Post-Discharge Care Cost Reduction £	**0%**	0	390	780	1,560	2,340	2,760
	2.5%	100	490	881	1,660	2,440	3,220
	5%	200	590	980	1,760	2,540	3,320
	10%	400	790	1,180	1,960	2,740	3,520

Supplementary Table 6 – Total UK Savings with Combinations of Inpatient Savings and Post-Discharge Savings in 2025. Data presented as mean, lower bound (LB) and upper bound (UB) in Great British Pounds (£).

2025		**UK Savings with Inpatient Stay Reduction £, (LB – UB)**				
		5%	**10%**	**20%**	**30%**	**40%**
UK Savings with Post-Discharge Care Cost Reduction £, (LB – UB)	**2.5%**	940,000 (750,000 – 1,190,000)	1,700,000 (1,350,000 – 2,140,000)	3,200,000 (2,560,000 – 4,040,000)	4,700,000 (3,760,000 – 5,950,000)	6,210,000 (4,960,000 – 7,850,000)
	5%	1,140,000 (910,000 – 1,440,000)	1,890,000 (1,510,000 – 2,390,000)	3,395,000 (2,710,000 – 4,290,000)	4,900,000 (3,910,000 – 6,190,000)	6,400,000 (5,110,000 – 8,090,000)
	10%	1,520,000 (1,210,000 – 1,920,000)	2,270,000 (1,820,000 – 2,870,000)	3,780,000 (3,020,000 – 4,770,000)	5,280,000 (4,220,000 – 6,670,000)	6,790,000 (5,420,000 – 8,580,000

Supplementary Table 7 – Estimated Cost per Case and UK Inpatient, Post-Discharge and Total Costs from 2030 – 2040 with Discounting (3.5%) from 2025. Data presented as mean, lower bound (LB) and upper bound (UB) in Great British Pounds (£).

Year	**Cost**					
	Inpatient		**Post-Discharge**		**Total**	
	Per Case £	**UK £, (LB – UB)**	**Per Case £**	**UK £, (LB – UB)**	**Per Case £**	**UK £, (LB – UB)**
2030	11,770	32,830,000 (26,210,000 – 41,480,000)	2,630	7,330,000 (5,850,000 – 9,260,000)	14,390	40,150,000 (32,060,000 – 50,750,000)
2035	11,210	31,270,000 (24,970,000 – 39,520,000)	2,500	6,980,000 (5,570,000 – 8,820,000)	13,710	38,250,000 (30,540,000 – 48,340,000)
2040	10,680	29,790,000 (23,790,000 – 37,650,000)	2,380	6,650,000 (5,310,000 – 8,400,000)	13,060	36,440,000 (29,100,000 – 46,050,000)

References

[1] Hutchinson PJ, Edlmann E, Hanrahan JG, Bulters D, Zolnourian A, Holton P, et al. A randomised, double blind, placebo-controlled trial of a two-week course of dexamethasone for adult patients with a symptomatic Chronic Subdural Haematoma (Dex-CSDH trial). *Health Technology Assessment*. 2024;28(12):1-122. doi:10.3310/XWZN4832

[2] Jones KC, Weatherly H, Birch S, Castelli A, Chalkley M, Dargan A, et al. Unit Costs of Health and Social Care 2022 Manual. doi:10.22024/UniKent/01.02.100519

[3] NRS Web Continuity Service. https://webarchive.nrscotland.gov.uk/20231202154959/https://www.isdscotland.org/Health%2DTopics/Finance/Costs/File-Listings-2013.asp. Accessed May 3, 2024

NOTE: Please save this file locally before filling in the table, DO NOT work on the file within your internet browser as changes will not be saved. Adobe Acrobat Reader (available free here) is recommended for completion.

The ARRIVE guidelines 2.0: author checklist

The ARRIVE Essential 10

These items are the basic minimum to include in a manuscript. Without this information, readers and reviewers cannot assess the reliability of the findings.

Item		Recommendation	Section/line number, or reason for not reporting
Study design	1	For each experiment, provide brief details of study design including: a. The groups being compared, including control groups. If no control group has been used, the rationale should be stated. b. The experimental unit (e.g. a single animal, litter, or cage of animals).	98 to 147
Sample size	2	a. Specify the exact number of experimental units allocated to each group, and the total number in each experiment. Also indicate the total number of animals used. b. Explain how the sample size was decided. Provide details of any *a priori* sample size calculation, if done.	106 to 109 190 to 199
Inclusion and exclusion criteria	3	a. Describe any criteria used for including and excluding animals (or experimental units) during the experiment, and data points during the analysis. Specify if these criteria were established *a priori*. If no criteria were set, state this explicitly. b. For each experimental group, report any animals, experimental units or data points not included in the analysis and explain why. If there were no exclusions, state so. c. For each analysis, report the exact value of *n* in each experimental group.	NA
Randomisation	4	a. State whether randomisation was used to allocate experimental units to control and treatment groups. If done, provide the method used to generate the randomisation sequence. b. Describe the strategy used to minimise potential confounders such as the order of treatments and measurements, or animal/cage location. If confounders were not controlled, state this explicitly.	NA
Blinding	5	Describe who was aware of the group allocation at the different stages of the experiment (during the allocation, the conduct of the experiment, the outcome assessment, and the data analysis).	NA
Outcome measures	6	a. Clearly define all outcome measures assessed (e.g. cell death, molecular markers, or behavioural changes). b. For hypothesis-testing studies, specify the primary outcome measure, i.e. the outcome measure that was used to determine the sample size.	110 to 166
Statistical methods	7	a. Provide details of the statistical methods used for each analysis, including software used. b. Describe any methods used to assess whether the data met the assumptions of the statistical approach, and what was done if the assumptions were not met.	156 to 166
Experimental animals	8	a. Provide species-appropriate details of the animals used, including species, strain and substrain, sex, age or developmental stage, and, if relevant, weight. b. Provide further relevant information on the provenance of animals, health/immune status, genetic modification status, genotype, and any previous procedures.	NA
Experimental procedures	9	For each experimental group, including controls, describe the procedures in enough detail to allow others to replicate them, including: a. What was done, how it was done and what was used. b. When and how often. c. Where (including detail of any acclimatisation periods). d. Why (provide rationale for procedures).	NA
Results	10	For each experiment conducted, including independent replications, report: a. Summary/descriptive statistics for each experimental group, with a measure of variability where applicable (e.g. mean and SD, or median and range). b. If applicable, the effect size with a confidence interval.	189 to 223

The Recommended Set

These items complement the Essential 10 and add important context to the study. Reporting the items in both sets represents best practice.

Item		Recommendation	Section/line number, or reason for not reporting
Abstract	11	Provide an accurate summary of the research objectives, animal species, strain and sex, key methods, principal findings, and study conclusions.	15 to 43
Background	12	a. Include sufficient scientific background to understand the rationale and context for the study, and explain the experimental approach. b. Explain how the animal species and model used address the scientific objectives and, where appropriate, the relevance to human biology.	45 to 91
Objectives	13	Clearly describe the research question, research objectives and, where appropriate, specific hypotheses being tested.	93 to 97
Ethical statement	14	Provide the name of the ethical review committee or equivalent that has approved the use of animals in this study, and any relevant licence or protocol numbers (if applicable). If ethical approval was not sought or granted, provide a justification.	NA
Housing and husbandry	15	Provide details of housing and husbandry conditions, including any environmental enrichment.	NA
Animal care and monitoring	16	a. Describe any interventions or steps taken in the experimental protocols to reduce pain, suffering and distress. b. Report any expected or unexpected adverse events. c. Describe the humane endpoints established for the study, the signs that were monitored and the frequency of monitoring. If the study did not have humane endpoints, state this.	NA
Interpretation/ scientific implications	17	a. Interpret the results, taking into account the study objectives and hypotheses, current theory and other relevant studies in the literature. b. Comment on the study limitations including potential sources of bias, limitations of the animal model, and imprecision associated with the results.	302 to 337
Generalisability/ translation	18	Comment on whether, and how, the findings of this study are likely to generalise to other species or experimental conditions, including any relevance to human biology (where appropriate).	NA
Protocol registration	19	Provide a statement indicating whether a protocol (including the research question, key design features, and analysis plan) was prepared before the study, and if and where this protocol was registered.	NA
Data access	20	Provide a statement describing if and where study data are available.	NA
Declaration of interests	21	a. Declare any potential conflicts of interest, including financial and non-financial. If none exist, this should be stated. b. List all funding sources (including grant identifier) and the role of the funder(s) in the design, analysis and reporting of the study.	352 to 365

Chronic Subdural Haematoma: A UK Cost Description Analysis

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Word Count: 4087 (excluding references).

Disclosure of interests: the authors report that there are no competing interests to declare.

Chronic Subdural Haematoma: A UK Cost Description Analysis

Purpose: Chronic subdural haematoma (cSDH) is a prevalent neurosurgical condition with an increasing incidence. Most cSDH occur in patients with complex perioperative needs and emerging clinical practice guidelines could provide substantial benefit. This study sought to understand current and future health service costs to inform guideline implementation.

Materials and methods: We utilised Cambridge University Hospital neurosurgical network data, published UK national audit data and unit cost data. This included predicted operative cases (including upper and lower bounds (UB, LB)), length of stay, laterality, recurrence rate and ambulance transfers. Costs were predicted in 5-year intervals to 2040 and adjusted for inflation (2.5% estimated) and shifting demographics (Office of National Statistics predictions). We estimated the savings of a 5, 10, 20, 30 and 40% reduction in length of stay and a 2.5, 5 and 10% reduction in post-discharge care costs.

Results: In 2025, operative cSDH is estimated to cost £15,100 per case and £42,150,000 across the UK. By 2040, this will rise by 45% and 88%, respectively. If guideline implementation can produce a 20% reduction in the length of neurosciences unit stay and 5% reduction in post-discharge costs, the anticipated total savings in 2025 are £1,220 per case and £3,395,000 UK wide. This will rise approximately two-fold by 2040.

Conclusion: cSDH has a significant, and increasing, economic impact. Integrated multidisciplinary care, like that advocated by emerging cSDH guidance, has achieved cost savings in other settings and our results suggest potential total UK savings of £3,395,000 per year in 2025 across the UK. However, the results must be viewed in terms of extrapolation from regional data, predicted inflation and consistent pattern of admission between secondary and tertiary care. Moreover, they do not consider additional benefits, including increased operative and hospital capacity.

Keywords: chronic subdural haematoma, cost, guidelines, economic

Introduction

A chronic subdural haematoma (cSDH) is a collection of blood, its degradation products and fluid within the subdural space.[1,2] cSDH can be incidental, but symptomatic cases are normally treated by neurosurgical drainage. Patients with cSDH are typically elderly, frail, and have significant comorbidities, resulting in complex perioperative needs.[3–5] Although the exact estimate of incidence varies between settings and case definitions (1/100,000/year – 60/100,000/year), data suggests that as demography shifts in the coming decades, the incidence of cSDH will rise.[5–9] Modelling from the UK forecasts a 50% increase in operative demand by 2040, a figure broadly matched by larger studies from the US.[7,10]

Although the morbidity and mortality of cSDH is significant, to date cSDH has lacked clear, evidence-based guidelines for management.[4,11,12] This gap is important, as adoption of guideline and audit driven multidisciplinary working practices in the management of neck of femur fractures, a condition to which cSDH has been compared, has shown significant benefits in improving outcomes.[13–16] Evidence suggests that the implementation of hip fracture guidance has produced 20 – 40% reductions in the length of hospital stay (LOS).[17–19] However, there is little clear data about how these guidelines decrease the post-discharge costs associated with hip fracture care.

Using novel co-design methods, the *Improving Care in Elderly Neurosurgery Initiative (ICENI*) group have now developed the first clinical practice guideline for cSDH, advocating a drive towards integrated, cross-centre, multidisciplinary working.[20] This is in reaction to a sequential identification of the challenges facing patients with cSDH.[21,22]

Guideline implementation can be challenging, as is likely the case in cSDH, where enaction of emerging guidance would reflect a paradigm shift from current working strategies. Understanding the current and anticipated costs of treating cSDH is an important component of engaging stakeholders and supporting the case for change. This is especially timely as work transitions towards a greater understanding of what an intervention to implement these guidelines might look like.

Attempts to estimate the costs of managing subdural haemorrhage have been made previously but figures are limited by well-recognised deficiencies in current coding systems for differentiating cases of chronic and acute subdural haematoma.[6,23–27] This is problematic, as aSDH is often associated with high impact trauma, other injuries, and affects a younger demographic.[28]

Management of undifferentiated acute and chronic SDH cost the US $1.6 billion nationally, with a median of $10,000 per hospitalisation in 2007 costs.[24] Similar costs were found in a US single-centre study (2008 costs).[23] In a Swiss study, the mean total cost of treating a cSDH was around 20,000 CHF (2016 costs) while a single centre Finnish study found a mean total cost of 5250€ per cSDH hospitalisation (2018 costs).[6,26] In all studies, the hospital stay, rather than the operative costs, was the greatest contributor to the overall cost, therefore it follows that the greatest economic savings will be seen if the length of hospital stay (LOS) is decreased.[6,23,24,26]

Our study had two aims. Firstly, to estimate the projected costs both per operative case, and UK wide, from 2025 – 2040, factoring in predicted rises in case numbers.[7] Secondly, to estimate the savings that could be achieved if emerging guidelines could bring about a reduction in neuroscience unit (NSU) LOS and health care post-discharge costs comparable to that seen in hip fracture.[17–19]

Materials and Methods

Referral route and length of stay

Neurosurgical care operates on a centralised system, with patients diagnosed in non-specialist units and referred to a neuroscience unit (NSU) for specialist advice and surgery. We used previously published data from the Cambridge University Hospital-based neurosurgical network to extract patterns of admission (e.g., direct admission to the NSU, referral from a district hospital, repatriation to a district hospital) as well as LOS in NSU and referring hospitals.[4,29]

Projections of Case Numbers and Inflation

The projected regional case numbers for Cambridgeshire, Bedfordshire, Suffolk, and Norfolk were taken from published studies and scaled to the total UK population using figures from the office for national statistics (ONS).[7,30]

Economic Costings

Costs were estimated from a UK NHS and Personal Social Services (PSS) perspective, as recommended by the National Institute for Health and Care Excellence (NICE), where published unit costs (detailed below) were adjusted to account for actual/expected inflation.[31] It should therefore be noted that the post-discharge costs which we use do not include estimates of costs associated with time spent in a care home, unpaid carer costs or lost productivity due changes in employment.[32] Early data on care needs from our network suggests that these costs may be substantial.[29]

Inpatient Stay

To calculate the costs of the inpatient stay, 2017/2018 costs for a unilateral surgical procedure, bilateral surgical procedure, ward bed per day and neurosciences unit bed per day were taken from a health economic analysis of a published RCT and the 2021/2022 costs of an ambulance journey (a core component of transfer between secondary and tertiary care) was taken from published NHS National Cost Data (**Supplementary Table 1**).[32,33] These were adjusted to 2025, 2030, 2035 and 2040 predicted costs using the NHS inflation figures from 2017/2018 to 2021/2022, with an assumed inflation rate of 2.5% from 2021/2022 to 2040 (**Supplementary Table 2**).[33] Although 45% of patients had a post-operative CT scan, this accounted for approximately 0.3% of the total cost, and for this reason, was excluded from the analysis post-hoc.

Post-Discharge Care

Post-discharge care costs, an amalgamation of the costs of health care professional visits, readmission, reoperation, further imaging and more, were taken from a health economic analysis of a published RCT (**Supplementary Table 1**) and adjusted to 2025, 2030, 2035 and 2040 predictions using an inflation factor, as specified above (**Supplementary Table 2**).[32] Post-discharge care costs were apportioned to all participants for a period of six months post-index operation and our calculations do not consider costs beyond that.

Projected Savings

Projected savings for a 5, 10, 20, 30 and 40% reduction in neurosciences unit length of stay and a 2.5, 5 and 10% reduction in post-discharge care costs were calculated from 2025 to 2040 using the above data. Evidence suggests that the implementation of guidelines in hip fracture care has produced 20 – 40% reductions in the length of hospital stay.[17–19] There is little clear evidence about the typical reduction in post-discharge care costs (especially from a predominantly NHS rather than PSS perspective), and so we made conservative estimates of 2.5, 5 and 10%. **The assumption of a post-discharge care cost reduction is predicated on the assumption that better peri-operative care increases physical functioning and rehabilitation. This is consistent with work in the setting of hip fractures where it is associated with increased number of patients returning to their pre-injury residence with associated reduction in post-discharge care costs.**[34–37]

Discounting

NICE recommend discounting future costs by 3.5% per annum, and presenting costs with and without discounting[31]. Since discounting is only likely to alter the magnitude but not direction of our relationship, undiscounted costs are presented in the main text, and discounted costs per case and UK costs are presented in the supplementary material (**Supplementary Table 7**).

Data analysis

An Excel (Microsoft, California, USA) spreadsheet was created containing the year, projected regional operative case numbers, projected UK operative case numbers, estimated unit costs (**Supplementary Table 1**), inflation factor (**Supplementary Table 2**) and pattern of disease and care.[7] This data was used to estimate the inpatient, post-discharge and total cost per case, and the inpatient, post-discharge, and total UK cost in Great British Pounds (GBP). A similar set of calculations were performed to estimate the savings per case and UK savings for a 5, 10, 20, 30 and 40% reduction in length of neurosciences unit stay and a 2.5, 5 and 10% reduction in post-discharge costs. All estimated costs were rounded to the nearest £5, £100 or £10,000 as appropriate. Data was exported to R (4.3.2) for the creation of figures using the ggplot2 package.

Assumptions

Our analysis makes several important assumptions. Firstly, we assumed inflation would be 2.5%, every year, until 2040. It is not possible to predict inflation until 2040 with great certainty but 2.5% is the approximate average of the last 35 years.[38] Secondly, we assumed that the patterns of disease and care (e.g., proportion of stay between secondary and tertiary care as well as ward level and higher dependency care costs) are homogenous both geographically and temporally. Thirdly, we assumed that a patient with a recurrence has the same pattern of disease and care as their original cSDH (e.g., a patient who is directly admitted to the NSU will also be directly admitted to NSU with a recurrence). Fourthly, we assume that there is no significant change in the quality or nature of care received between now and 2040 that may decrease the length of stay or otherwise decrease the cost (e.g., novel, cheaper intervention). Finally, we have only considered operative cases, rather than the non-operative cases as data for this cohort is sparse.

Presentation of results

Data regarding projected case numbers are presented as the expected number of cases with the 95% confidence (CI) interval.[7] For the cost analysis, the mean cost with the upper bound (UB) and lower bound (LB) is presented (mean, LB – UB) based on the upper and lower bounds of the projected case numbers 95% CI.[7]

Results

Patterns of Disease and Care

By 2040, the estimated regional (Suffolk, Cambridgeshire, Norfolk, Bedfordshire) and UK operative case load is 174 (95% CI: 140 – 219) and 3623 operative cases per year (95% CI: 2913 – 4560), respectively (**Supplementary Table 3**). Based on current disease and care patterns, 75% of patients suffer unilateral cSDH, 25% have bilateral cSDH, 9% have a recurrence, 7.4% are directly admitted and discharged from the neurosciences unit, 54.8% are admitted elsewhere, transferred to, and discharged from, the neurosciences unit and discharged from there and finally, 37.8% are admitted elsewhere, transferred to the neurosciences unit and then repatriated back to, and discharged from, the initial referring unit (**Figure 1**).[4,7,29,32]

Projected Costs

In 2025, the estimated average inpatient, post-discharge and total costs per case are £12,300, £2,800, and £15,100, respectively (**Table 1, Figure 1**). When scaled to the UK population, the estimated inpatient, post-discharge, and total costs are £33,460,000 (£27,520,000 – 43,550,000), £7,690,000 (£6,140,000 - £9,720,000) and £42,150,000 (£33,660,000 - £53,270,000), respectively (**Table 1, Figure 1**). These costs are driven predominantly by the NSU stay (35.7%), non-NSU stay (21.1%), post-discharge care

(18.3%), with smaller contributions from surgery (12.1%), recurrence (9.3%) and ambulance transfer (3.6%) (**Figure 1**).

Projected Savings

In 2025, a 20% reduction in neurosciences unit length of stay is estimated to save £1,080 per case and £3,010,000 (£2,410,000 – £3,810,000) UK wide, which rises to £1,560 per case and £5,660,000 (£4,550,000 – £7,110,000) UK wide in 2040 (**Supplementary Table 4 and 5, Figure 2a**). Similarly, a 5% decrease in post-discharge care costs in 2025 is estimated to save £140 per case and £385,000 (£310,000 – £485,000) UK wide, which rises to £200 per case and £725,000 (£580,000 – £910,000) in 2040 (**Supplementary Table 4 and 5, Figure 2b**).

In 2025, a combined 20% reduction in neurosciences unit length of stay and 5% reduction in post-discharge care costs is estimated to save £1,220 per case and £3,395,000 UK wide (**Figure 3, Supplementary Tables 4, 5 and 6**). This can be scaled to 2030, 2035 and 2040 using a factor of 1.3, 1.6 and 1.9. The savings with different length of stay reductions for 50, 100, 150 and 200 cases per year in 2025 is shown in **Figure 4**. This can be scaled to 2030, 2035 and 2040 using a factor of 1.1, 1.3 and 1.5.

Discussion

Currently, we estimate that treating an operative case of cSDH until six months post-discharge, from an NHS and PSS perspective, costs £15,100 per case, with a UK total cost of £42,150,000 (£33,660,000 – £53,270,000). By 2040, inflation is expected to increase the per case cost by 45% to £21,900. The total UK cost, driven by inflation and increasing predicted case numbers, is expected to increase by 88% to £79,250,000

(£63,735,000 – £99,750,000) by 2040. In 2018/2019, the annual spend on neurosurgical services in England was £660 million.[39] Extrapolating this to the UK as a whole based on population estimates, and inflating to 2025 and 2040 predictions, the UK neurosurgical services spend is estimated to be £970 million in 2025 and £1.4 billion in 2040, respectively. As such, the costs of treating cSDH is significant and occupies approximately 5% of the neurosurgical services budget.

Overall, 75% of costs are driven by the NSU stay (35.7%), non-NSU stay (21.1%) and post-discharge care (18.3%). Given that the NSU stay, and post-discharge care is common to all patients, and is amenable to change via guideline implementation, this is a key area for intervention to decrease costs.[6,23,24,26] Therefore, in 2025, a 40% reduction in length of NSU stay could save £2,160 per case and £6,020,000 for the UK while a 10% reduction in post-discharge care costs could save an additional £275 per case and £770,000 for the UK. A more conservative, and likely more realistic estimate, based on hip fracture care, is a 20% reduction in length of NSU stay, which is estimated to save £1,080 per case and £3,010,000 for the UK, and a 5% reduction in post-discharge care costs, which could save £140 per case and £385,000 for the UK in 2025.[17–19]

cSDH treatment (burr hole decompression with a drain) lasts around 72 hours, but is followed by a prolonged hospital stay in the NSU or referring hospital (up to 19.6 days, SD: 32.1).[4] The lack of clear guidance on key perioperative decisions, such as anticoagulation, may be a contributor to prolonged post-operative neurosciences unit stay; with anticoagulated patients suffering a prolonged post-operative stay compared to those not on baseline anticoagulants.[4] It is therefore possible that reductions in length of NSU stay beyond 40% are possible, but this remains to determined. Similarly, it is not clear how valid our 2.5, 5 and 10% reductions in post-discharge care costs are, and additional savings may be possible with guideline implementation.

As part of our analysis, we stratified the costs by pattern of care (**Figure 1**) and identified that pattern three (DGH-NSU-DGH-discharge) have the greatest cost per case, followed by pattern one (NSU-discharge) and then pattern two (DGH-NSU-discharge). However, on a population scale, the position of pattern one and two is reversed, because pattern one, at least in the East of England, is rather uncommon (7.4%). These findings will be important in identifying areas of priority when improving services and decreasing costs.

Strengths, Assumptions and Limitations

The main strength of this study lies in its case definition. The ICD codes for SDH are unreliable for defining cases, and do not reliably distinguish acute SDH and cSDH.[25] Incidence figures here were drawn from studies using a clinician-coded database and cross-referenced with theatre activity to determine operative cases of cSDH.[7] Moreover, cases at the periphery of the region (i.e., those at the boundary of neurosurgical centres) were excluded to refine the case definition.

A further strength of our work is the robustness with which we have drawn on detailed examination of the regional patient pathway, including the costs of the inpatient admission and post-discharge care, including up to six months post-operation. The costs beyond this are not known but would only serve to increase the estimate of the total costs, and therefore, our post-discharge cost estimate is likely an underestimate.

Our results must be viewed as an estimate in the context of our numerous assumptions. In particular, we assumed that the pattern of disease and the nature and quality of care are geographically and temporally homogenous, which are unlikely to be true. For example, it is documented that the cSDH length of stay has decreased with time.[6,23] In our analysis, we extrapolated the pattern of disease and the nature of care from regional data (East of England) to the UK population as a whole, which may be misleading. Additionally, we did not include additional benefits of a decreased length of stay, such as increased hospital and operative capacity, in our analysis. Moreover, we estimated post-discharge care costs from **a** published study in which post-discharge levels of resource use were missing (due to non-response) for nearly 30% of patients and only measured until six months post-discharge.[32]

More generally, our assumptions mean it is likely that our figures are underestimates of the true costs. We were, for example, not able to reliably consider the costs associated with care home use or all carer costs which would likely represent a significant additional cost, especially as preliminary data suggests that individuals repatriated to local hospitals following surgery exhibit significant rates of new care need.[29] Beyond this, data regarding post-discharge social care is minimal, particularly the specifics of what that care involves, how long it lasts for, and how it is funded (e.g., personal vs government). This represents a crucial avenue for further work.

Implications

Although this current work is based on several assumptions, it aligns with the results of other studies. In a Swiss study, the mean cost of cSDH treatment was approximately 18,000 – 21,000 CHF in 2016 costs.[26] Adjusted for inflation and the exchange rate, this is approximately £30,000 by 2040. Although this is a higher estimate than ours, there are likely to be differences in the costs of providing healthcare between Switzerland and the UK, as well as the fact that the protocols may be different. Indeed, Switzerland is now recognised to have the second highest direct healthcare costs of any nation.[40] Similarly, in a Finnish study, the mean total costs per patient from admission to last follow-up were 5,250€ (2018 costs) which translates to approximately £7,700 in 2040.[6] An American study found median total direct costs of $10,000 (2008 costs) but this is a median and did not distinguish between non-operative and operative cases, and acute, subacute and chronic SDH.[23] Moreover, our results indicate that the length of stay is the greatest contributor to overall costs, and this is a finding shared by other studies.[6,23]

The morbidity and mortality associated with cSDH is significant, but the economic consequences of cSDH have not been thoroughly studied. Since the anticipated costs will be paramount in the development and implementation of guidelines that standardise cSDH **care**, it will be essential to conduct a formal economic analysis of the benefits and effectiveness of new guidelines, as well as to estimate the costs of treating cSDH from now until 2040 to determine the accuracy of our predictions. **Currently, it is unclear how pathways and outcomes of cSDH care will be changed by the guidelines, so it was not possible for us to perform a more nuanced cost analysis of treatment, nor to consider the costs of guideline implementation, which is likely to vary substantially between regions and across time. This is especially true as different solutions may well be better suited to specific settings. However, we would expect that the better peri-operative care advocated for in the guideline, with early geriatric assessment, early rehabilitation and minimisation of unnecessary resource use, would decrease the overall costs of cSDH care, including**

NSU length-of-stay, complications, readmissions, re-operations and mortality, as has been seen in hip fracture care.[34–37,41] Moreover, better peri-operative care leads to improved physical functioning and greater likelihood of return to pre-injury residence, which are linked to lower post-discharge care costs.[37] However, this must be balanced against greater commitment to, and engagement with, post-discharge rehabilitation, which may abrogate some post-discharge care cost savings, as seen in some studies of hip fracture care.[34,42] Even if post-discharge care costs are cost-neutral, there are likely to be additional benefits from better rehabilitation which makes the overall pathway more cost-effective.[42] Although we recognise the two conditions are not identical, the parallels between these patient cohorts have been well noted by other authors.[16,43]

Moreover, the treatment of cSDH is constantly evolving and so our baseline costs are likely to vary, potentially to a significant degree, if paradigm shifts in practice occur. One technique, middle meningeal artery embolisation (MMAE) is gaining traction and, although not currently in widespread practice in the UK due to the most recent interventional procedures guidance from NICE, emerging evidence suggests a significant benefit on recurrence rate.[44] Systematic reviews of currently peer-reviewed literature suggests a recurrence rate of 1.4 – 8.9% compared to 10 – 20% when used **adjunctively** with surgery.[45] Based on our analysis and accounting for assumptions, the recurrence pathway amounts to approximately 10% of the total pathway cost for treating cSDH and thus may represent a maximum cost-saving of approximately 1 – 9% of the total cost if MMAE were to become more widespread. These figures should be interpreted cautiously pending peer-reviewed publication of trials reported in abstract form at the 2024 international stroke conference (ISC).[46] We have not ascribed specific numbers to the costing of MMAE, since it is beyond the scope of this research, and many aspects of the procedure, set up, implementation and efficacy remain unclear.

Conclusion

cSDH is an important neurosurgical pathology that is becoming more common and occurring in increasingly frail and co-morbid patients. The development and implementation of guidelines to standardise the care of cSDH is of paramount importance. As part of this, it is necessary to estimate the costs of treating cSDH from admission to discharge as well as the associated post-discharge costs. Using regional data, we estimate the costs of treating a cSDH from admission to six months post-operation and extrapolate this to the UK population estimates from 2025 to 2040. In this time, the total cost per case and total UK cost are estimated to rise by 45% and 88% to be £21,900 and £79,250,000 (£63,735,000 – £99,750,000) in 2040, respectively. If guideline implementation can produce a 20% reduction in the length of neurosciences unit stay and 5% reduction in post-discharge costs, the anticipated total savings are £1,760 per case and £6,380,000 (5,130,000 – 8,030,000) across the UK in 2040.

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Figure 1 – Cost per Case (a) and UK cost (b) from Admission to Discharge in 2025, divided based on patterns of care[4,7,29]. Length of stay presented as mean (SD). District general hospital, DGH; neurosciences unit, NSU; length of stay, LOS.

Figure 2 – UK savings with 5%, 10%, 20%, 30% and 40% neurosciences unit length of stay reduction (a) and 2.5%, 5% and 10% post-discharge care cost reduction (b). Data presented as mean, lower bound (LB) and upper bound (UB) in Great British Pounds (£).

Figure 3 – UK savings with neurosciences unit length of stay reduction and post-discharge care cost reduction in 2025. Scale by 1.26, 1.55 and 1.88 for 2030, 2035 and 2040, respectively. Data presented as mean cost in Great British Pounds (£).

Figure 4 – UK savings with neurosciences unit length of stay reduction for 50, 100, 150 and 200 cases per year in 2025. Scale by 1.13, 1.28 and 1.45 for 2030, 2035 and 2040, respectively. Data presented as mean cost in Great British Pounds (£).