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Original Article

Impact of patient ethnicity, socioeconomic deprivation, and comorbidities on length of stay after cranial meningioma resections: A public healthcare perspective

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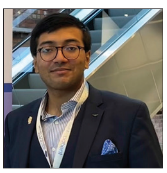

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ABSTRACT

Background: Postoperative hospital length of stay (LOS) is crucial for assessing care quality, patient recovery, and resource management. However, data on how preoperative non-tumor variables affect LOS post-meningioma resection are scarce. We aimed to evaluate how ethnicity, comorbidities, and socioeconomic indices influence LOS after non-skull base meningioma resection.

Methods: A single tertiary center retrospective case series analysis of all patients undergoing non-skull base meningioma resection from 2013 to 2023 was conducted. Fourteen independent variables (age, ethnicity, sex, hypertension, diabetes mellitus [DM], chronic obstructive pulmonary disease [COPD], heart failure, myocardial infarction, stroke, dementia, cancer, index of multiple deprivations [IMD] decile, smoking, and alcohol status) were analyzed to predict the binary outcome of short (≤5 days) or extended (>5) LOS.

Results: Four hundred and seventy-nine patients were analyzed, with 65.8% of patients having a short LOS of ≤5 days. Patient ethnicity (hazard ratio [HR]: 1.160 [1.023–1.315], $P = 0.02$) and the presence of DM (HR: 0.551 [0.344–0.883], $P = 0.013$) and COPD (HR: 0.275 [0.088–0.859], $P = 0.026$) were statistically significant predictors of LOS after meningioma resection. Asian ethnic patients had the highest mean LOS compared to all other ethnicities. Patients with an IMD decile of ≤5 (with a higher degree of health deprivation) had a higher postoperative LOS compared to those with an IMD decile >5, but this was not statistically significant ($P = 0.793$).

Conclusion: Preoperative factors such as ethnicity, deprivation index, and comorbidities can potentially predict postoperative hospital LOS after meningioma resection. There is potential to develop decision support tools integrating these preoperative factors with peri- and post-operative data.

Keywords: Index of multiple deprivation, Length of stay, Meningioma, National health service

INTRODUCTION

Meningiomas represent the most common primary brain tumor and are mostly benign.[47] Prevalent in older adults and females, these tumors harbor select risk factors, such as NF2 gene deletion and exposure to high-dose ionizing radiation.[23] Exposure to female sex hormones has been associated with an increased risk of meningioma, although the biological mechanism behind this is not fully understood.[23] Despite most meningiomas being encapsulated, their intracranial location can lead to severe consequences.[47] Consequently, surgical excision, often complemented by radiotherapy based on resection extent, tumor location, and World Health Organization grade, is the standard treatment.[16]

Given that many studies have implicated length of hospital stay post-surgery as a predictor of postoperative complications, we wanted to assess the factors predisposing patients to prolonged LOS post-resection of non-skull base meningiomas. From a public healthcare perspective, a commonly discussed predictor is socio-economic deprivation. Within the United Kingdom (UK), metrics such as the index of multiple deprivation (IMD), a marker of health disparity, are employed to categorize the relative deprivation of all geographical areas in the country.[25] In this classification, the lowest rank (1) corresponds to the most deprived area, while the highest rank (10) signifies the least deprived area.[25] However, there is limited literature examining the influence of IMD as a discrete variable on patients' LOS post-surgery, particularly in the context of neurosurgery. In addition, analyzing the effects of non-clinical baseline demographic factors, such as age, ethnicity, sex, alcohol, and smoking status, can help promote better clinical decision making, facilitate efficient resource allocation and preoperative patient optimization and counseling.

Thus, this study aims to assess the influence of ethnicity, preoperative comorbidities, and socio-economic deprivation on the length of hospital stay following meningioma resection surgery. As a result, for the 1st time on this topic, we seek to evaluate the effectiveness of such parameters in predicting postoperative LOS in a public healthcare system.

MATERIALS AND METHODS

Data source and feature selection

This study was a single tertiary center retrospective analysis of all patients who had undergone non-skull base meningioma resection at a local neurosurgery unit in the UK from 2013 to 2023. The exclusion criteria removed patients with missing data, non-elective cases, and outlier data points. A total of 479 patients were identified. For further analysis, the results for LOS were converted from a continuous variable into categorical values. Of these patients, 315 had a short LOS (≤5 days), and 164 had a long LOS (>5 days). The distinction of 5 days was decided as this was the median cutoff of LOS in our cohort. The study was blinded and all data was anonymized at source with no traceability to original patients. The IRB thus approved the study, stating that formal patient consent was not required due to the methodology of the study (Reference number: 24HIP22).

Fourteen variables were identified and extracted from the database: age in years, sex, ethnicity, hypertension, heart failure, diabetes mellitus (DM), myocardial infarction, cerebrovascular accident, dementia, smoking status, previous alcohol use, chronic obstructive pulmonary disease, cancer, and IMD. Ethnicity was categorized as per the UK Home Office national census guidelines with five resultant umbrella ethnic groups compressed from the 20 suggested groups. Alcohol use was binarized using the recommended limit of 14 units (as per the National Health Service [NHS]). Smoking status predominantly referred to tobacco use unless otherwise specified. In this study, socio-economic deprivation was measured through IMD. IMD is a measurement of deprivation in a location relative to other locations. This IMD score contributes to an overall Indices of Deprivation value that distinguishes between poverty – being a lack of financial resources, and deprivation – a lack of resources (not limited to financial). Each location within the UK is then scored on seven distinct categories, such as employment, education, crime, etc., which are then grouped into deciles – with the 1st decile being the most deprived area and the 10th decile being the least.

Statistical analysis

All statistical analysis was conducted using the R coding language version 3.4.3 (The R Foundation, Vienna, Austria) and the IBM Statistical Package for the Social Science (SPSS) software (SPSS Inc., Chicago, IL, USA) Version 28 for Mac. Analysis of inter-variable associations was conducted utilizing the Chi-squared test to evaluate categorical data distinctions, whereas continuous data were assessed using the independent samples *t*-test/analysis of variance (ANOVA) tests. To depict the discharge probability trajectories of patients over time, stratified by various prognostic indicators, Kaplan–Meier survival curves were generated utilizing the "survival" package within R. Log-rank tests were used for intergroup pairwise comparisons between the classes of each variable. Subsequently, a multivariate Cox proportional hazards regression model with a forward stepwise selection approach was developed to identify the predictors that had a statistically significant impact on postoperative LOS. $P < 0.05$ was considered statistically significant.

RESULTS

Baseline patient characteristics

In this study, 479 patients who underwent meningioma resection were included to evaluate the impact of predictors of LOS in hospital post-surgery. The mean age of the cohort was 53.93 (± 14.28) and had a female predominance (70.1%). The majority of patients in the cohort were ethnically caucasian (85.6%), had an IMD decile of ≤5 (52.2%), reported previous alcohol use (61.2%), were non-smokers (68.3%), and had no co-morbidities (66.0%). The mean LOS for the total cohort was 4.3 days/103.79 h. ANOVA test results revealed a statistically significant difference in the mean LOS for patients when stratified by ethnicity (*P* = 0.017), with *post hoc* analysis demonstrating a significant difference only between patients of Asian ethnicity and those from any other background. Spider plot analysis further demonstrates the distribution of average LOS across all ethnic groups [Figure 1]. Univariable Chi-square analysis further revealed that patient age (*P* = 0.003) and the presence of hypertension (*P* = 0.020), DM (*P* = 0.006), and COPD (*P* = 0.001) had a statistically significant association with a longer LOS. Detailed cohort demographics for this study are summarized in Table 1.

Time to discharge analysis

Kaplan–Meier analysis was performed to analyze the time to discharge for each variable [Figure 2]. Log rank test results revealed ethnicity (*P* = 0.013), [Figure 2b] and the presence of preoperative DM (*P* = 0.013), [Figure 2d] and COPD (*P* = 0.007), [Figure 2e] to be the only statistically significant variables associated with LOS. All other predictor variables were non-significant [Figure 2a,c,f-i]. Patients with an IMD decile of ≤5, that is, a higher degree of health deprivation, had a higher postoperative LOS (104.27 ± 44.80) compared to those with an IMD decile >5 (103.27 ± 37.88), but this was not statistically significant (*P* = 0.793).

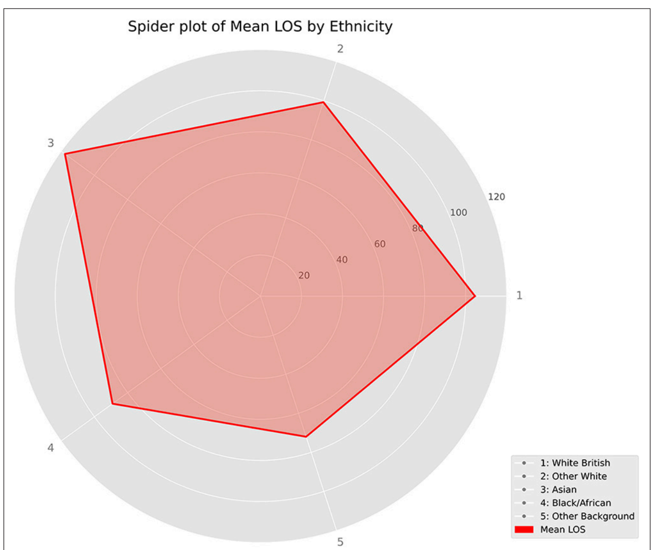

Figure 1: Spider plot demonstrating the distribution of mean length of stay across five different ethnic groups in our patient cohort.

Multivariable Cox proportional hazard regression modeling identified patient ethnicity, DM, and COPD as significant predictors of LOS. The results are highlighted in Table 2 and Figure 3. The backward regression method was used as it successively removed non-significant variables based on the likelihood ratio test and allowed us to see which covariates had a significant impact on length of stay. Patient ethnicity (hazard ratio [HR]: 1.160 [1.023–1.315], *P* = 0.02), absence of DM (HR: 0.551 [0.344–0.883], *P* = 0.013), and absence of COPD (HR: 0.275 [0.088–0.859], *P* = 0.026) were significantly associated with having a short LOS. Of note, analysis of additional predictors of extended LOS, patient sex demonstrated a trend toward significance, with female patients having a longer LOS than male patients (HR: 0.718 [0.509–1.015], *P* = 0.06). The overall Harrell's concordance index of the model was 0.761.

DISCUSSION

To the best of our knowledge, this is the first study to have analyzed the impact of comorbidities and patient demographics on post-meningioma length of stay in the NHS in the UK. There are previous studies, particularly from private healthcare systems, investigating the influence of preoperative variables on postoperative LOS for surgically resected meningiomas,[6,11,26,36,38] but this is the first study to explore the impact of socio-economic deprivation, particularly through the application of IMD deciles, and non-clinical/clinical patient characteristics and demographics on postoperative LOS in a public healthcare system. Our multivariable time to discharge analysis identified three main contributors to extended LOS – ethnicity (Asian), DM, and chronic obstructive pulmonary disease (COPD). Importantly, our findings were not able to identify any significant relationship between IMD and LOS.

IMD is a well-established and validated metric for assessing relative deprivation in small geographic areas within the U.K.[25] It provides a comprehensive overview of the overall deprivation level in a given area and it is used to guide resource allocation and prioritization of policies to address health inequalities.[30] This is important as the Marmot review found socioeconomic deprivation to be a significant contributor to poor health.[15] Nevertheless, despite the associations between IMD and health outcomes, such as co-morbidities and longer hospital stays, some studies, including ours, found no significant link between IMD deciles and LOS post-craniotomy.[5,24,28,45] Neurosurgical services in the UK are centralized in a relatively small number of centers.[24] This centralization thus diminishes the impact

Table 1: Cohort demographics with descriptive statistical analysis using *t*-tests for continuous variables (Mean [±Standard Deviation]) and Chi-square tests for categorical variables (*n* [%]).

	Length of stay categories		Total (*n*=479)	*P*-value
	Short (≤5 days)	Extended (>5 days)		
Age (years)	52.62 (±14.35)	56.46 (±13.84)	53.93 (±14.28)	0.003
Ethnicity (%)				
White British	267 (65.1)	143 (34.9)	410 (85.6)	0.227
Other white background	15 (62.5)	9 (37.5)	24 (5.0)	
Asian origin	15 (65.2)	8 (34.8)	23 (4.8)	
African/Caribbean origin	6 (60.0)	4 (40.0)	10 (2.1)	
Any other background	12 (100.0)	0 (0.0)	12 (2.5)	
Sex (%)				
Female	220 (65.5)	116 (34.5)	336 (70.1)	0.840
Male	95 (66.4)	48 (33.6)	146 (29.9)	
Hypertension (%)				
No	239 (68.9)	108 (31.1)	347 (72.4)	0.020
Yes	76 (57.6)	56 (42.4)	132 (27.6)	
Heart failure (%)				
No	314 (65.7)	164 (34.3)	478 (99.8)	0.470
Yes	1 (100.0)	0 (0.0)	1 (0.02)	
Diabetes (%)				
No	296 (67.6)	142 (32.4)	438 (91.4)	0.006
Yes	19 (46.3)	22 (53.7)	41 (8.6)	
Myocardial infarction				
No (%)	315 (65.8)	164 (34.2)	479 (100.0)	–
Yes	0	0	0	
Cerebro–vascular accident				
No (%)	315 (65.8)	164 (34.2)	479 (100)	–
Yes	0	0	0	
Dementia				
No (%)	315 (65.8)	164 (34.2)	479 (100)	–
Yes	0	0	0	
COPD (%)				
No	312 (67.0)	154 (33.0)	466 (97.3)	0.001
Yes	3 (23.1)	10 (76.9)	13 (2.7)	
Cancer (%)				
No	306 (66.1)	157 (33.9)	463 (96.7)	0.415
Yes	9 (56.3)	7 (43.8)	16 (3.3)	
Smoking (%)				
No	220 (67.3)	107 (32.7)	327 (68.3)	0.305
Yes	95 (62.5)	57 (37.5)	152 (31.7)	
Alcohol use (%)				
No	125 (67.2)	61 (32.8)	186 (38.8)	0.596
Yes	190 (64.8)	103 (35.2)	293 (61.2)	
IMD decile (%)				
1	49 (62.0)	30 (38.0)	79 (16.5)	0.894
2	34 (64.2)	19 (35.8)	53 (11.1)	
3	29 (61.7)	18 (38.3)	47 (9.8)	
4	22 (68.8)	10 (31.3)	32 (6.7)	
5	28 (71.8)	11 (28.2)	39 (8.1)	
6	29 (74.4)	10 (25.6)	39 (8.1)	
7	31 (68.9)	14 (31.1)	45 (9.4)	
8	41 (68.3)	19 (31.7)	60 (12.6)	
9	23 (59.0)	16 (41.0)	39 (8.1)	
10	29 (63.0)	17 (37.0)	46 (9.6)	

IMD: Index of multiple deprivation

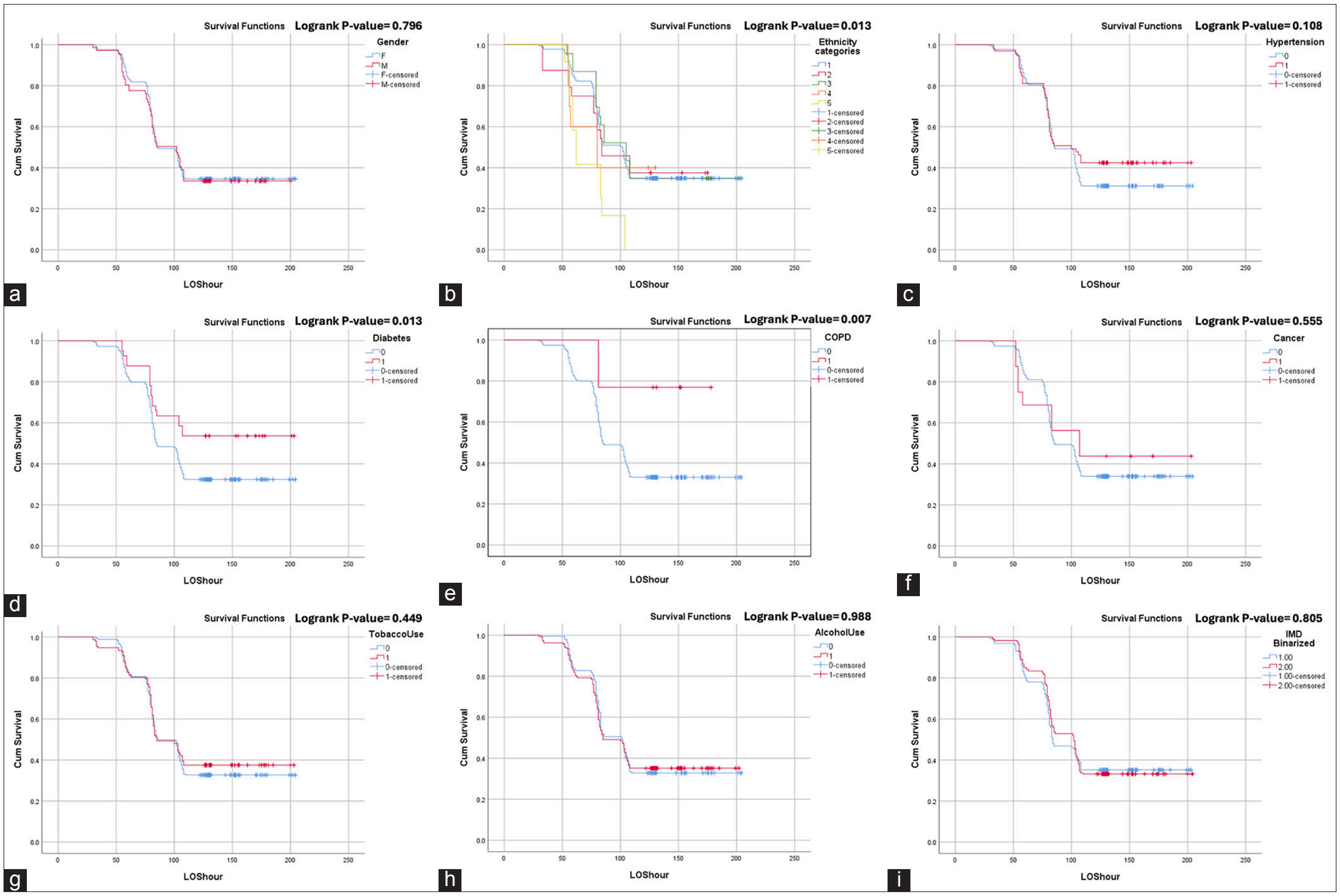

Figure 2: Univariable time to discharge Kaplan-Meier analysis; (a) gender, (b) ethnicity, (c) hypertension, (d) diabetes, (e) COPD, (f) cancer, (g) tobacco use, (h) alcohol use, and (i) IMD binarized. COPD: Chronic obstructive pulmonary disease, IMD: Index of multiple deprivations.

Table 2: Multivariable cox proportional hazards regression model co-efficients to predict postoperative length of stay.

	Hazard ratio	95% CI	*P*-value
Age	0.995	0.987–1.003	0.196
Ethnicity	1.160	1.023–1.315	0.020
Sex	0.987	0.772–1.262	0.915
Hypertension	0.937	0.711–1.235	0.643
Diabetes	0.551	0.344–0.883	0.013
COPD	0.275	0.088–0.859	0.026
Cancer	1.201	0.609–1.370	0.597
Smoking	1.073	0.834–1.380	0.583
Alcohol use	1.099	0.867–1.394	0.435
IMD	1.258	0.913–1.733	0.160

IMD: Index of multiple deprivation, CI: Confidence interval, COPD: Chronic obstructive pulmonary disease

of socioeconomic status, as care is standardized even in units serving socioeconomically deprived populations, and therefore, the value of a patient's postcode is perhaps negated.[24] In addition, the U.K. is a public healthcare system, and discrepancies in outcomes for brain tumor patients are less likely to appear compared to private health care systems.[3,9,10,24] Having said this, a study showed that even within a public health care system, differences in income or educational achievement (subdomains of deprivation) impact preoperative performance status, which can then influence postoperative outcomes.[3] Furthermore, the disparities in clinical outcomes created by socioeconomic deprivation are greatest for diseases with influential behavioral components, such as lung cancer and liver disease.[20] Therefore, while sparse literature exists on the influence of IMD on outcomes for neurosurgical patients, we suggest that IMD may be less likely to impact the post-resection length of stay for meningiomas, given the etiology, nature, and management of the disease within the UK.[24,40]

Ethnic disparities in neuro-oncology patients have been extensively documented.[10,27,33] In general, previous publications have found that non-white patients have worse outcomes than their white counterparts. Non-caucasian and Asian patients, in particular, are significantly more likely to develop postoperative complications and have higher rates of non-routine discharge, which contributes to significantly longer hospital stays.[27,33,38,41,44] Population-based data from the USA have shown that the incidence of meningioma is

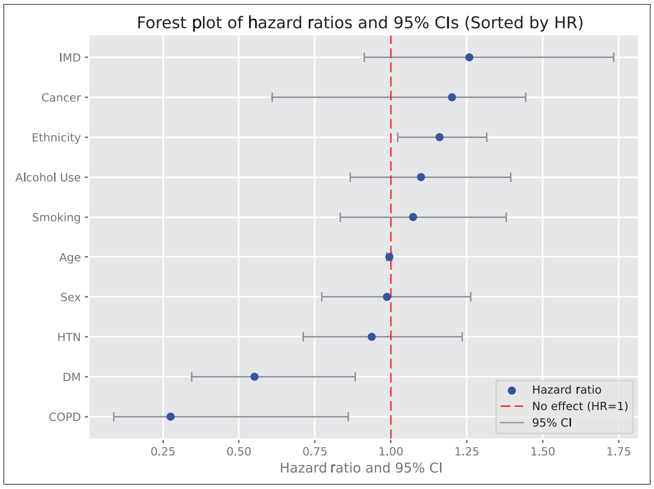

Figure 3: Forest plot of the hazard ratios (HR) and 95% confidence intervals (CI) for the multivariable Cox regression model.

significantly higher in black people compared to their white counterparts.[34] Our results do not support these findings but this may be a reflection of the different demographic composition within the two countries.

In our study, ethnicity was a significant predictor of a short LOS, and Asian patients tended to have a higher mean LOS (117.78 ± 10.54) [Figure 1]. This is not surprising given that previous findings reported in the literature show that Asian patients have an increased risk of prolonged LOS, even when controlling for demographic and socioeconomic variables.[26,41] It is important to acknowledge that there was a significant imbalance in patient demographics within our study cohort which could influence the observed LOS disparities. Specifically, 85.6% of our patients were of White ethnicity, whereas Asian and African/Caribbean patients constituted only 4.8% and 2.1% of the total patient population, respectively.

The longer LOS observed in Asian patients may be explained by cultural influences on healthcare decision-making.[4] Western cultures promote shared decision-making, while some other cultures, with a more traditional approach, may defer to the doctor's authority.[2,4] These cultural factors can affect patient expectations, including preferences for inpatient or outpatient rehabilitation and the duration of care. In addition, language barriers, especially if English is not the patient's first language, can further burden both the patient and the healthcare provider, potentially contributing to prolonged LOS.[7]

Another variable that was a significant predictor of LOS in our study was the presence of DM preoperatively. When stratified by ethnicity, Asians (34.7%) had the highest incidence of DM, followed by African/Caribbeans, which accounted for 20%. Another study also found that a greater proportion of the diabetic cohort was non-caucasian, while caucasian patients largely represented the non-diabetic cohort.[37] Furthermore, while 58.5% of diabetic patients were from a lower IMD decile (1–5), we found no significant association between DM and IMD. However, studies have found there to be an association between the prevalence of DM and related complications with low socioeconomic status and a greater relative risk of diabetes-related hospital admissions for patients who are in deprived IMD quintiles.[8,17,31] More research is needed to explore this relationship.

Our results support previous publications in that DM is significantly associated with extended hospitalization post meningioma resection.[11,29,37] While our study did not look at postoperative complications in diabetic patients, this association has also been frequently reported and can contribute toward extended LOS.[14,29,37,38] For example, in another retrospective cohort study, the mean blood glucose of diabetic patients compared to non-diabetic patients had significantly increased postoperatively.[29] While this may be expected with the stresses of a major surgery, it poses a challenge to the patient's recovery and can increase stay in hospital, either directly or indirectly. Many studies, including ours, use national databases that do not register detailed information about each patient's comorbidity. This limitation raises uncertainties about factors like glycemic control, making it challenging to determine if prolonged LOS is solely due to DM as a comorbidity or influenced by the presence of a poorly managed chronic, multi-system condition. Nevertheless, our findings underscore the importance of healthcare professionals initiating preoperative counseling for patients with a history of DM. This counseling should address the risks of hyperglycemia, focusing on proactive management to prevent complications linked to erratic blood glucose control, a potentially modifiable risk factor for prolonged hospital stays.

Finally, a history of COPD was a significant predictor of LOS in our study. Previous publications support this, and some studies have also shown that COPD is a significant risk factor for postoperative complications such as cerebrospinal fluid leak, pneumonia, extended ventilator requirement, reintubation, and sepsis.[13,12,21,35,36,46] Studies looking at the association between frailty status and LOS have found a significant association between the variables, and it is important to note that many frailty scores include COPD as a variable.[6,18,19] Patients with such a chronic lung disease may have difficulty completing pulmonary rehabilitation, have significantly decreased rates of ambulation, and are more likely to experience oxygen desaturation in the postoperative setting.[22,32] Thus, to minimize postoperative complications and reduce hospitalization duration, accurate preoperative risk assessments are essential, focusing on establishing the patient's functional status. Pre-rehabilitation, including interventions such as preoperative chest physiotherapy and pulmonary rehabilitation, can optimize potentially modifiable factors such as COPD, lowering the risk of postoperative pulmonary complications.[19,43] After surgery, early inpatient rehabilitation for COPD patients is crucial, along with routine examinations and spirometry, which could help identify the development of complications such as pneumonia or acute exacerbation of COPD.[42] From a public healthcare perspective, a significant proportion of COPD patients have a history of smoking (in our study, 84.6% of patients with COPD had a history of tobacco use), and this is a predictor of pulmonary complications post-surgery.[1,21]

Limitation

This study has a few limitations. First, this study was a retrospective analysis of patients who had undergone meningioma resection at a single tertiary center, and the data were obtained from an administrative database. Therefore, the quality of the retrospective data is dependent on the accuracy and completeness of records, and those patients with missing data had to be excluded from the analysis. Furthermore, the study period encompassed the COVID-19 pandemic, which introduced significant challenges to the healthcare system, including staff and bed shortages and changes to operating schedules. Second, this study was based on a relatively small set of patients from a single center in the U.K., and thus, the reliability and generalizability of these results to other centers, both within the U.K. and internationally, remains to be seen. Patients accessing private healthcare are often more likely to belong to higher IMD deciles, and therefore, comparative analysis of public and private healthcare system data would allow us further to evaluate the impact of socio-economic factors on LOS. Third, the predictor variables included in this analysis were not exhaustive. A holistic analysis of pre-, peri- and post-operative patient factors, presence of intraoperative complications, availability of hospital resources, and level of social support would be required to predict postoperative LOS accurately. In addition, preoperative social factors such as smoking status and alcohol use were not recorded in a quantitative format using questionnaires such as the AUDIT-C and Smoking History Questionnaire, as these are not currently standardized within our hospital's clinical practice but are something that may improve the robustness of such models in the future. Furthermore, distinguishing tobacco smoking from vaping or inhaled drug use would enhance clarity and is a further improvement for the model in future investigations. Finally, neurosurgery differs from other surgical branches in that, it is necessary to reserve an intensive care bed not only for emergency but also for elective craniotomy patients. Therefore, neurosurgeons are often forced to cancel surgeries if the postoperative intensive care unit cannot accommodate their patients, sometimes resulting in increased LOS. In addition, in neurosurgery, there is higher uncertainty about the outcome, and optimal use of the operating room can be considerably variable. Thus, the interplay between all these factors on LOS needs further investigation.

CONCLUSION

Our study on meningioma resection operations identifies key factors influencing postoperative LOS, such as comorbidities, patient demographics, and degree of socio-economic health deprivation. Out of the factors analyzed, only patient ethnicity, DM, and COPD were identified as significant predictors of LOS. Interestingly, IMD did not emerge as a significant predictor, suggesting the need for further research to explore the influence of IMD subdomains on outcomes. Further research is warranted to analyze a wider range of clinical and non-clinical variables to predict LOS post-meningioma resection surgery more holistically and reliably. Determining accurate predictors of LOS both preoperatively and postoperatively can reduce unnecessarily long patient admissions, reduce financial overheads, and promote patient safety by aiding clinicians in stratifying patients into a low or high-risk category for prolonged LOS.

Ethical approval

The Institutional Review Board has approved the study given the blinded study methodology and anonymized nature of the data and the analysis. The reference code is 24HIP22. Institute Name: Northern Care Alliance Research and Innovation Team. Date of approval: 09/2023.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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