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Predictors of Hospital Readmission for Patients Undergoing Emergency Neurosurgeries

Saleh Nasr Saleh[1], Mona Aly Mohammed[2], Asmaa Aly Mahgoub[3] & Wael Mohammed Ali[4]
[1.] Demonstrator of Critical Care & Emergency Nursing, Faculty of Nursing, Assuit University, Egypt.
[2.] Professor of Critical Care & Emergency Nursing, Faculty of Nursing, Assuit University, Egypt.
[3.] Professor of Critical Care & Emergency Nursing Faculty of Nursing, Assuit University, Egypt.
[4.] Professor of Neuro Surgery, Faculty of Medicine, Assuit University, Egypt.

Abstract
Background: Emergency neurological surgeries are often associated with complex recovery requirements, increased risk of complications, and high morbidity. Finding readmission predictors is essential to improving recovery and lowering healthcare costs. **Aim of study** was to assess predictors of hospital readmission for patients undergoing emergency neurosurgeries. **Research design:** Descriptive research design was utilized. **Setting:** This study was conducted in Emergency and Intensive Care Unit in trauma hospital and Neuro-Psychiatry _Neuro Surgery hospital at Assuit University. **Sample:** Convenience sample of 131 both male and female patients undergoing emergency neurosurgery, with age groups ranging from 18-65 years. **Tools:** two tools were utilized**, Tool (I)**: Patient Neurological assessment sheet. **Tool (II):** Clinical risk scoring tool to predict readmission after neurosurgery by using LACE score. **Results:** The incidence of Hospital readmission among neurosurgical patients about 22.1%, common in age group 51 -65, about (57.1%). Results showed that mortality rate for patients undergoing emergency neurosurgeries about (16.0%).**Conclusion:** Following emergency neurosurgery, the primary risk factors influencing hospital readmission and mortality are age, comorbidities, length of hospital stay, and perioperative clinical signs. **Recommendation:** Nursing protocol must be implemented for nurses, who are integral in patient care, for early recognition and management of complications after emergency neurosurgeries.

Keywords: Hospital readmission, Neurosurgeries & Predictors.

Introduction:
The majority of neurosurgical crises entail either decompression of the brain parenchyma and cranial nerves, diversion of cerebrospinal fluid, or management of intracranial pressure. The most frequent neurosurgical emergencies include: severe traumatic brain injury, skull fractures, penetrating cerebral trauma, acute hydrocephalus, cerebral edema, intracranial epidural abscess, spontaneous intra-parenchymal hemorrhage, intraventricular hemorrhage, and intracranial hemorrhage. **(Lee et al., 2020)**

Readmission to the hospital occurs when a patient who has been discharged is admitted again within a predetermined time frame, such 30 or 90 days, following their initial stay. **(Wang et al., 2022**)

Unplanned hospital readmission after cranial neurosurgery is a common event. The identification of high-risk patients who undergo cranial procedures might allow hospitals to reduce unplanned readmissions and their associated healthcare costs. **(Lopez Ramos et al., 2018**)

The actions of nurses are essential in neurosurgery work and have a direct impact on the prognosis of patients as well as the image of the institution in addition to relating to their safety while in the hospital. Inadequate nursing care and delayed diagnosis of the patients' illnesses will impact the effectiveness of therapy and may lead to disability or even death. The primary treatment option in the neurosurgery field is surgery, however this procedure carries a high risk of complications and a poor outcome. **(Simon et al., 2024).**

Significance of the study:
Approximately twenty-two million people annually seek the services of a neurosurgeon due to neurological injuries or diseases, with more than thirteen millions of those patients requiring surgery. The majority of critical neurosurgical treatment provided globally is for injuries to the brain such as subdural hemorrhage, tumors , hydrocephalus, and. **(Dewan et al., 2019)** .

In Neuro-Psychiatry & Neuro Surgery Hospital - Assuit University. More than 250 patients admitted to the hospital with neurosurgical emergencies disorders **(Hospital Records)** at 2021 - 2022. It has been consistently observed that a considerable number of patients who undergo neurosurgery are susceptible to experiencing subsequent hospital readmissions following their discharge. In light of this observation, it becomes imperative to identify and examine the predictive factors that significantly influence the likelihood of patient readmission.

Aim of the study:
To assess predictors of hospital readmission for patients undergoing emergency neurosurgeries.

Research question:
What are predictors of hospital readmission for patients undergoing emergency neurosurgeries?

Operational definitions:
Predictors: mean a declaration of perioperative risk factors related to neurosurgery which increases patients' risk of postoperative hospital readmission.
Neurosurgery: is a specialized branch of surgery that deals with the surgical treatment of diseases and conditions affecting spinal cord and brain.
Emergency neurosurgery refers to surgical procedures performed urgently to manage critical neurological conditions, these emergencies often progress rapidly necessitating prompt intervention to minimize further damage.

Patients and Methods:

Research design
For this study, a descriptive research design was used.

Setting
This research was carried out in Emergency and Intensive Care Unit in trauma hospital and Neuro-Psychiatry _Neuro Surgery Hospital at Assuit University.

Sample
Convenience sampling of 131 patients of both male and female patients undergoing neurosurgery, with age groups ranging from 18–65 years, the data collected within six months started from November 2024 to April 2025. Patients admitted to the hospital with emergency neurosurgies at 2021 – 2022 were 250 patients and data collected in 6 months.

Exclusion criteria:
Patients who met the following criteria were not included in this study:

- Patient age more than 65 years.
- Patient refusal to participate in study.
- Failed surgery

Tools of data collection:

Tool (I): Patient Neurological assessment sheet.
This tool was developed by a researcher based on literatures review **(Hoffmann et al., 2017)** contain three parts, to assess the following.

Part (1): Demographic and medical data:
This part included patients' demographic data such as patients code, age, gender, personal habits such as smoking, and medical diagnosis

Part 2: Past medical history:
This portion evaluated the patients' medical histories, including blood product transfusions, hypertension, diabetes, COPD, hepatitis, CHF, and prior neurologic disease.

Part (3): Laboratory tests:
This part included complete blood count (White blood cells, Red blood cells, hemoglobin, platelets and hematocrit), Arterial blood gases ABG(SaO_2, pao_2, PH, $paCO_2$, HCO_3).

Tool (II): A Clinical Risk Scoring Tool to Predict Readmission After Neurosurgery by LACE score:
This tool was adapted by researcher to predict risk for mortality and readmission after discharge **(Linzey et al., 2020)** . It consisted of (length of stay 0 - 6, acuity of admission 0 – 3, comorbidity 0 – 5, emergency department visit 0 – 4), a score of 1 to 4 indicates low risk of early mortality or 30-day readmission, a score of 5 to 9 indicates moderate risk, and a score of more than 9 indicates high risk, according to the LACE index.

Methods

Ethical Considerations:
The faculty of nursing's ethical committee gave its approval 1120240880 to the research idea. The study subjects were not at risk while the research was being applied. Common ethical guidelines for clinical research were adhered to in this investigation. Patients or guidance who are willing to participate in the study have given their written consent after being informed of its nature and goal. Patients were given the assurance that the research's data would only be utilized for that reason. Anonymity and confidentiality are guaranteed. Patients were free to decline participation in the trial at any time and/or to leave at any time without explanation.

Tools development:
Official permission was obtained to carry out the proposed study, enabling the researcher to initiate data collection**.**
Using texts such as magazines, newspapers, and references, data collection tools were created by examining national, worldwide, historical, and current literature in a variety of areas.

Pilot study:
A pilot study included 10% of the studied sample (13 patients) they were used to determine the tools' applicability and clarity as well to estimate time needed to fill in the data collection tools. The data from the pilot study were analyzed; no changes were made to the tools utilized, so the sample selected for the pilot study were involved in the study.

Content validity and Reliability
Face validity: was done by five specialists who evaluated the tools for clarity, relevance, comprehensiveness, and understanding, including three professors and one assistant professors from the critical care nursing team and one professor from neurology specialist. Minor modifications were made and the tools were then designed in their final version and reliability tests were conducted.
Reliability: of the tools was measured by Cronbach's

alpha coefficient (r-0.722).

Assessment phase: assessment of patients at admission, postoperative and at discharge.

- In order to obtain their consent to participate, the researcher presented himself to each patient or family member and discussed the significance and goal of the study.
- Researcher recorded demographic data such as patient code, age, gender, and personal habits such as smoking by using tool I. Part I.
- Researcher assessed the health history of studied patients such as the history of previous neurologic disease, hypertension, diabetes, COPD, hepatitis, CHF and blood product transfusion by using tool I. Part II.
- Researcher assessed laboratory tests included complete blood count (White blood cells, Red blood cells, hemoglobin, platelets and hematocrit), arterial blood gases ABG(SaO_2, pao_2, PH, $paCO_2$, HCO_3), by using tool I. Part III .
- Researcher assessed risk factors that predict readmission and mortality after emergency neurosurgeries by using tool II.
- Patients were followed up through the hospital's outpatient neurology clinics and emergency department.

Field work:

Results

- The data collected in six months started from November 2024 to April 2025.
- Data collection started from the first 24 hours of admission
- Assessment information for patients was gathered from the admission to the intensive care unit until their discharge, Patients were followed up through the hospital's outpatient neurology clinics and emergency department.
- The study sample was (131).
- Formulation of dissemination and implementation strategy.

Statistical analysis:

The researcher entered the data by using a personal computer. All data were entered into statistical packages for the social sciences (SPSS) version 26.0 software for analysis and figures were created in Excel. The researcher analyzed, categorized, and then coded the content of each tool. The mean and standard deviation (Mean, SD) were used to characterize continuous variables, whereas the number and percentage were used to characterize categorical variables. Whereas the T-test was used to compare continuous variables, the chi-square test was employed to compare categorical variables. A P-value of less than 0.05 was deemed statistically significant. **(Boscardin et al., 2024**)

Table (1): Frequency and distribution of demographic and medical data (N=131)

Items		N	%
Age Group			
	18< 35	17	13.0
	35< 50	66	50.4
	50< 65	48	36.6
	Mean (SD)	48.9 (8.8)	
Sex			
	Female	50	38.2
	Male	81	61.8
Death			
	Yes	21	16.0
	No	110	84.0
length of stay	Mean (SD)	9.6 (3.98)	

Frequencies (number and percent).

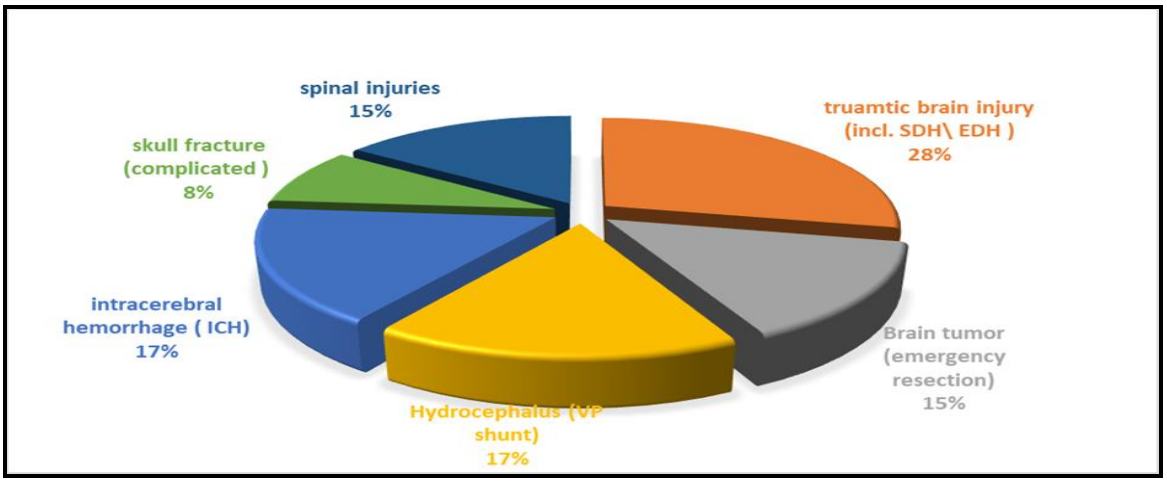

Figure (1): Medical diagnosis among patients (N =131)

Table (2): Correlation between hospital readmission with Demographic Data (N =131)

Demographic and medical data	Readmitted		Not Readmitted		P. Value
	N	%	N	%	
Age Group					
18< 35	2	7.1	15	14.6	0.038
35< 50	10	35.7	56	54.4	
50< 65	16	57.1	32	31.1	
Sex					
Male	16	57.1	65	63.1	0.565
Female	12	42.9	38	36.9	
Medical Diagnosis					
Traumatic Brain Injury	7	25.0	30	29.1	0.983
Brain Tumor (Emergency Resection)	4	14.3	15	14.6	
Hydrocephalus (VP Shunt)	6	21.4	16	15.5	
Intracerebral Hemorrhage	5	17.9	17	16.5	
Skull Fracture (Complicated)	2	7.1	9	8.7	
Spinal Injuries	4	14.3	16	15.5	
length of stay	12.50 (2.603)		8.84 (3.934)		0.001

Chi-Square Test ** statistically significant difference (P-Value < 0.05)*
***highly significant difference (P-Value < 0.01)* *Non-significant difference (P-Value > 0.05)*

Table (3): Association between hospital readmission and past medical history (N =131)

Past medical history		Readmitted		Not Readmitted		P. Value
		N	%	N	%	
Hypertension	Yes	24	85.7	59	57.3	0.006
	No	4	14.3	44	42.7	
Diabetes mellitus	Yes	19	67.9	53	51.5	0.122
	No	9	32.1	50	48.5	
Stroke	Yes	2	7.1	0	0.0	0.006
	No	26	92.9	103	100	
Hepatitis	Yes	1	3.6	0	0.0	0.054
	No	27	96.4	103	100	
Atrial Fibrillation	Yes	2	7.1	0	0.0	0.006
	No	26	92.9	103	100	
CHF	Yes	2	7.1	0	0.0	0.006
	No	26	92.9	103	100	

Past medical history		Readmitted		Not Readmitted		P. Value
		N	%	N	%	
COPD	Yes	6	21.4	11	10.7	0.133
	No	22	78.6	92	89.3	
Surgical History	Yes	16	57.1	21	20.4	<0.001
	No	12	42.9	82	79.6	
Previous Neurologic Diseases	Yes	6	21.4	15	14.6	0.380
	No	22	78.6	88	85.4	
Blood Product Transfusion	Yes	13	46.4	35	34.0	0.225
	No	15	53.6	68	66.0	

Chi-Square Test ** statistically significant difference (P-Value < 0.05)*
***highly significant difference (P-Value < 0.01)* *Non-significant difference (P-Value > 0.05).*
CHF(chronic heart failure) *COPD (chronic obstructive pulmonary disease)*

Table (4): Association between hospital readmission and Laboratory tests (N=131)

Lab tests		readmitted	not readmitted	p.value
		Mean (SD)		
Red Blood Cells	Pre-Operation	4.39 (.513)	4.51 (.374)	0.168
	Post-Operation	4.25 (.815)	4.35 (.549)	0.479
	At Discharge	4.45 (.642)	3.80 (1.80)	0.065
White Blood Cells	Pre-Operation	10.15 (1.683)	9.61 (1.434	0.092
	Post-Operation	12.99 (2.360)	11.90 (2.092)	0.031
	At Discharge	10.83 (1.176)	8.055 (3.839)	0.001
Hemoglobin	Pre-Operation	11.73 (1.341)	11.76 (1.397)	0.904
	Post-Operation	10.50 (1.432)	10.288 (1.355)	0.470
	At Discharge	11.21 (1.361)	9.48 (4.646)	0.001
Platelets	Pre-Operation	248.50 (33.117)	254.76 (29.666)	0.336
	Post-Operation	240.36 (41.431)	248.16 (39.283)	0.359
	At Discharge	243.75 (35.372)	212.61 (25.371)	0.011

Independent-Samples T Test ** statistically significant difference (P-Value < 0.05)*
***highly significant difference (P-Value < 0.01)* *Non-significant difference (P-Value > 0.05).*

Table (5): Association between hospital readmission and arterial blood gases (N =131)

Arterial Blood Gases		Readmitted	Not Readmitted	P.Value
		Mean (SD)		
SaO2	Pre-Operation	93.89 (12.641)	96.21 (1.453)	0.341
	Post-Operation	94.96 (2.516)	95.70 (1.857)	0.089
	At Discharge	96.21 (3.035)	80.50 (37.244)	<0.001
PaO2	Pre-Operation	84.36 (6.154)	82.55 (12.219)	0.452
	Post-Operation	79.04 (6.658)	78.92 (14.271)	0.952
	At Discharge	83.61 (6.112)	71.75 (15.099)	0.001
PaCO2	Pre-operation	40.04 (3.415)	40.47 (3.360)	0.550
	Post-operation	42.71 (4.634)	42.39 (4.869)	0.752
	at Discharge	39.11 (3.281)	32.35 (5.053)	<0.001
HCO3	Pre-operation	21.82 (1.278)	22.26 (3.214)	0.480
	Post-operation	21.57 (2.168)	21.76 (4.127)	0.819
	at Discharge	22.93 (1.438)	18.1848 (2.331)	<.001

Independent-Samples T Test ** statistically significant difference (P-Value < 0.05)*
***highly significant difference (P-Value < 0.01)* *Non-significant difference (P-Value > 0.0.*
-SaO2 (saturation of arterial oxygen) *- PaO2 (partial pressure of arterial oxygen)*
- PaCO2 (partial pressure of arterial carbon dioxide) *- HCO3 (serum bicarbonate)*

Table (6): Association between hospital readmission and Clinical Risk Scoring Tool (LACE) (N =131)

Clinical Risk Scoring Tool		Readmitted		Not Readmitted		P.Value
		N	%	N	%	
LACE Risk Category	Low risk 0 – 4	0	0.0	15	14.6	< 0.001
	Moderate risk 5 -9	1	3.6	61	59.2	
	High risk >9	27	96.4	27	26.2	

Chi-Square Test ** statistically significant difference (P-Value < 0.05)*
***highly significant difference (P-Value < 0.01)* *Non-significant difference (P-Value > 0.05).*
LACE (length of hospital stay, acuity of admission, comorbidities and emergency visit).

Table (7): Association between mortality and Clinical Risk Scoring Tool (LACE) (N =131)

Clinical Risk Scoring Tool		Died		Not Died		P.Value
		N	%	N	%	
LACE Risk Category	Low risk 0 – 4	0	0.0	15	13.6	< 0.001
	Moderate risk 5 -9	0	0.0	62	56.4	
	High risk >9	21	100.0	33	30.0	

Chi-Square Test ** statistically significant difference (P-Value < 0.05)*
***highly significant difference (P-Value < 0.01)* *Non-significant difference (P-Value > 0.05).*
LACE (length of hospital stay, acuity of admission, comorbidities and emergency visit).

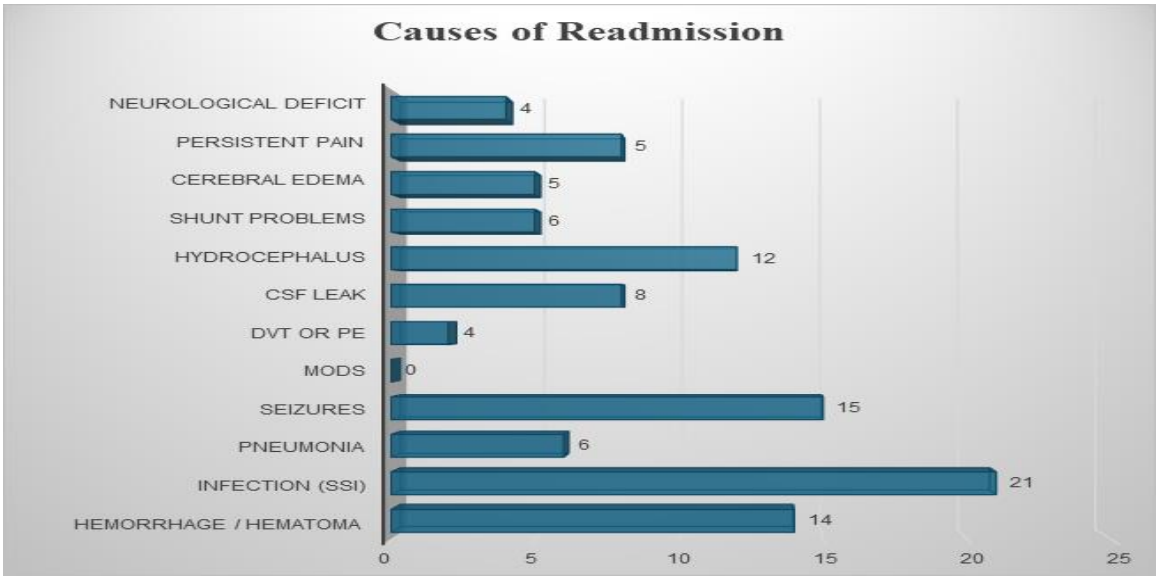

Figure (2): Most Common Causes of Readmission (N =131)

Table (1): Shows distribution of demographic data and medical information of study sample which mean age of 48.9 years (SD=8.8). The patients were in the 35–50 age group (50.4%), followed by 50–65 years (36.6%). Most patients were male (61.8%). Mortality occurred in 16% of patients (21 cases). The mean length of hospital stay was 9.6 days (SD=3.98).

Table (2): Shows relation between hospital readmission with demographic and medical data, Older age was significantly associated with hospital readmission (P=0.038), with more than half of readmitted cases being between 50 and 65 years old (57.1%). Gender showed no significant relationship with readmission (P=0.565). Similarly, the type of neurosurgical diagnosis did not differ significantly between readmitted and non-readmitted patients (P=0.983). However, length of hospital stay was significantly longer in patients who were readmitted (12.5 ± 2.6 vs. 8.54 ± 3.93 days, P=0.001).

Table (3): Shows relation between hospital readmission and past medical history, Past medical history revealed that hypertension (P=0.006), previous stroke (P=0.006), atrial fibrillation (P=0.006), congestive heart failure (P=0.006), and prior surgical history (P<0.001) were significantly associated with readmission.

Table (4): Shows relation between Laboratory tests and hospital readmission which white blood cell count was significantly higher postoperatively (P=0.031) and at discharge (P=0.001) among readmitted patients. Hemoglobin levels at discharge were also higher in readmitted patients (P=0.001). Platelet counts were significantly elevated at discharge (P=0.011). Red blood cell counts did not show significant differences.

Table (5): Shows relation between hospital readmission and arterial blood gases, Arterial blood gas analysis demonstrated no significant differences preoperatively or postoperatively. However, at discharge, SaO2 (P<0.001), PaO2 (P=0.001), PaCO2 (P<0.001), and HCO_3 (P<0.001) were all significantly different between the two groups, indicating that unresolved respiratory or metabolic abnormalities at discharge were associated with higher readmission rates.

Table (6): Shows relation between hospital readmission and clinical risk scoring tool (LACE score), the LACE score showed a strong predictive association with readmission. None of the patients with low risk (0–4) were readmitted, while 96.4% of readmitted patients belonged to the high-risk group (>9) (P<0.001). LACE (length of hospital stay, acuity of admission, comorbidities and emergency visit).

Table (7): shows relation between mortality and clinical risk scoring tool (LACE), mortality was exclusively observed in patients with high LACE scores, with 100% of deaths occurring in this group (P<0.001). LACE (length of hospital stay, acuity of admission, comorbidities and emergency visit).

Figure (1): Shows present the distribution of medical diagnoses among patients, the most common indications for emergency neurosurgical admission were traumatic brain injury (28%), intracerebral hemorrhage (17%), and hydrocephalus requiring ventriculoperitoneal shunt (17%), spinal injuries (15%), and brain tumors requiring emergency resection (15%). Skull fractures accounted for 8% of admissions.

Figure (2) presents common causes of readmission, the leading causes of hospital readmission were surgical site infection (21 %), seizures (15 %), hemorrhage or hematoma (14%), and hydrocephalus (12 %). Other causes included cerebrospinal fluid leak (8 %), shunt malfunction (6 %), pneumonia (6 %), persistent pain (5 %), cerebral edema (5 %), neurological deficits (4 %), and thromboembolic events (4 %).

Discussion:

Regarding Demographic and medical data

According to age, the current study showed that old age more than 50 years old are susceptible for hospital readmission it is due to comorbidities, have reduced physiological reserves, and slower recovery rates. This study was supported by **(Lopez Ramos et al., 2018**) who explained that readmitted patients had inferior preoperative test results, were older, and had more illnesses as Blood coagulation disorders, diabetes, and hypertensive.

In light of the patient's gender, this study demonstrated that there is no difference between patients returning to the hospital in terms of gender, this finding was contradicted with **(Anderson et al., 2022**) who discovered that one predictor of unexpected readmission was female. And assume that the female returned patients' elevated PCCL is the cause of this.

Concerning past medical history, the study result revealed that chronic comorbidities emerged as significant predictors of both readmission and mortality. This aligns with **(Botros et al., 2022**) who reported that comorbidities were strong predictors of early hospital readmission, with affected patients experiencing worse overall survival and increased postoperative complications such as thromboembolism and neurological deficits. Also, **(Sander et al., 2020**) found that in operated patients, the presence of cardiovascular comorbidities significantly elevated the odds of early readmission.

Concerning hypertension and diabetes mellitus, the current study illustrated that most patients who readmitted to the hospital had hypertension and diabetes, this result was confirmed by **(Lopez Ramos et al., 2018**) who found that hypertension, diabetes, coagulopathy and COPD were all independently associated With unplanned readmissions after neurosurgeries. Moreover, in craniotomy patients, diabetes was specifically associated with higher rates of surgical site infection and subsequent readmission, these findings were proven by **(Buchanan et al., 2018**).

By looking at laboratory Tests, the study investigation indicated that Laboratory markers, especially leukocytosis, anemia, and coagulation abnormalities, were significantly linked to readmission. Confirmed by **(Li et al., 2024**) who clarified that anemia was identified as a potential risk for poor surgical recovery and increased complications, with preoperative anemia doubling the risk of postoperative morbidity.

Concerning arterial blood gases, the present study found that abnormalities in ABG, particularly low PaO2 and derangements in PaCO2, were strongly associated with readmission. This results were confirmed by **(Carney et al., 2017**) who showed that hypoxemia has long been recognized as a major determinant of poor neurological outcomes, especially in traumatic brain injury and intracerebral

hemorrhage, where it significantly increases mortality and morbidity .

In relation to predicting hospital readmission by using LACE score, this study clarified that The LACE score is a reliable scale for prediction of readmission in the study, with higher scores correlating with significantly increased risk for readmission and mortality. this result was in agreement with **(Joseph R Linzey et al., 2020**) They shown that patients undergoing neurosurgical procedures who had a moderate or higher LACE score had roughly twice the likelihood of dying and being readmitted, and that the LACE index accurately predicts readmission after thirty days and mortality in these patients. LACE (length of hospital stay, acuity of admission, comorbidities and emergency visit).

In highlighting of readmission causes, the current results found that the most common reasons for readmission after neurosurgery are surgical site infection SSI, seizures and intracranial hematoma, similarly to study carried out by **(Sander et al., 2021**) who clarified that SSI ,seizures and progressive intracranial hematoma have been given as the main reasons for unplanned readmission. This result was confirmed by **(Schipmann et al., 2020**), who reported that surgical site infection accounted for over 25% of all unwanted readmissions within thirty days of surgery, with postoperative bleeding coming in second (18.8%). Cases with repeated chronic SDH accounted for 67.3% of hemorrhaging cases.

In relation to length of stay , the present results demonstrated that length of hospital stay is an prominent factor in readmission to the hospital after neurosurgeries, The findings align with **(Sander et al., 2021**), who discovered that LOS was found to be a significant predictor, which can be explained by postoperative complications with associated prolonged hospitalization. In disagreement with **(Schipmann et al., 2020),** who clarified that a shorter LOS during index admission is associated with a higher readmission rate.

Regarding mortality rate, the present study showed that mortality rate among patients undergoing emergency neurosurgery was 16% depending on patient medical diagnosis and type of surgery. **(Clark et al., 2022**) discovered that mortality rate among severe injury to the brain patients undergoing emergency neurosurgical procedures was 18%. Similarly, in patients with spontaneous intracerebral hemorrhage ICH, early mortality remains substantial, in addition, **(Abulhasan et al., 2023)** discovered that mortality rate was 16% in 30-day and mortality rate was 22% in 90-day in patients diagnosed with ICH.

Conclusion:

- Unexpected readmissions to the hospital following neurosurgery are frequent. High-risk patients who have neurosurgical procedures may be identified, which could help hospitals cut down on unscheduled readmissions and the related medical expenses.
- Readmission and mortality following emergency neurosurgery were significantly associated with older age, comorbidities HTN, DM, prolonged hospital stay, and abnormal perioperative parameters including GCS, ABG, and coagulation profile.

Recommendations

- Systematic tools such as the LACE score should be incorporated alongside optimized postoperative care may reduce adverse outcomes and improve long-term survival.
- Strengthen discharge plan and education: Patients and caregivers should receive clear instructions on wound care, medications, and warning signs to minimize avoidable readmissions. Effective discharge communication improves patient safety and continuity of care.

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