Extended Length of Hospital Stay for Surgical and Medical Patients – Insights from Hospital and Psychosocial Predictors

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Abstract

Ensuring that patients do not overstay the expected Length of Stay (LOS) in the hospital is an important indicator of the quality of care and helps to reduce the cost of healthcare. This study identifies the predictors of Extended Length of Hospital Stay (ELOHS) for surgical and medical patients to include LOS (>20 days), Age (> 40 years), Hour to Surgery (HTS) – within 4 hours of admission, zero and one Rapid Response Team (RRT) calls, Average Operating Room Time (AORT) of 0 – 120 minutes and one Theatre Session (TS). Apart from the "ear, nose, mouth & throat", "kidney and urinary tract", "circulatory system", "nervous system" and "digestive system" Major Diagnostic Categories (MDCs), other considered MDCs have significant differences in the Classification of Hospital Acquired Diagnoses (CHADx) rate for ELOHS and Normal Length of Hospital Stay (NLOHS) patients. It is expected that the early consideration of ELOHS predictors will be vital in improving patients' outcomes in the hospital

1. Introduction

Hospital admission is very important for saving lives through enhanced care for the sick with facilities that will ordinarily not be available in health centres. However, when patients overstay in the hospital, it starts to constitute problems for them, the hospital, and the wider economy due to the mounting costs [1-4]. Patients can develop other comorbidities and complications due to the numerous nosocomial infections [5] that have been shown to hamper the quality-of-life during and after hospital admissions [6].

Extended Length of Hospital Stay (ELOHS), which is described as patients overstaying the high trim point (3*average LOS) for a particular Diagnosis Related Group (DRG), has also contributed negatively to the hospital image because it has been used as one of the quality indicators of good hospital care [7]. Imperatively, affecting hospitals' insurance reimbursement because of the penalties imposed on them for poor patient care [8]. Numerous studies have looked at ELOHS for different disease conditions to identify the factors responsible for patients overstaying the time they are expected to stay in hospital. Passias et al. [9] studied the influencing factors of ELOHS for cervical spondylotic myelopathy and showed that age, diabetes, posterior surgical approach, and operative time are among the contributors. ELOHS amongst patients that underwent hindfoot arthrodesis procedure were identified to include diabetes neuropathy, external fixation and infections, and external factors such as possession of health insurance policy [10]. Cheng et al. [29] attributed ELOHS to older age, cognitive impairment, higher number of medical conditions requiring medication, and violence during hospital stay for psychiatric patients whereas Dial et al. [30] identified those older than 65 years, marital status, private health insurance, African American race, removal of iliac crest autograph used for spinal fusion as some of the psychosocial factors contributing to ELOHS. Marfil-Garza et al. [23] showed that younger age, male gender, a lower physician-to-patient ratio, emergency and weekend admissions, surgery, the number of comorbidities, residence outside the city and lower socioeconomic status are influencers of ELOHS.

ELOHS has been linked to increased hospitalization and decreased survival rate after carotid endarterectomy while being influenced by risk factors such as history of congestive heart failure, chronic obstructive pulmonary disease, total time in operating room, number of hospital visits, Intensive Care Unit (ICU) transfers, and placement of Foley catheter over [11]. Patients with deep sternal wound infection have been identified to overstay in hospitals due to factors that include diabetes, obesity, heart failure, renal impairment, and complex surgical procedures [12]. Patients with unruptured adult cerebral aneurysms have risk factors of ELOHS that comprise demographics factors, preadmission comorbidities, choice of procedures, and inpatient complications [3]. For the elderly patients in the acute care hospital context, ELOHS is influenced by tube feeding, consumption of five or more medications, non-independent status, urinary tract infection, pneumonia, congestive heart failure, and hypoalbuminemia [13].

Despite the myriads of studies and the findings, ELOHS has not been considered holistically to allow hospitals to tailor down their focus on patients of specific characteristics to improve care and facilitate recovery. Even though many studies have relied on the ELOHS that

URI: https://hdl.handle.net/10125/79783
978-0-9981331-5-7

varied from 1 – 9 days for different DRGs [9, 14-16], they have produced DRG specific risk factors that failed to consider a wide range of hospital-specific predictors. Looking at the fact that complication rates in hospitals are always higher for patients that overstayed than those with a normal length of stay [31], it becomes necessary to understand how the influencers of ELOHS impact Hospital-acquired complications (HACs). Since the use of Classification of Hospital Acquired Diagnoses *(*CHADx) to measure HAC for patients [32] makes it easier to narrow the hospital complications by identifying, counting, and observing the numerous adverse events on patients during admission to improve their safety [33], it suffices to understand how ELOHS, and the factors studied in this study can influence CHADx. Because the importance of having a bigger picture of patients' status in managing ELOHS cannot be overemphasized and knowing the hospital-specific factors can help caregiving ab initio, this study intends to answer the following research questions.

- *What are the psychosocial and hospital-specific predictors of ELOHS for surgical and medical patients undergoing various treatments in the hospital?*
- *What is the relationship between these risk factors?*
- *How does ELOHS impact the CHADx for patients of different age groups?*

To answer these questions involves analyzing available medical records, categorizing the hospital and psychosocial traits of the patients, and ensuring that only hospital-based factors relating to patient's admission are considered. This will help to give administrators an indication of the outlier conditions that need better control in patients' management to forestall their contributions to ELOHS.

This study, therefore, aims to use the medical records of patients from an academic hospital to determine the hospital and psychosocial predictors of ELOHS for surgical and medical patients. The major contribution of this study is separately identifying the risk factors of ELOHS for surgical and medical patients in a hospital context where patients of numerous DRGs are treated at the same time. By relying on hospital-specific factors, which include VMO specialty, admission category, distance to hospital, socioeconomic status, *etc.*, this study can bring a new dimension to the understanding of ELOHS predictors, hence giving room for prioritizing patients' management on admission. This will help to minimize overstaying in hospitals for the patients that are most vulnerable to ELOHS.

2. Methods

This study relied on de-identified data from an academic hospital situated in Melbourne Australia for the retrospective analysis of ELOHS for surgical and medical patients admitted between 10/2015 – 12/2020. Surgical patients were identified as those who had time in the operating theatre for any procedure whereas medical patients were not sent to the operating theatre. The patients with ELOHS are those identified as staying more than the high trim point (3 * average LOS) for a Diagnosis Related Group (DRG) whereas those with Normal Length of Hospital Stay (NLOHS) did not overstay the high trim point of their DRG despite the LOS in hospital.

The features used for the analysis include Visiting Medical Office (VMO) Specialty, Patient Age, Patient Gender, Admission Category (ADC), Patient LOS, Hours to Surgery (HTS), MDC Details, Patient Care Class, Average Operating Room Time (AORT) in minutes, Charlson Score (CS), Unplanned readmission (UPR), CHADx, Hospital-Acquired Complications (HACs), Return to Operating Room (ROR), ICU transfer, Transfusion (TRAF), Theatre Sessions (TS), Rapid Respond Team (RRT) calls, Day of Admission Surgery Patients (DOP) and Postcode. The postcode was used in conjunction with the socio-economic indexes for areas (SEIFA) from the Australian Bureau of Statistics (ABS) [17] to determine the Socioeconomic Status (SES) of the patients by ranking them as low (1-4 decile), middle (5-7 decile) and high (8-10 decile). The patient's distance to the hospital (DTH) was determined by using the Global Positioning System (GPS) distance calculation that relies on the longitudes, and latitudes of the patient postcode and the hospital postcode.

2.1. Statistical Analysis

The study relies on descriptive statistics, Pearson Chi-squared and correlation coefficient analysis, and multivariate regression analysis for establishing the frequencies of occurrence and interrelationship between the features for ELOHS and NLOHS of patients. The Odds Ratio (OR), which depicts the likelihood of ELOHS is determined by using the dichotomous yes (ELOHS) or no (NLOHS) classification of patients' episodes from the retrospective records using the high trim points of the DRGs as the boundaries. Thus, patients who overstayed the high trim points are classified as *yes* whereas those who did not overstay are classified as *no*. To establish the statistical significance of the rate of hospital complications on admission, the Pearson Chi-squared analysis was used to determine the statistical significance of the CHADx between the ELOHS and NLOHS patients. The rate of patients' CHADx for various age groups namely, <18 years, 18 – 40 years, 40 – 65 years, and ≥65 years was used for establishing the statistical significance difference at a 95% confidence interval. The correlation coefficient is used to establish the influence the studied features have on each other to understand how the changes in each one for both ELOHS and NLOHS influence others.

3. Results

3.1 Descriptive Statistics of Predictors

The analysis is done on 21926 surgical and 11826 medical patients records, which has 46% male and 54%

female for the surgical patients, and 36% male and 64% female medical patients. The mean ages of the surgical patients are male – 64.53±20.46 years and female – 61.57±21.71 years whereas medical patients have the mean ages of male and female as 69.36±23.86 and 66.05±25.37, respectively. The AORT and LOS of surgical patients are – AORT: male – 65.12±62.10 mins, female – 65.63±58.10 mins; LOS male – 5.91± 10.74 days, female – 6.28±9.98 days. The LOS of medical patients are – male 6.22±8.32 days and female 6.99±8.72 days while the ELOHS rate is 12.41% and 9.94%, respectively for surgical and medical patients.

The various MDCs admitted between 0 – 1.79% and 0.14 – 1.36% of surgical and medical patients respectively, who overstayed their LOS in the hospital. The VMO specialties admissions for patients with NLOHS are 0.26 – 13.17% (±3.22%) for surgical patients and 0.69 – 13.17% (±3.11%) for medical patients. The summary of some descriptive statistics of some parameters used for the analysis is shown in Table 1 whereas the high trim points for the MDCs and the various DRGs are shown in Table 2. Please note that some psychosocial and hospital parameters such as VMO specialties, SES of patients, and DTH are not included in Table 1 due to the need to optimize space and reduce redundancy.

Table 1: Descriptive statistics (count, %) of some of the features used for predicting the ELOHS and NLOHS for surgical and medical patients

Parameters	**NLOHS**	**ELOHS**	**NLOHS**	**ELOHS**
	Surgical Patients		**Medical Patients**	
Population	21926		11826	
ELOHS rate	12.41%		9.94%	
Patient Age				
under_18	933(98.11%)	18(1.89%)	548(96.31%)	21(3.69%)
18-40	2429(94.55%)	140(5.45%)	1698(97.31%)	47(2.69%)
40-65	5663(91.38%)	534(8.62%)	1691(93.68%)	114(6.32%)
65 and over	10180(83.38%)	2029(16.62%)	6713(87.1%)	994(12.9%)
Patient Gender				
Female	10179(86.48%)	1591(13.52%)	6733(89.2%)	815(10.8%)
Male	9026(88.87%)	1130(11.13%)	3917(91.56%)	361(8.44%)
Patient Length of Stay (LOS)				
≤5days	15600(99.43%)	90(0.57%)	7828(99.92%)	6(0.08%)
6-10days	2319(71.22%)	937(28.78%)	1969(94.53%)	114(5.47%)
11-20days	942(51.96%)	871(48.04%)	667(53.83%)	572(46.17%)
>20days	344(29.48%)	823(70.52%)	186(27.76%)	484(72.24%)
Major Diagnostic Category (MDC)				
BLOOD, BLOOD FORM ORGANS, IMMUNOLOG	158(84.49%)	29(15.51%)	240(90.91%)	24(9.09%)
CIRCULATORY SYSTEM	2809(86.01%)	457(13.99%)	1343(89.95%)	150(10.05%)
DIGESTIVE SYSTEM	2823(85.18%)	491(14.82%)	1308(90.02%)	145(9.98%)
EAR, NOSE, MOUTH & THROAT	891(93.89%)	58(6.11%)	551(86.09%)	89(13.91%)
ENDOCRINE, NUTRITIONAL & METABOLIC	624(91.9%)	55(8.1%)	192(89.3%)	23(10.7%)
HEPATOBILIARY SYSTEM & PANCREAS	712(85.58%)	120(14.42%)	150(93.75%)	10(6.25%)
INFECTIOUS & PARASITIC DISEASES	140(74.07%)	49(25.93%)	430(89.03%)	53(10.97%)
INJURY, POISON & TOXIC EFFECT DRUGS	313(82.37%)	67(17.63%)	279(90%)	31(10%)
KIDNEY & URINARY TRACT	1303(86.64%)	201(13.36%)	637(89.47%)	75(10.53%)
MUSCULOSKELETAL SYS & CONN TISSUE	3809(88.56%)	492(11.44%)	914(88.65%)	117(11.35%)
NEOPLASTIC DISORDERS	108(70.13%)	46(29.87%)	160(88.89%)	20(11.11%)
NERVOUS SYSTEM	539(83.96%)	103(16.04%)	928(86.97%)	139(13.03%)
PREGNANCY, CHILDBIRTH & PUERPERIUM	782(98.36%)	13(1.64%)	1161(99.23%)	9(0.77%)
RESPIRATORY SYSTEM	639(90.25%)	69(9.75%)	1386(94.41%)	82(5.59%)
SKIN, SUBCUTANEOUS TISSUE & BREAST	1422(84.14%)	268(15.86%)	423(91.96%)	37(8.04%)
Classification of Hospital-acquired Diagnosis (CHADx)				
No	16119(91.28%)	1540(8.72%)	8687(91.98%)	757(8.02%)
Yes	3086(72.32%)	1181(27.68%)	1963(82.41%)	419(17.59%)
Charlson Score (CS)				
0-1	6901(93.19%)	504(6.81%)	3323(95.87%)	143(4.13%)
2-4	9966(87.1%)	1476(12.9%)	5021(88.18%)	673(11.82%)
5-8	1992(75.66%)	641(24.34%)	1956(86.51%)	305(13.49%)
>8	346(77.58%)	100(22.42%)	350(86.42%)	55(13.58%)
Average Operating Theatre Time -AOTT (min)				
0-60	11159(86.25%)	1779(13.75%)		
60-120	5210(89.95%)	582(10.05%)		
>120	2836(88.74%)	360(11.26%)		

VMO (Visiting Medical Officer) Specialty				
Cardiology	2028(87.79%)	282(12.21%)	842(91.32%)	80(8.68%)
Colorectal Surgery	1187(86.64%)	183(13.36%)	247(92.86%)	19(7.14%)
Endocrinology	58(53.21%)	51(46.79%)	58(53.21%)	51(46.79%)
Gastroenterology	980(85.07%)	172(14.93%)	980(85.07%)	172(14.93%)
Gynecology	394(92.49%)	32(7.51%)	394(92.49%)	32(7.51%)
Hematology	129(65.82%)	67(34.18%)	129(65.82%)	67(34.18%)
Medical Oncology	251(69.53%)	110(30.47%)	251(69.53%)	110(30.47%)
Nephrology	137(45.67%)	163(54.33%)	137(45.67%)	163(54.33%)
Neurology	83(51.88%)	77(48.13%)	83(51.88%)	77(48.13%)
Neurosurgery	1085(95.51%)	51(4.49%)	1085(95.51%)	51(4.49%)
Obstetrics & Gynae	938(98.01%)	19(1.99%)	938(98.01%)	19(1.99%)
Orthopedic Surgery	2888(90.59%)	300(9.41%)	2888(90.59%)	300(9.41%)
Distant to Hospital (DTH)				
>20km	5232(89.53%)	612(10.47%)	1121(88.9%)	140(11.1%)
5-10km	4686(87.36%)	678(12.64%)	3002(89.96%)	335(10.04%)
0-5km	5440(85.97%)	888(14.03%)	4467(91%)	442(9%)
10-20km	3847(87.63%)	543(12.37%)	2060(88.83%)	259(11.17%)
Socioeconomic status (SES)				
High	15230(87.31%)	2213(12.69%)	9893(90.35%)	1057(9.65%)
Low	1802(87.73%)	252(12.27%)	313(86.7%)	48(13.3%)
Middle	2163(89.49%)	254(10.51%)	444(86.21%)	71(13.79%)

*Table 2: The Diagnosis Related Groups (DRGs) high trim point – 3 * average LOS (Q_3) of the Length of Stay (LOS) of the various Major Diagnostic Categories (MDCs) and examples of DRG considered in the study.*

MDC	**DRG description**	**DRG (Q_3) in (days)**	
		Mean ± std	**Min - Max**
Nervous System	cranial and peripheral nerve disorders; degenerative nervous system disorders; delirium; dementia and other chronic disturbances of cerebral function; headache; nervous system neoplasm; nontraumatic stupor and coma; seizure. stroke and other cerebrovascular disorders	20.25±12.03	6 - 58
Endocrine, Nutritional & Metabolic	metabolic disorders; endocrine disorders; diabetes; severe nutritional disturbance.	19.26±9.41	5 - 60
Kidney & Urinary Tract	renal failure; kidney and urinary tract signs; urinary stones and obstruction.	15.93±10.48	5 - 56
Male Reproductive System	inflammation and malignity of the male reproductive system; benign prostatic hypertrophy.	14.2±8.02	4 - 31
Female Reproductive System	menstrual and other female reproductive system disorders; malignancy, female reproductive system; infections,	12.15±6.29	4 - 33
Pregnancy, Childbirth & Puerperium	vaginal delivery; antenatal and other obstetric admission; vaginal delivery single uncomplicated; postpartum and post abortion.	11.81±1.6	3 - 18
Newborns & Other Neonates	neonate, admission wt. 2000-2499 g	20.89±14.18	7 - 60
Blood, Blood Form Organs, Immunology	reticuloendothelial and immunity disorders; red blood cell disorders; coagulation disorders	12.98±6.75	7 - 31
Neoplastic Disorders	lymphoma and non-acute leukemia; neoplastic disorders.	16.64±11.5	13 - 60
Infectious & Parasitic Diseases	viral illness; septicemia; postoperative and post-traumatic infections; fever of unknown origin; infectious and parasitic diseases.	19.39±12.22	9 - 60
Mental Diseases & Disorders	anxiety disorders; personality disorders and acute reactions; major affective disorders age >69;	29.65±18.88	16 - 60
Eye Diseases & Disorders	retinal procedures; hyphemia and medically managed trauma to the eye; neurological and vascular disorders of the eye; acute and major eye infections.	13.95±6.12	4 - 32
Alcohol/Drug Use Disorders	drug intoxication and withdrawal	31.11±14.55	18 - 56
Injury, Poison & Toxic Effect Drugs	poisoning and toxic effect diagnosis; allergic reactions; injuries.	15.49±8.46	7 - 46
Factors Influencing Health Status	surgical follow-up and medical care.	14.63±6.06	6 - 41
Ear, Nose, Mouth & Throat	tonsillectomy and/or adenoidectomy; otitis media and URI; nasal trauma and deformity; epistaxis; disequilibrium.	9.49±2.89	3 - 13
Respiratory System	whooping cough and acute bronchiolitis; respiratory system diagnosis; respiratory neoplasms; respiratory infections/inflammations; pulmonary embolism; chronic obstructive airways disease; bronchoscopy;	21.66±9.13	4 - 47

	pneumothorax; major chest trauma; interstitial lung disease; bronchitis and asthma.		
Circulatory System	venous thrombosis; valvular disorders; unstable angina; syncope and collapse; peripheral vascular disorders; heart failure and shock; chest pain; arrhythmia, cardiac arrest, and conduction disorders; hypertension; heart failure and shock; arrhythmia, cardiac arrest, and conduction disorders.	15.56±10.34	4 - 60
Digestive System	esophagitis and gastroenteritis; GI obstruction; digestive malignancy; complex gastroscopy; abdominal pain or mesenteric adenitis; inflammatory bowel disease; anal and stomal; abdominal pain or mesenteric adenitis	13.13±6.22	4 - 46
Hepatobiliary System & Pancreas	malignancy of hepatobiliary system, pancreas; hepatobiliary; disorders of the biliary tract;	16.93±8.62	8 - 44
Musculoskeletal Sys & Conn Tissue	sprains, strains, and dislocations of hip, pelvis, and thigh; non-surgical spinal disorders; injury to the shoulder, arm, elbow, knee, leg, or ankle. fractures of the neck of femur; distal femoral fractures; aftercare of musculoskeletal implants; sprains, strains, and dislocations; spinal fusion of hip, pelvis, and thigh; pathological fracture; musculoskeletal malignant neoplasms; injury to forearm, wrist, hand, or foot.	23.01±13.64	4 - 60
Skin, Subcutaneous Tissue & Breast	trauma to the skin, subcutaneous tissue, and breast; trauma to the skin, subcutaneous tissue, and breast; malignant breast disorders; skin ulcers.	19.7±9.96	2 - 60

3.2. Association of MDC with CHADx

For the population of surgical patients admitted to the hospital, the CHADx rate of 27.68% is 10.09% higher than medical patients (with ELOHS rate of 17.59%) admitted in the same period. The P-value of the Pearson Chi-squared between ELOHS and NLOHS for surgical and medical patients having CHADx is shown in Table 3. It can be deduced from Table 3 that most of the MDCs have the rate of CHADx amongst ELOHS and NLOHS not statistically significant at $P \leq 0.05$ because of the variation in patients' CHADx rates between them. Nonetheless, for medical patients suffering from "*Nervous system"* related MDC ($P = 0.0294$), and surgical patients suffering from "*circulatory system*" ($P = 0.0018$), "*ear, nose, mouth & throat*" ($P = 0.0011$), and "*kidney & urinary Tract*" ($P < 0.001$) MDCs, there is no significant difference in the CHADx rates of the NLOHS and ELOHS cohorts. For surgical patients, apart from the "*blood, blood from organs, immunology*" and "*factor influencing health status*" MDCs that have 16 – 20% more CHADx cases for ELOHS than NLOHS, other MDCs have more CHADx cases (7 – 1100%) amongst NLOHS than ELOHS patients. The same is attenable with medical patients that have "*factor influencing health status*" and "*ear, nose, mouth &throat*" MDCs that have 30 – 105% more ELOHS cases of CHADx than those NLOHS patients. Other MDCs have between 78.5 – 759% more cases of CHADx amongst NLOHS than ELOHS patients.

Table 3: Chi-square analysis for the rate of diagnosis in patients of various age groups with Classification of Hospital-acquired Diagnosis (CHADx) for various MDC amongst NLOHS and ELOHS (bold means significant at 95% confidence level)

MDC Details	NLOHS (count, %)	ELOHS (count, %)	P value
Medical Patients			
Blood, Blood Form Organs, Immunology	25(0.21%)	14(0.12%)	0.619
Circulatory System	184(1.56%)	46(0.39%)	0.987
Digestive System	118(1%)	55(0.47%)	0.09
Ear, Nose, Mouth & Throat	23(0.19%)	30(0.25%)	0.125
Endocrine, Nutritional & Metabolic	23(0.19%)	9(0.08%)	0.953
Factors Influencing Health Status	18(0.15%)	37(0.31%)	0.997
Hepatobiliary System & Pancreas	16(0.14%)	2(0.02%)	0.812
Infectious & Parasitic Diseases	70(0.59%)	22(0.19%)	0.217
Injury, Poison & Toxic Effect Drugs	28(0.24%)	10(0.08%)	0.920
Kidney & Urinary Tract	82(0.69%)	25(0.21%)	0.664
Musculoskeletal Sys & Conn Tissue	127(1.07%)	47(0.4%)	0.911
Neoplastic Disorders	23(0.19%)	10(0.08%)	0.487
Nervous System	110(0.93%)	55(0.47%)	**0.029**
Newborns & Other Neonates	36(0.3%)	6(0.05%)	0.899
Pregnancy, Childbirth & Puerperium	786(6.65%)	-	-
Respiratory System	232(1.96%)	27(0.23%)	0.397
Skin, Subcutaneous Tissue & Breast	39(0.33%)	12(0.1%)	0.851
Surgical Patients			
Blood, Blood Form Organs, Immunology	12(0.05%)	14(0.06%)	0.9999
Circulatory System	590(2.69%)	174(0.79%)	**0.0018**
Digestive System	559(2.55%)	220(1%)	0.0838
Ear, Nose, Mouth & Throat	26(0.12%)	20(0.09%)	**0.0011**

Endocrine, Nutritional & Metabolic	69(0.31%)	37(0.17%)	0.4416
Eye Diseases & Disorders	12(0.05%)	1(0%)	0.8557
Factors Influencing Health Status	10(0.05%)	12(0.05%)	0.6011
Female Reproductive System	82(0.37%)	26(0.12%)	0.269
Hepatobiliary System & Pancreas	128(0.58%)	63(0.29%)	0.2638
Infectious & Parasitic Diseases	45(0.21%)	29(0.13%)	0.3851
Injury, Poison & Toxic Effect Drugs	48(0.22%)	34(0.16%)	0.4959
Kidney & Urinary Tract	134(0.61%)	82(0.37%)	**<0.001**
Male Reproductive System	87(0.4%)	38(0.17%)	0.2795
Musculoskeletal Sys & Conn Tissue	608(2.77%)	210(0.96%)	0.6606
Neoplastic Disorders	32(0.15%)	21(0.1%)	0.6105
Nervous System	91(0.42%)	53(0.24%)	0.5148
Pregnancy, Childbirth & Puerperium	252(1.15%)	4(0.02%)	0.0756
Respiratory System	143(0.65%)	29(0.13%)	0.8609
Skin, Subcutaneous Tissue & Breast	91(0.42%)	85(0.39%)	0.8113

3.3 Risk Factors of ELOHS

Some of the risk factors of ELOHS for surgical and medical patients at a 95% significance level ($P \leq 0.05$) are shown in Table 4. Following Table 4, the predictors that have the likelihood of influencing ELOHS for surgical patients include LOS(>20days) – (OR:4.907, TS (once) – (OR:2.341, ROR (Yes) – (OR: 3.05), AORT (60 mins) – (OR:1.807), AORT (120 mins) – (OR: 1.622), Age (≥65) – (OR:1.794), Age (40-65) – (OR:1.501), HTS (4 hours) – (OR:1.621). Other parameters such as MDCs comprise "*ear, nose, mouth & throat*" – (OR: 7.7499), "*male reproductive system*" – (OR: 5.149), "*circulatory system*" – (OR: 1.995), "*digestive system*" – (OR:2.012), "*factors influencing health status*" – (OR: 2.894), *etc.*, also influence ELOHS amongst surgical patients. For medical patients, the following parameters LOS (>20 days) – (OR:5.521), RRT (No calls) – (OR:4.69) and MDCs such as "*ear, nose, mouth & throat*" – (OR: 7.0513), "*factors influencing health status*" – (OR: 2.632), "*neoplastic disorders*" – (OR: 3.952) and "*digestive system*" – (OR:2.481) also have the probability of influencing ELOHS. Due to the smaller values of some of the other significant parameters (OR < 1), they may have less likelihood of resulting in ELOHS amongst surgical and medical patients.

The accuracy of the multivariate Logistic model used to determine the risk factors of ELOHS is computed with the Receiver Operating Characteristics (ROC) Area Under the Curve (AUC) and confusion matrix computed for a 30% test data per Figure 1. The prediction accuracy of the surgical patients is 91.57% for training dataset and 92.43% (AUC: 96%) for the testing dataset whereas the accuracy for medical patients is 94.95% for the training dataset and 94.36% (AUC: 97%) for the testing dataset. These accuracies show there is no overfitting because of the closeness of the training and testing prediction accuracies.

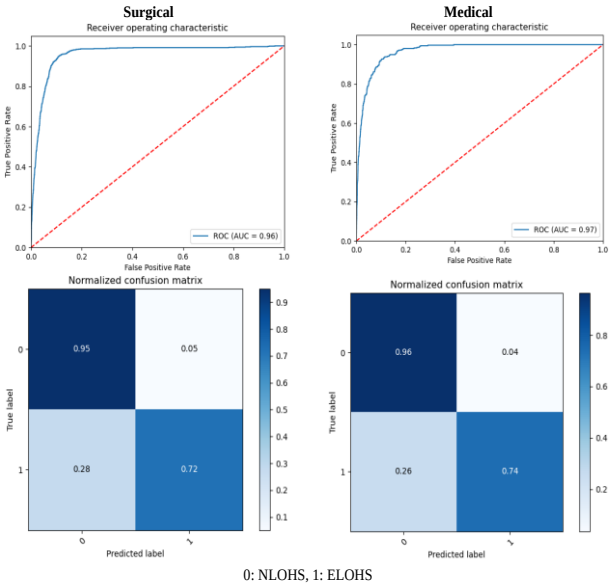

Figure 1: Summary of Logistic model prediction accuracy of 30% of the data used for testing

Table 4: Significant Predictors of ELOHS with multivariate Logistic Regression analysis showing the Odds Ratio (OR), 95% Confidence Interval (CI), and P-Value

Features	Surgical Patients	Medical Patients
ADC(Others)	OR:1.671,95% CI (1.143,2.442), P=0.008	-
ADC(PL1)	OR:0.775,95% CI (0.643,0.934), P=0.007	-
ADC(UC1)	OR:0.771,95% CI (0.642,0.927), P=0.006	-
ADC(MAT)	-	OR:0.072,95% CI (0.011,0.469), P=0.006
AORT (60 mins)	OR:1.807,95% CI (1.494,2.185), P<0.001	-
AORT (120 mins)	OR:1.622,95% CI (1.339,1.965), P<0.001	-
CHADx (Yes)	OR:0.687,95% CI (0.594,0.795), P<0.001	-
CS (>8)	OR:0.173,95% CI (0.118,0.255), P<0.001	OR:0.184,95% CI (0.085,0.4), P<0.001
CS (2-4)	OR:0.454,95% CI (0.355,0.581), P<0.001	OR:0.444,95% CI (0.244,0.807), P=0.008

CS (5-8)	OR:0.297,95% CI (0.224,0.393), P<0.001	OR:0.15,95% CI (0.079,0.283), P<0.001
DOP(Yes)	OR:0.479,95% CI (0.353,0.65), P<0.001	-
HACs (Yes)	OR:0.819,95% CI (0.673,0.997), P=0.046	-
HTS(4hrs)	OR:1.621,95% CI (1.179,2.229), P=0.003	-
ICU(Yes)	OR:0.628,95% CI (0.511,0.771), P<0.001	OR:0.508,95% CI (0.267,0.965), P=0.039
MDC		
Circulatory System	OR:1.995,95% CI (1.207,3.299), P=0.007	-
Digestive System	OR:2.012,95% CI (1.245,3.25), P=0.004	OR:2.481,95% CI (1.264,4.87), P=0.008
Ear, Nose, Mouth & Throat	OR:7.75,95% CI (3.52,17.063), P<0.001	OR:7.051,95% CI (3.35,14.844), P<0.001
Eye Diseases & Disorders	OR:5.11,95% CI (1.844,14.155), P=0.002	-
Factors Influencing Health Status	OR:2.894,95% CI (1.148,7.293), P=0.024	OR:2.632,95% CI (1.231,5.629), P=0.013
Female Reproductive System	OR:9.925,95% CI (3.972,24.802), P<0.001	-
Hepatobiliary System & Pancreas	OR:2.083,95% CI (1.209,3.59), P=0.008	-
Infectious & Parasitic Diseases	OR:0.442,95% CI (0.247,0.791), P=0.006	-
Kidney & Urinary Tract	OR:2.71,95% CI (1.544,4.757), P=0.001	-
Male Reproductive System	OR:5.149,95% CI (2.545,10.414), P<0.001	-
Skin, Subcutaneous Tissue & Breast	OR:1.66,95% CI (1.039,2.652), P=0.034	-
Neoplastic Disorders	-	OR:3.952,95% CI (1.41,11.081), P=0.009
Newborns & Other Neonates	-	OR:0.031,95% CI (0.006,0.164), P<0.001
Respiratory System		OR:0.358,95% CI (0.181,0.708), P=0.003
Age (40-65)	OR:1.501,95% CI (1.116,2.019), P=0.007	-
Age (≥65)	OR:1.794,95% CI (1.264,2.547), P=0.001	-
LOS(>20days)	OR:4.907,95% CI (4.015,5.997), P<0.001	OR:5.521,95% CI (4.289,7.108), P <0.001
LOS(≤5days)	OR:0.002,95% CI (0.002,0.003), P<0.001	OR:0,95% CI (0,0.001), P<0.001
LOS(6-10days)	OR:0.319,95% CI (0.276,0.369), P<0.001	OR:0.039,95% CI (0.03,0.051), P <0.001
ROR(Yes)	OR:3.05,95% CI (2.209,4.211), P<0.001	-
RRT (one call)	OR:0.543,95% CI (0.44,0.67), P<0.001	OR:2.464,95% CI (1.232,4.93), P=0.011
RRT(No)		OR:4.688,95% CI (2.581,8.516), P<0.001
TS (once)	OR:2.341,95% CI (1.857,2.953), P<0.001	-
TS (twice)	OR:0.726,95% CI (0.551,0.957), P=0.023	-
VMO Specialty		
Cardiothoracic Surg.	OR:0.182,95% CI (0.099,0.334), P<0.001	-
Colorectal Surgery	OR:0.272,95% CI (0.16,0.463), P<0.001	-
Endocrinology	OR:0.392,95% CI (0.202,0.76), P=0.006	-
Gastroenterology	OR:0.43,95% CI (0.25,0.74), P=0.002	-
General Medicine Phy	OR:0.32,95% CI (0.191,0.538), P<0.001	-
Gerontology	OR:0.265,95% CI (0.146,0.479), P<0.001	-
Gynecology	OR:0.13,95% CI (0.047,0.359), P<0.001	-
Hematology	OR:0.454,95% CI (0.247,0.834), P=0.011	-
Medical Oncology	OR:0.383,95% CI (0.219,0.67), P=0.001	-
Neurosurgery	OR:0.262,95% CI (0.143,0.481), P<0.001	-
Obstetrics & Gynae	OR:0.271,95% CI (0.089,0.824), P=0.021	-
Orthopedic Surgery	OR:0.399,95% CI (0.232,0.687), P=0.001	-
Respiratory Medicine	OR:0.405,95% CI (0.206,0.798), P=0.009	-
Upper GI Surgery	OR:0.494,95% CI (0.28,0.87), P=0.015	-
Urogynecology	OR:0.16,95% CI (0.028,0.922), P=0.04	-
Vascular Surgery	OR:0.524,95% CI (0.294,0.935), P=0.029	-
Nephrology	-	OR:0.516,95% CI (0.301,0.884), P=0.016

3.4 Association between the Risk Factors

The results of the Pearson correlation coefficient between the risk factors for the surgical and medical patients are shown in Table 5. Although the Pearson correlation coefficient for most of the features are negligible ($r < \pm 0.3$), there are a few others that show low ($\pm 0.3 < r < \pm 0.5$) and moderate ($\pm 0.5 < r < \pm 0.7$) correlations. Interestingly, the features considered in this study have a negligible correlation with the death rate of surgical and medical patients, which is in contrast with the findings of previous studies [11]. However, Age has a moderate correlation with Charlson Score, LOS has a low correlation with CHADx, HACs, ROR, and HTS for surgical patients, and negligible correlation with features considered for medical patients except CHADx with low correlation.

4.0 Discussion

This study identifies the predictors of ELOHS for surgical and medical patients, shows the correlation of these predictors amongst each other, and establishes how ELOHS influences CHADx for patients with different MDCs. The risk of ELOHS is very predominant for patients who are 40 years and over and have been treated with MDC such as "*ear, nose, mouth & throat*", "*male reproductive system*", "*circulatory system*", "*digestive system*", "*factors influencing health status*" and

"*neoplastic disorders*". Previously studies have also linked age to ELOHS [9] because of the increased vulnerability of the elderly to hospital-acquired infections and other complications in hospitals [18]. Unfortunately, with these complications and ELOHS, the hospitals can be hit with an increased cost of managing patients and shortage of available bed spaces for managing new patients [19-20]. ELOHS is also connected to the number of comorbidities, health complications, and socioeconomic status of patients [21-22]. Nonetheless, despite linking ELOHS to some of the MDCs identified earlier, socioeconomic status did not contribute to ELOHS. Admission Category (ADC) played a role in ELOHS due to the complications faced by patients under certain categories and the strategies used for managing them. It may therefore be important to adjust caregiving strategies for such ADC categories in consideration of other risk factors to improve patients' outcomes and reduce the LOS [23].

Even though patients that stayed > 20 days in hospital posed a greater risk of ELOHS, there is the need to balance the management of those patients staying <20 days to forestall Hospital-acquired complications (HACs), which are the direct consequences of ELOHS [24-25]. Despite the importance of RRT calls in improving patients' status on hospital admission via moderating pulses, respiratory rates, blood pressures, oxygen saturation, *etc.* [26-27], it provided mixed results for surgical and medical patients. Thus, RRT calls did not influence ELOHS among surgical patients but those with no RRT calls have 90 – 369% more risk of ELOHS amongst medical patients than those with one or more RRT calls. So, the assumption that patients who have no RRT calls may be doing very well and may not overstay their expected LOS in the hospital may not always be accurate.

Table 5: Correlation matrix of the features showing Pearson Correlation coefficient r and the P-Value for the patients

CS	TS	RRT calls	ROR	HACs	CHAD	DOP	AORT	Death	HTS	LOS	
0.555(<0.001)	-0.063(<0.001)	0.023(0.23)	0.01(0.614)	0.068(<0.001)	0.029(0.131)	-0.141(<0.001)	-0.206(<0.001)	0.031(0.106)	0.014(0.475)	0.037(0.052)	**Age**
0.231(<0.001)	0.246(<0.001)	0.261(<0.001)	0.362(<0.001)	0.475(<0.001)	0.412(<0.001)	-0.136(<0.001)	0.019(0.314)	0.168(<0.001)	0.331(<0.001)		**LOS**
0.06(0.002)	0.031(0.102)	0.1(<0.001)	-0.074(<0.001)	0.081(<0.001)	0.081(<0.001)	-0.404(<0.001)	-0.2(<0.001)	0.055(0.004)			**HTS**
0.185(<0.001)	0.079(<0.001)	0.2(<0.001)	0.079(<0.001)	0.153(<0.001)	0.125(<0.001)	-0.073(<0.001)	-0.027(0.165)				**Death**
-0.068(<0.001)	-0.072(<0.001)	-0.022(0.247)	-0.039(0.044)	0.118(<0.001)	0.121(<0.001)	0.3(<0.001)					**AORT**
-0.124(<0.001)	-0.126(<0.001)	-0.053(0.005)	0.007(0.714)	0(0.999)	0.005(0.794)						**DOP**
0.161(<0.001)	0.087(<0.001)	0.219(<0.001)	0.214(<0.001)	0.522(<0.001)							**CHAD**
0.22(<0.001)	0.091(<0.001)	0.276(<0.001)	0.217(<0.001)								**HACs**
0.093(<0.001)	0.084(<0.001)	0.096(<0.001)									**ROR**
0.088(<0.001)	0.1(<0.001)										**RRT calls**
0.074(<0.001)											**TS**

Surgical

			CS	RRT calls	TRAF	UPR	HACs	CHAD	Deaths	LOS	
			0.524(<0.001)	0.02(<0.001)	0.022(0.499)	0.006(0.457)	0.097(0.831)	0.069(<0.001)	0.043(0.018)	0.095(0.143)	**Age**
			0.191(<0.001)	0.165(<0.001)	0.02(<0.001)	-0.116(0.489)	0.281(<0.001)	0.301(<0.001)	0.126(<0.001)		**LOS**
			0.265(<0.001)	0.051(<0.001)	0.063(0.078)	-0.076(0.03)	0.159(0.009)	0.141(<0.001)			**Deaths**
			0.157(<0.001)	0.182(<0.001)	0.078(<0.001)	-0.038(0.007)	0.494(0.188)				**CHAD**
			0.176(<0.001)	0.09(<0.001)	0.078(0.002)	-0.061(0.007)					**HACs**
			0.031(<0.001)	0.025(0.296)	0.133(0.388)						**UPR**
			0.133(<0.001)	0.061(<0.001)							**TRAF**
			0.045(<0.001)								**RRT calls**

Medical

Psychosocial factors such as DTH and SES are not identified risk factors of ELOHS because they are not significant at a 95% confidence interval, however, previous studies have linked the factors to ELOHS [23, 25, 34]. Surgical patients treated for *"female reproductive system"* have between 28.06 – 497.98% more risk of ELOHS than patients treated for other MDCs. With the higher likelihood of ELOHS for *"female reproductive system"*, "*ear, nose, mouth and throat*", "*male reproductive system*", and "*eye disease and disorder*" MDC patients than the other MDCs and risk factors, the need for strategic plans to manage these patients on admission and surgical procedures cannot be overemphasized. Similarly, Surgical patients that spent < 60 minutes in the operating theatre have a higher likelihood of ELOHS than those that stayed between 60

– 120 minutes in the theatre. Although it may be premature to make conclusions about the reasons for this occurrence, research has previously linked 14-17% hospital-acquired infections to surgical site infections resulting from endogenous and procedure-related risk factors [35]. It can also be inferred from the result that hospital factors such as VMO specialty e.g., hematology, vascular surgery, orthopedic surgery, medical oncology, endocrinology, neurology, colorectal surgery, neurosurgery, and general medical physician, have limited influence on ELOHS despite being risk factors. The risk of ELOHS amongst surgical patients also increased with age, a finding that is supported by previous studies [23, 25, 29].

Medical patients admitted with "*ear, nose, mouth and throat*" MDC have significantly higher ELOHS expectation than other patients with neoplastic disorder, digestive system, factors influencing health, respiratory system and musculoskeletal system and connected system MDCs. Charlson score and Intensive Care Unit (ICU) visit though are risk factors for ELOHS have limited likelihood of causing ELOHS.

5.0 Conclusions

This study looked at the hospital records of 21926 surgical and 11826 medical patients to identify the predictors of ELOHS using hospital and psychosocial factors. By using descriptive statistics, Chi-square, Pearson correlation, and multivariate Logistic regression, the risk factors of ELOHS were identified while establishing the prevalence of CHADx amongst ELOHS and NLOHS patients. It was found that 9.94% and 12.41% of medical and surgical patients respectively overstayed the high trim points of their DRGs. There were 22 MDCs for over 90 DGRs with the high trim points from 3 - 60 days considered in this study. The risk factors of ELOHS were identified as CS, AORT, CHADx, HACs, DOP, HTS, ICU transfer, LOS, TS, RRT call, ADC, and Age. Some MDCs such as "*ear, nose, mouth & throat*", "*male reproductive system*", "*circulatory system*", "*digestive system*, "*factors influencing health status*", and "*neoplastic disorders*". were also identified as potential risk factors of ELOHS.

There is a difference in the prevalence of CHADx amongst ELOHS and NLOHS patients except for "*kidney and urinary tract*", "*nervous system*", "*circulatory system*" and "*ear, nose, mouth & throat*" MDCs. There is a moderate correlation between patients' age and the Charlson Score and CHADx and HACs while many other relationships amongst the features are low and negligible. It will be important to consider the risk factors in managing patients of different MDCs and DRG vulnerabilities to improve their health outcomes within the expected LOS. This will go a long way to reduce the cost of managing patients and improve their quality-of-life.

The limitations of this study include the reporting accuracy of inputted and extracted data from the database and the data size of some MDCs. There may be the need to study the MDCs separately to have a better picture of the predictors' behaviour. Finally, despite the DRGs being identified separately, it may be important to have better granular information about them to facilitate analysis that will identify predictors of ELOHS for different diagnosis severity.

Acknowledgment

The authors wish to thank the Digital Health Cooperative Research Centre (DHCRC) for the financial supports and other contributions that made this research possible.

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