The role of ageing in hospital utilisation

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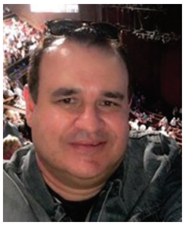

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Abstract Patient age correlates significantly with the average hospital length of stay (HLOS), regardless of illness or injury, with older-age groups having longer HLOS. This study aimed to explore this relationship with patient age individually and within the age groups when the normal ageing process begins to become phenotypically noticeable up to the age of the estimated life expectancy at birth. The objective was to adjust the prediction model using ageing-only populations and compare the results to better understand the role of ageing in hospital utilisation. A random sample of 132 discharge records from the 2010 National Hospital Discharge Survey (NHDS) was stratified in four ageing groups (31–42, 43–54, 55–66, and 67–78). Using Pearson's correlation and simple linear regression analyses, the results confirmed that age correlated significantly with the average HLOS, ($r(132) = .915$, $p < 0.01$) in ageing populations. The prediction model was also statistically significant, ($F(1, 132) = 82.741$, $p < 0.01$), with an r^2 of 0. 837, whereby the ageing groups explained 84 per cent of the variability of the average HLOS. The primary contribution was that patient age scored 6 per cent lower individually in the prediction model (78 per cent) when compared with the ageing groups (84 per cent) and 9 per cent lower when compared with the predictions in the NHDS age groups (87 per cent). While the correlation between patient age and the average HLOS remained statistically significant, the importance of this contribution is that these lower scores may support the assumption of individual differential evolutionary skill sets and speeds in the normal ageing and functional decline processes. Further examination and testing are needed to understand the reasons behind these changes in the prediction strength as to why older patients in age groups would explain a higher HLOS variability than individually.

KEYWORDS: hospital length of stay, age, ageing, functional decline, prediction, elderly

INTRODUCTION

Patient age has multiple connotations in the healthcare industry. The number that merely denotes a person's age is a powerful demographic indicator in health science, but it is also involved in incalculable cultural and social constructs and beliefs.[1] Age is also a vital criterion in the health business operations as well as a determinant in the financial weight of health conditions. While the identification of the payer source may disclose the patient's age, it is also a factor in the distribution of government funds for public health programmes. Patient age is, then, relevant in the configuration of insurance plans, federal health programmes and in the management of hospital reimbursement.[2,3]

As part of the daily clinical operations, hospitals eliminate barriers that are identified throughout the inpatient stay since most of them are controllable factors. Other factors such as patient age or gender, however, are unadjustable when patients seek care because of illness or trauma.[4] This lack of controllability is intrinsic to the human condition. Ageing is chronologically inevitable and relates conceptually to vulnerability, disease, injury, disability, dependence and death.[5–7] Consequently, decreasing the risk of acquiring or developing diseases is one of the current strategies for successful healthy ageing.[8] But what can hospital leaders do about ageing regarding hospital utilisation?

Previous research found a significant interaction between inappropriate HLOS and age in patients with chronic illnesses in North Italy.[9] In a multiple regression model, D'Agostino et al.,[10] discovered that the number of nursing diagnoses along with other variables, including age, were predictors of the HLOS in Italy (p. 1). Sayed and Fawzy[11] demonstrated a correlated increase in HLOS in adult patients with schizophrenic and schizoaffective diagnoses and positive psychiatric scores, making the model a predictor of almost 50 per cent of the causes of higher HLOS in Egypt. Contradictorily, age was not among the factors associated with longer HLOS (21 or more days) for patients in the oldest-old age groups in Singapore.[12] These investigations, however, did not explore age as a sole determinant and independent predictor of longer HLOS.

Masip[13] found a statistically significant relationship between patient age and the average HLOS, regardless of illness or injury. A prediction model established a direct link between ageing and hospital utilisation, where age explained 87 per cent of the variability of the average HLOS. These results confirmed that ageing undoubtedly drives the physiological body decline that, conjointly with the independent appearance of illness, causes inappropriate LOS in inpatient settings. This study aimed to further these recent findings by revising this relationship in age groups when the body's functional decline would start becoming physically noticeable owing to ageing until the age of the life expectancy at birth (LEB).

BACKGROUND

AGE-LOS conceptual framework

As humans age, there is a 'decline in the proliferative capacity of cells leading to senescent phenotype',[14] that is, the physically noticeable traits of ageing (p. 2). Ageing is more physiologically apparent after the fourth decade of life.[15] Concurrently, the exponential curves of mortality begin after age 30, and the most common causes of death are neoplasia and cardiovascular disease.[16,17]

As a result of ageing, humans experience a biological functional decline that makes the species more fragile and subject to higher risk of falls, sickness and accidents. Nonetheless, the expected normal deterioration of the human body does not occur at the same speed and intensity for all individuals, which opens the argument to linking ageing to the survival patterns ingrained in the theories of evolution. Human beings face the acquisition and regularity of diseases that may happen while the body is normally declining but independently influencing each one.[18] While death is eventually inevitable, scientists have targeted the ageing process in the search for human longevity by either reversing it or slowing it down, the latter being the most frequent approach. Science may have then contributed to prolonging life span for up to 120 years.[19]

Ageing is, then, a crucial determinant in the expected functional decline of individuals and the independent appearance of diseases. Functional decline in conjunction with ageing theory, evolutionary theory and age-related health management drivers became the backbone of the assumption that age had a direct relationship with hospital HLOS.[20,21] The AGE-LOS framework then assumed that ageing had a decisive role in the generation of Avoidable Hospital Delays (AHD), regardless of illness and injury, prolonging HLOS as patients aged. This role is presumed to have a relevant adverse effect on hospital reimbursement. Figure 1 shows the conceptual relationship between ageing, AHD and HLOS.

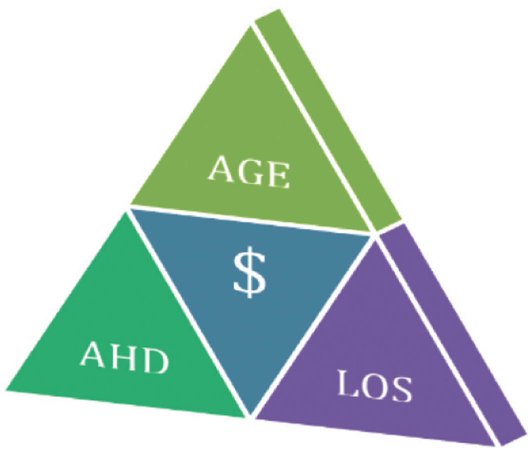

Figure 1: The AGE-LOS conceptual framework: the relationship between age and hospital length of stay.
Source: Masip, J. (2019) 'The relationship between age & hospital length of stay: a quantitative correlational study', *ProQuest Dissertations & Theses Global*, available at: https://search.proquest.com/docview/2305556633?accountid=45853.

Life expectancy at birth

The concept of LEB plays an indicative role in the study of ageing too. According to the World Health Organization,[22] global LEB in 2016 was 72 years. In the US, total LEB has been higher than the global expectation in the last decade and has remained in the 78–79 age range with a significant, two-tenths, decline in 2017.[23–25] In recent years, increases in deaths due to 'unintentional injuries, suicide, diabetes, and influenza and pneumonia' may explain a recent small LEB drop.[26]

Also, the concept of disability-free life expectancy (DFLE) resonates as being more important than just living longer. Chiu[27] examined the differences in total and DFLE among older Americans and found that living arrangements, gender, partnership, education and civil status could exert some influence in living longer without disabilities. Thus, the calculation of the LEB may include individuals with and without disabilities at the time of death, which would be relevant when selecting the age groups that may predict longer average hospital stays.

The ageing groups distribution

Growing individuals experience other types of conditions with dissimilar vulnerabilities, particularly at a very young age. Longer HLOS in the very young groups (0–14) may be a consequence of illness secondary to their immaturity and developmental growth, whereas, in older groups, ageing appeared as the fundamental driver.[28] Also, while individuals undergo a process of growth and development in the first two decades of life, the production of the growth hormone begins declining in the third decade.[29,30]

On the other hand, the oldest age groups tend to have shorter hospital stays secondary to higher incidences of cancer with treatments at the outpatient settings or inpatient hospice settings. Seniors older than 80 are notoriously more fragile and more prone to low surgical success rates or are even ineligible for the procedures. Moreover, these groups have the lowest discharge alive rates.[31,32]

In summary, the AGE-LOS conceptual framework recapitulated that hospitals would observe longer stays in older populations regardless of the independent incidence and prevalence of illness or injury. Thus, ageing, as an unstoppable process and an uncontrollable factor extending HLOS, was worth exploring further in light of the LEB indicators in age groups with physical signs of ageing — the ageing groups.

METHODS

Study design

This study is a quantitative correlational design that explored the relationship between patient age and the average HLOS in the ageing groups between 31 and 78 years old in short-stay hospitals in the US during 2010. The study used data from the 2010 National Hospital Discharge Survey (NHDS).[33] The dataset has records of inpatient discharges from 203 non-federal hospitals. The independent variable was patient age arranged in age groups as follows: (a) 31–42 (b) 43–54 (c) 55–66 (d) 67–78. The dependent variable was the average HLOS. The ageing groups matched the proposed phenotypically ageing brackets up to the average LEB age.

Population and sample

The universe was the total number of discharges from 3,954 non-federal short-stay hospitals equivalent to approximately 35 million inpatient discharges in 2010.[34] The 2010 NHDS data set contained information from 203 hospitals, accounting for 151,551 records that permitted the random calculation of the minimum sample size (N = 132) on IBM-SPSS.[35] The G*Power application facilitated the estimation of (N) using the following values: 0.95 power, 0.30 effect and 0.03 alpha. Table 1 displays the random stratification of hospital discharges in the ageing groups. The study rounded the numbers to the nearest tenth.

Table 1: Stratified sampling of patient discharges per ageing groups

Age groups	Patient age (years)	Sample
1	31–42	23
2	43–54	36
3	55–66	33
4	67–78	40
Total	31–78	132

RESULTS

Descriptive statistics

Table 2 illustrates the average HLOS for the discharged patients per age group in the data set and additional information about the days of care. While the average HLOS was 4.8 days, the table reported that patients 65 years old and older had the highest days of care and average HLOS. Similarly to the data set values, Table 3 showed that the older-age subgroups (55–66 and 67–78) in the sample also had the highest average HLOS.

Table 2 and Figure 3 portrayed the average HLOS of the 203 hospitals in the data set with increased values in the older brackets. In Table 3 and Figure 4, the sample of 132 records of hospital discharges distributed the days of care and average HLOS for each ageing group showing a 5.2 average HLOS. The average HLOS for the two younger ageing groups was below the mean, whereas the two older ageing groups were above it. The longest and most frequent HLOS in the sample was 6.1, whereas the most frequent age was 62 years old. The 67–78 group age had the majority of patients in the sample.

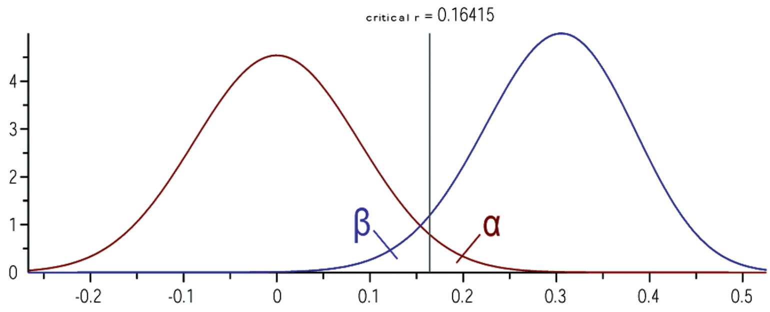

Figure 2: G*Power analysis for one tail.

Table 2: Average HLOS and days of care per age group

Patient age (years)	Days of care (in thousands)	Discharges (in thousands)	Average LOS
0–14	8,883	1,974	4.5
15–44	36,067	10,031	3.6
45–64	47,685	9,483	5.0
65–74	28,146	5,189	5.4
75–84	29,318	5,165	5.7
85+	17,675	3,237	5.5
TOTAL	167,774	35,079	4.8

Source: CDC/National Center for Health Statistics. (2012, March). 'National hospital discharge survey of 2010', Centers for Disease Control and Prevention, available at: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHDS/NHDS_2010_Documentation.pdf.

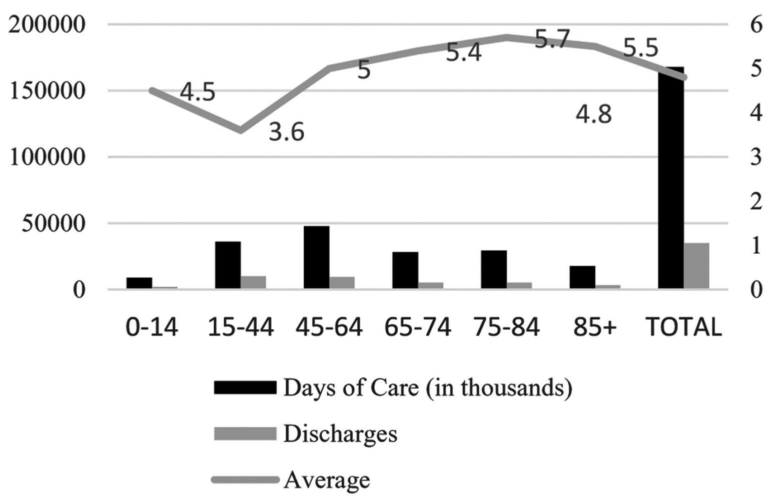

Figure 3: Patient discharges per age group and HLOS.

Source: Masip, J. (2019) 'The relationship between age & hospital length of stay: a quantitative correlational study', *ProQuest Dissertations & Theses Global*, available at: https://search.proquest.com/docview/2305556633?accountid=45853.

Table 3: Age, days of care and average HLOS in the sample

Patient age (years)	Days of care	Average HLOS
31–42	100	4.3
43–54	151	4.2
55–66	192	5.8
67–78	242	6.1
total	685	5.2

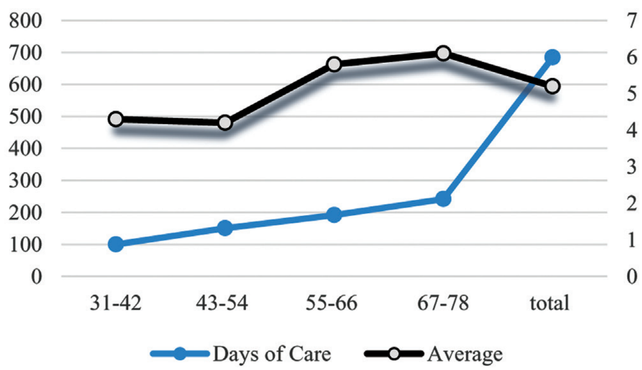

Figure 4: Patient discharges per ageing group and HLOS.

Table 4: Descriptive statistics of the study sample per ageing group

	Patients age	Ageing groups	Hospital LOS
N	132	132	132
Missing	0	0	0
Mean	57	2.68	5.2
Median	58	3.00	5.8
Mode	62	4	6.1
Std. Deviation	13.480	1.086	0.8689
Variance	181.698	1.180	0.755

Correlations analysis

Table 5 indicates that patient age and the average HLOS correlated significantly, ($r(132) = 0.864$, $p < 0.01$). The analysis also probed the relationship between the ageing groups and the average HLOS. With a value of 0.915 at the 0.01 level (1-tailed), the results in Table 6 confirm the same significant statistical findings ($r(132) = 0.915$, $p < 0.01$), with comparable values in ageing groups and individual patient age. The variation between the two r values was 0.51.

Regression analysis

A simple linear regression analysis corroborated the significant relationship between patient age and the average HLOS. An r^2 value of 0.783 in Table 7 indicated that patient age could explain 78 per cent

Table 5: Pearson's correlation between patient age and HLOS

Patient age	**Pearson**	**1**	**0.864***
	Sig.		0.000
Average HLOS per age group	Pearson	0.864*	1
	Sig.	0.000	

* Correlation is significant at the 0.01 level (1-tailed).

Table 6: Pearson's correlation between ageing groups and LOS

Age groups	**Pearson**	**1**	**0.915***
	Sig.		0.000
Average HLOS	Pearson	0.915*	1
	Sig.	0.000	

* Correlation is significant at the 0.01 level (1-tailed).

Table 7: Regression analysis of patient age and HLOS

r	r^2	Adjusted r^2	F change	F sig. change	Durbin-Watson
0.885	0.783	0.781	468.943	0.000	0.113

Table 8: Regression analysis of ageing groups and HLOS

r	r^2	Adjusted r^2	F change	F sig. change	Durbin-Watson
0.915*a*	0.837	0.835	665.473	0.000	0.101

Table 9: Additional regression coefficients at the age level

	Unstandardised coefficients		Standardised coefficients
Model	B	Std. error	Beta
Constant	1.946	0.154	
Patient age	0.057	0.003	0.885

Table 10: Additional regression coefficients at the group level

	Unstandardised coefficients		Standardised coefficients
Model	B	Std. error	Beta
Constant	3.231	0.082	
Age group	0.731	0.028	0.915

* Dependent variable: HLOS.

of the total variation in the average HLOS, ($F(1, 132) = 77.437$, $p < 0.01$). Also, an r^2 value of 0.837 in Table 8 conveyed the same outcome for the ageing groups, ($F(1, 132) = 82.741$, $p < 0.01$). The variation between the two r^2 values was 0.54.

Tables 9 and 10 show the mathematical results of the prediction model from additional regression analyses. The regression equation was as follows: predicted HLOS = unstandardised Coefficient B for the dependent variable (1.946) plus the unstandardised Coefficient B for the independent variable multiplied by the patient age (0.057 × age). The values 1.946 and 3.231 were baseline scores unrelated to any variable but a constant over patient discharges regardless of patient age. The prediction model followed the same methodology using age groups. Table 11 reported several practical examples when using age or age group with the prediction model. The records with the lowest, median and highest ages from the sample illustrated the different practical results. The results expressed the average HLOS for patient age, and the overall difference in this set of records was 0.01.

The ANOVA analysis in Tables 12 and 13 reported that the predictor model was significant for the relationship tested with patient age ($F(1, 132) = 82.741$, $p < 0.01$) and with the ageing groups ($F(1, 132) = 77.437$, $p < 0.01$), respectively.

Table 11: Average HLOS predictive values

#	Patient age	Group age	Age predictor	Group predictor	Difference
1	32	1	3.8	4.0	−0.2
2	36	1	4.0	4.0	0.0
3	42	1	4.3	4.0	0.4
4	43	2	4.4	4.7	−0.3
5	49	2	4.7	4.7	0.0
6	54	2	5.0	4.7	0.3
7	56	3	5.1	5.4	−0.3
8	61	3	5.4	5.4	0.0
9	66	3	5.7	5.4	0.3
10	67	4	5.8	6.2	−0.4
11	73	4	6.1	6.2	0.0
12	78	4	6.4	6.2	0.2

Table 12: ANOVA analysis of patient age and HLOS

Model	Sum of squares	Mean square	F	Sig.	df
Regression	77.437	77.437	468.943	0.000[a]	1
Residual	21.467	0.165			130
Total	98.904				131

* Dependent variable: HLOS.
[a] p-value.

Table 13: ANOVA analysis of age groups and HLOS

Model	Sum of squares	Mean square	F	Sig.	df
Regression	82.741	82.741	665.473	0.000[a]	1
Residual	16.163	0.124			130
Total	98.904				131

* Dependent variable: HLOS.
[a] p-value.

Collinearity diagnostics and statistical assumptions

Table 14 displays the eigenvalues and condition index for the Patient-Age-Hospital Prediction model. Both eigenvalues were close to zero, indicating that the predictor was highly intercorrelated. Both values were lower than 15, indicating no problems with data collinearity. Although this study carried only one independent variable, the variance of inflation factor (VIF) and tolerance values did not evidence any collinearity issues either.

The tests of normality for the dependent variable also reported values above 0.05, confirming the normality distribution of the data as well as its homoscedasticity (Table 15). Figure 4 showed a linear relationship and homoscedasticity. The Durbin-Watson values in Tables 7 and 8 ruled out any positive or negative autocorrelation. Table 3 showed the measurement of the dependent variable at the continuous level in the number of days and the independent variable in the number of years. With these results, the analyses met all statistical assumptions, and the statistics were appropriate to satisfy the validity of the results.

DISCUSSION AND CONCLUSIONS

This study revised the AGE-LOS framework and demonstrated how the predictor formula could be applied to estimate the HLOS in older patients at a group level and individually. Like children, seniors were also classified as vulnerable populations because of their fragility, but the ageing factor was not a commonality.[36,37] Hence, the new group distribution removed individuals from the first three decades of life with longer HLOS in the younger groups and the population of individuals older than the

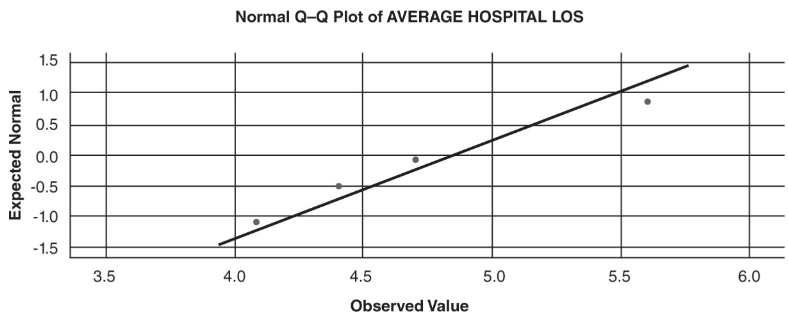

Figure 5: Normal Q-Q plot of average HLOS.

Table 14: Collinearity diagnostics

Dimension	Eigen value	Condition index	Variance proportions		Collinearity statistics	
			(K)	Age	Tolerance	VIF
1	1.973	1.000	0.01	0.01		
2	0.027	8.596	0.99	0.99	1.000	1.000

* Dependent variable: HLOS.

Table 15: Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Average HLOS	0.311	132	0.000	0.713	132	0.000

[a] Lilliefors significance correction.

age of LEB with shorter HLOS. The results with the ageing groups confirmed that older populations were expected to have longer HLOS owing to ageing. The statistical inspection of each discharge and the average HLOS drew similar results to those at the ageing group level.

The regression resulted in a 3 per cent reduction in the prediction strength when comparing the outcomes from both studies' age groups (87–84 per cent), a 6 per cent reduction between the ageing groups and individual predictions (84–78 per cent), and a 9 per cent reduction between the NHDS and individual predictions (87–78 per cent). These discrepancies support the assumption of differential evolutionary skill sets, and speeds in the ageing and functional processes.[38] Now, the question is, why would individual ageing patients explain lower HLOS variabilities than in age groups?

In practice, the model predicted a 5.4 HLOS for a 60-year-old patient admitted to the inpatient setting 1.946 + (600 × 0.057). In the ageing groups, a patient of the same age predicted a 5.4 HLOS, as a result of 3.231 + (60 × 3), where 3 was the age group for a 60-year-old patient. The difference between the two HLOS predictive values was 0.058, which coincided with the 6 per cent discrepancy in the prediction models. Table 11 illustrates the distinct HLOS values in 12 random cases ranging from 0 to 0.4.

NEW CONTRIBUTIONS AND RECOMMENDATIONS

While the prediction model is not 100 per cent accurate, hospital administrators could benefit from estimating the average HLOS of older populations in cases where clinical diagnoses are not available and there is a need to establish an initial duration of the patient's hospitalisation. Leaders should use this model with caution in patients over the current LEB and under 30 years old as the particularities of these population groups may require further research as to what their relationship is with the average HLOS. The model does not appear exclusive for patients whose body composition is changing secondary to ageing. Removing the potential confounding factors behind the growing and oldest-old individuals, however, permitted the adjustment of the prediction strength.

Hospital leaders should use this prediction model as a potential indicator of the accommodation of the baseline resources to cover the future hospital needs of their communities. These new findings may be useful when negotiating tariffs and fees with health insurance companies too. The increasing volume of ageing patients may carry additional operating costs and utilisation of services because of inappropriate HLOS.

While patient age remains uncontrollable and the current findings do not resolve the problem of stagnant HLOS, this new perspective promotes the improvement of the clinical, discharge and transitioning processes for elderly populations. The implementation and strengthening of transitioning coordination programmes could reduce the utilisation of inpatient services in the long term.[39] The impact of these transitional programmes on the average HLOS is still uncertain as this is still a developing idea in the US, which warrants further investigation.

Recommendations for Scholars

This study is the second attempt to augment the body of knowledge regarding patient age, ageing and the average HLOS. The recommendation is to pursue retrospective or prospective research with primary data from local hospitals in different regions and other countries where the management of ageing patients along with the HLOS is also primordial for the health systems.

The next step should include replicating this investigation filtering disease and trauma as well as clinical criteria, scores or cofactors. Ageing individuals may have established comorbidities, multimorbidities and multi-pharmacy therapies and may be prone to major complications from medical-surgical interventions. These illness-related issues might confound the strength of the AGE-LOS relationship. Additional quantitative causal-comparative research may examine the potential differences between groups with and without these factors.

Researchers have the opportunity to deepen their understanding of the current clinical and non-clinical reasons behind hospital stays. The scrutiny of analogous relationships between uncontrollable patient factors (UPF) and HLOS such as gender, civil status and ethnicity is in line for a third delivery. These UPF might also be embedded in the natural history of disease akin to the case of patient age. Their impact on the variability of HLOS, regardless of illness or injury, is still unknown.

Specialised clinical services and outpatient services may also be of interest regarding ageing and the utilisation of services. Adult populations under 30 years old hold lower days of care, rates of inpatient admissions and average HLOS.[40] This group may not present with the acute severity of illness and the need for intensity of care, which agrees with the implications of ageing in the AGE-LOS conceptual framework.[41,42]

The social, clinical and financial determinants of patients older than 80 years may differ from those in the rest of the elderly population. The presence of confounding elements such as the clinical ineligibility for certain procedures and the decision not to seek invasive, complex treatments and interventions may intrude into the utilisation patterns and associations with the average HLOS. The expansion of the AGE-LOS model by considering the concept of DFLE instead of LEB would also be ideal to undertake. Research in these areas is incipient.

Limitations

This study used the 2010 NHDS dataset, which excluded federal hospitals, mental health institutions and outpatient services. Although the age of the data is almost a decade old, countless studies have utilised it, making it reliable and valid. The data set did not include avoidable hospital delays. Multimorbidities, comorbidities, trauma and chronic conditions were not consistently available either. The new NHDS dataset based on the 2020 U.S. population census should be available in 2021-22.

AUTHOR'S NOTE

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