Original Article

Resource Consumption in Hospitalised, Frail Older Patients

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Abstract

Introduction: The objective of this study was to determine factors, other than the Diagnostic Related Grouping (DRG), that can explain the variation in the cost of hospitalisation and length of hospital stay (LOS) in older patients. Materials and Methods: This was a prospective, observational cohort study involving 397 patients, aged 65 years and above. Data collected include demographic information, admission functional and cognitive status, overall illness severity score, number of referral to therapists, referral to medical social worker, cost of hospitalisation, actual LOS, discharge DRG codes and their corresponding trimmed average length of stay (ALOS). Results: The mean age of the cohort was 80.2 years. The DRG's trimmed ALOS alone explained 21% of the variation in the cost of hospitalisation and actual LOS. Incorporation of an illness severity score, number of referral to therapists and referral to medical social worker into the trimmed ALOS explained 30% and 31% of the variation in the cost and actual LOS, respectively. Conclusion: The DRG model is able to explain 21% of the variation in the cost of hospitalisation and actual LOS in older patients. Other factors that determined the variation in the cost of hospitalisation and LOS include the degree of illness severity, the number of referral to therapists and referral to medical social worker.

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Introduction

The number of older adults in Singapore has been steadily increasing over the years and will continue to do so. In 2007, older adults aged 65 years and above accounted for 8.5% of the total population[1] and by the year 2030, it is estimated that this group will account for 19% of the population.[2] Current data reveal that the admission rate to public hospitals in Singapore is highest amongst those aged 65 years and above.[3] As the population ages, the utilisation of healthcare facilities and the consumption of healthcare resources can be expected to increase further.

The Diagnostic Related Grouping (DRG) model was introduced in Singapore in 1999 to fund inpatient hospital care. The DRG model attempts to define homogenous groups of patients requiring similar amounts of resources. While this model is adequate in estimating the average cost of hospitalisation when large aggregate data are being used,[4,5] it is inadequate in accounting for cost variance at the ground level. Various studies have shown that the DRG model does not adequately reflect resource utilisation in older persons. A study conducted locally in 1999 showed that DRG alone accounted for only 8% of the variation seen in the length of hospital stay in a cohort of elderly medical inpatients.[6] Similarly, reports from elsewhere have shown that the length of hospital stay and the cost of hospitalisation were significantly higher in older patients, even within the same DRG groups.[7-9]

The objective of this study was to determine factors, other than the DRG groups, that can explain the variation in the cost of hospitalisation and the length of hospital stay (LOS) in older patients. The hypothesis was that in addition to the DRG groups, resource utilisation in hospitalised, older patients was also influenced by the degree of illness severity, functional and psychosocial factors.

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Materials and Methods

Study Design and Participants

This was a prospective, observational cohort study. The study population consisted of 397 patients who were consecutively admitted under the departments of geriatric medicine (GRM) and general medicine (GM) in preselected wards in an acute general hospital between August 2003 and May 2004.

Patients were included in the study if they were aged 65 years or older. Patients were excluded if their functional and mental status could not be evaluated within 48 hours of admission due to logistic reasons, such as admission on Saturdays or eve of public holidays or if they were transferred in from other departments or wards; if they were transferred out to other departments or wards; if they were previously enrolled in the study; if they had a terminal illness or were under the palliative care service.

Informed consent for participation was obtained verbally from the patients or their families. This non-interventional study was performed with the approval of the institutional review board.

Measurements

A trained research assistant conducted structured interviews with the primary caregivers of the patients enrolled in the study. Demographic information was obtained during the interview. The functional and mental status of all study participants were assessed within 48 hours of admission, using the Barthel Activities of Daily Living (BADL) index[10] and the Abbreviated Mental Test (AMT)[11] respectively. The BADL index and AMT were used as continuous variables in this study, rather than as dichotomous variables, because the degree of functional impairment has been shown in previous studies to influence the cost of hospitalisation[12] and LOS[13,14] in older patients. The medical records of study participants were reviewed and data collected included the principal diagnosis, additional diagnoses, the total number of referral to therapists (physiotherapists, occupational therapists and speech therapists) during the hospital stay, presence or absence of referral to the medical social worker and the actual LOS. The overall illness severity for each patient was also determined using the modified Severity of Illness Index. The discharge DRG codes and their corresponding trimmed average length of stay (ALOS) and the cost of hospitalisation for each patient were obtained from the hospital's health information system database.

Modified Severity of Illness Index (mSII)

The mSII is a 4-level burden of illness measure, modified from Horn et al's original Severity of Illness Index.[15,16] Level 1 represents the least severe illness, while level 4 represents the most severe illness. The 4 levels of illness severity are defined in Table 1.

The illness severity scores of the first 200 patients were evaluated to determine the reliability and validity of the mSII. For each patient, the illness severity measure of the coded principal diagnosis (PD) and each of the coded additional diagnoses (AD) were scored from levels 1 to 4, based on the definition in Table 1. The overall illness severity for an episode of hospitalisation was determined in 2 ways. The first was based on the illness severity score of the PD alone and the second was based on the most severe score from the combined PD and AD list.

Two clinicians established the illness severity score of the coded PD of the first 30 cases independently. Inter-rater reliability of the mSII was established using the weighted kappa coefficient. As patients with higher degree of illness severity were expected to have longer hospital stay, the predictive validity of the mSII was assessed by evaluating the strength of association of the mSII with the length of hospital stay using linear regression analysis with ordinary least squares estimation. The analysis was performed first with the illness severity score derived from the PD score alone and then with the most severe score derived from the combined PD and AD list. Two patients who died during their hospital stay were excluded from this part of the analysis.

The inter-rater agreement of the mSII was 97% with a weighted kappa statistics of 0.80 (P <0.0001). On average, patients grouped with overall mSII scores of 3 and 4 had 3.1 days increase in the LOS when compared to the cohort with scores of 1 and 2, thus establishing the predictive validity of the mSII.

The overall illness severity score derived using the PD score alone, accounted for 44% of the variation seen in the LOS. The overall score derived using the most severe score from the combined PD and AD list, accounted for 45% of the variation seen in LOS. As the latter predicted a marginally higher proportion of the variation in the LOS,

Table 1. Modified Severity of Illness Index

Levels of severity	Definition
1	Asymptomatic
2	Symptomatic but vital signs are not affected
3	Presence of any *one* of the following: i. Systolic blood pressure < 100 mmHg ii. Heart rate > 100 beats per minute iii. Temperature > 38°C iv. Oxygen requirement more than 2L per minute, delivered intranasally v. Nil orally for more than 24 hours
4	Intensive care unit or high dependency unit admission

the overall illness severity score of the study population used in subsequent analyses was derived from the combined PD and AD list.

Statistical Analysis

Bivariate analyses were initially performed to identify independent variables that had statistically significant associations with the cost of hospitalisation and actual LOS. Anticipating that the cost of hospitalisation and actual LOS would be skewed with outlying observations, 2 robust linear regression models based on iterative re-weighted least squares were subsequently constructed to determine how the statistically significant variables identified on bivariate analyses could further explain the cost of hospitalisation and actual LOS, in addition to the DRG. Unlike the conventional regression model, the robust models accommodated the outlying and influential data automatically by assigning more weights to the inlying observations. The weights were generated objectively by the algorithm based on sample features. As such, no outlying observations were discarded in the analysis as long as they fulfilled the inclusion criteria of the study. The model building was done sequentially, beginning with the DRG's trimmed ALOS as the first independent variable, followed in sequence by illness related variables, variables associated with patients' functional status and social and demographic variables. The major criterion for determining the additional variables that can further explain the cost of hospitalisation and LOS was the adjusted coefficient of determination (adjusted R^2).

As the study participants were recruited from 2 different medical departments where differences in the admission criteria may influence resource utilisation, a subgroup analysis was performed to evaluate any differences in the cost of hospitalisation and actual LOS between the 2 departments. At the time when this study was carried out, older patients with acute functional impairments that were potentially reversible were typically admitted under the department of GRM while those who did not have any functional impairment or who were already chronically and totally disabled were admitted under the department of GM. This part of the analysis involved only patients from both the departments who shared common DRG codes to ensure that different DRG codes would not be a confounding factor in explaining the differences in cost of hospitalisation and actual LOS. In this subgroup analysis, model building began with the department variable, followed by other variables in the sequence outlined above.

The variance inflation factors (VIF) were computed as a post-hoc analysis to ascertain the severity of multi-collinearity among the variables selected in the above models. A variable is highly correlated with other variables if its' VIF is higher or equal to 5. All statistical analyses were performed using Stata version 10.0 (Stata Corp, Texas, USA) and all statistical tests were conducted at 5% level of significance.

Results

Patient Characteristics

The flow of participants eligible and consented to participate in the study is presented in Figure 1. Fourteen (3.5%) patients died during the hospital admission. Three hundred and eighty-three patients were included in the study analysis. Table 2 illustrates the characteristics of patients included in the study analysis. The mean age of the patients was 80.2 years and 56.4% of the study population were female. Patients admitted under the department of GRM were significantly older, were more dependent in their basic activities of daily living and had lower AMT scores on admission compared to those admitted to the department of GM. The GRM cohort also had more referral to therapists and a higher proportion of patients required referral to the medical social worker. The top 5 DRG groups for the study population are shown in Table 3.

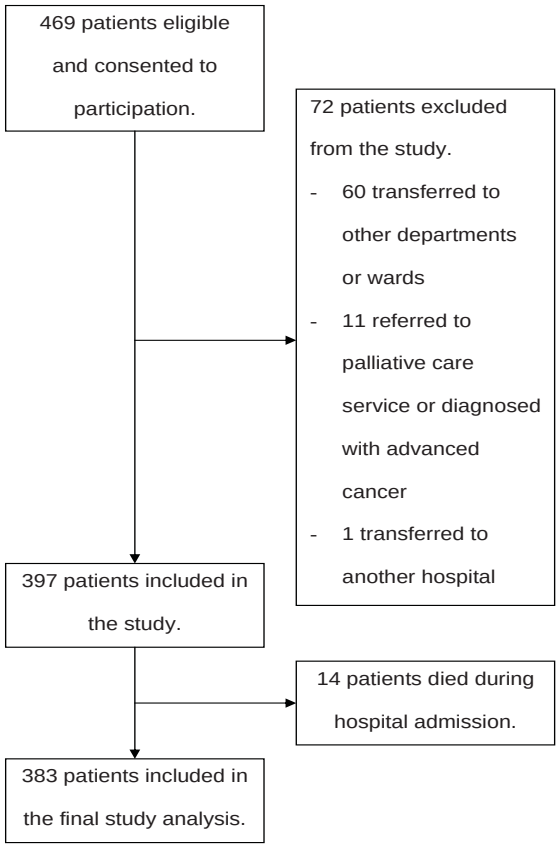

Fig. 1. Participant flow diagram.

Table 2. Patient Characteristics

Characteristics	Entire cohort(n = 383)	GRM(n = 212)	GM(n = 171)	*P* value
Age (years), mean ± SD (range)	80.2 ± 8.2 (65 – 104)	82.3 ± 7.7 (67 – 104)	77.7 ± 8.1 (65 – 103)	<0.001
Gender				
Male, n (%)	167 (43.6)	96 (45.3)	71 (41.5)	
Female, n (%)	216 (56.4)	116 (54.7)	100 (58.5)	0.460
Overall illness severity score				
1 or 2, n (%)	256 (66.8)	139 (65.6)	117 (68.4)	0.686
3 or 4, n (%)	127 (33.2)	73 (34.4)	54 (31.6)	
Admission Barthel Activities of Daily Living index, mean ± SD (range)	47.8 ± 34.7 (0 – 100)	41.7 ± 31.8 (0 – 100)	55.4 ± 36.7 (0 – 100)	<0.001
Admission Abbreviated Mental Test score, mean ± SD (range)	4.82 ± 3.39 (0 – 10)	4.42 ± 3.32 (0 – 10)	5.32 ± 3.43 (0 – 10)	0.010
Number of referral to therapists				
0, n (%)	139 (36.3)	34 (16.0)	105 (61.4)	<0.001
1, n (%)	60 (15.7)	30 (14.2)	30 (17.5)	
2, n (%)	121 (31.6)	92 (43.4)	29 (17.0)	
3, n (%)	63 (16.4)	56 (26.4)	7 (4.1)	
Referral to medical social worker				
No, n (%)	347 (90.6)	183 (86.3)	164 (95.9)	
Yes, n (%)	36 (9.4)	29 (13.7)	7 (4.1)	0.001
Cost of hospitalisation (S$), median (range)	2494.00 (526 – 47578)	2956.50 (661 – 47578)	1907.00 (526 – 15267)	<0.001
Length of hospital stay (days), median (range)	7.0 (1 – 110)	8.0 (1 –110)	5.0 (1 – 48)	<0.001

GM: Department of General Medicine; GRM: Department of Geriatric Medicine

Variation in Cost of Hospitalisation and Actual Length of Hospital Stay

The relationships between the cost of hospitalisation and the actual length of hospital stay and baseline patient characteristics, illness severity, admission functional and cognitive status, number of referral to therapists and referral to the medical social worker are presented in Table 4. On bivariate analysis, overall mSII scores of 3 and 4, lower admission BADL index scores, lower admission AMT scores, higher number of referral to therapists and the need for referral to the medical social worker were associated with higher cost of hospitalisation and longer hospital stay.

Using the adjusted R^2 of a linear regression model, the DRG's trimmed ALOS alone explained 21% of the variation seen in the cost of hospitalisation in the entire cohort of patients. Incorporating the illness severity score, number of referral to therapists and referral to medical social worker into the trimmed ALOS accounted for 30% of the variation seen in the cost of hospitalisation (Table 5).

Similarly, the DRG's trimmed ALOS alone explained only 21% of the variation seen in the actual LOS in the entire cohort of patients on linear regression analysis. As shown in Table 5, 31% of the variation in the actual LOS can be explained by the addition of the illness severity score, number of referral to therapists and referral to medical social worker into the trimmed ALOS.

Table 3. Top 5 Diagnostic Related Grouping for the Study Population

DRG code	DRG diagnosis	n (%)
575	Urinary tract infection, site not specified	31 (8.1%)
170	Pneumonia, organism unspecified	25 (6.5%)
37	Unspecified cerebral artery occlusion with cerebral infarction	20 (5.2%)
56	Arteriosclerotic dementia with delirium	20 (5.2%)
348	Non infectious gastroenteritis and colitis	18 (4.7%)

DRG: Diagnostic Related Grouping

Differences in Cost of Hospitalisation and Actual Length of Hospital Stay

This part of the subgroup analysis involved only patients from both departments who shared common DRG codes. Two hundred and forty-eight patients were included in this part of the analysis. The characteristics of the patients who

Table 4. Association with Cost of hospitalisation and Actual Length of Hospital Stay (Bivariate Analysis)

Covariates	Cost of hospitalisation		Length of hospital stay	
	Cost (S$), median (range)	***P* value**	**Days, median (range)**	***P* value**
Age	*r* = 0.086	0.093	*r* = 0.094	0.066
Gender				
Male	2354.00 (526 – 47578)	0.131	6.0 (1 – 110)	0.186
Female	2724.50 (560 – 15389)		7.0 (1 – 38)	
Overall illness severity score				
1 or 2	2303.00 (526 – 11276)	<0.001	6.0 (1 – 38)	<0.001
3 or 4	3422.00 (683 – 47578)		9.0 (2 –110)	
Admission Barthel Activities of Daily Living index, mean ± SD (range)	*r* = -0.356	<0.001	*r* = -0.375	<0.001
Admission Abbreviated Mental Test score, mean ± SD (range)	*r* = -0.218	<0.001	*r* = -0.234	<0.001
Number of referral to therapists				
0	1563.00 (526 – 13706)	<0.001	4.0 (1 – 36)	<0.001
1	2256.50 (608 – 15267)		6.0 (2 – 48)	
2	3032.00 (860 – 47578)		9.0 (2 – 110)	
3	3750.00 (1388 – 18609)		11.0 (4 – 50)	
Referral to medical social worker				
No	2438.00 (526 – 21602)	0.001	6.0 (1 – 71)	<0.001
Yes	3718.50 (1041 – 47578)		11.0 (3 – 110)	

r: Spearman's correlation

Table 5. Variation in Cost of Hospitalisation and Actual Length of Hospital Stay (Final Regression Models)

	Cost of hospitalisation		Length of hospital stay	
	Coefficient* (95% confidence interval)	***P* value**	**Coefficient* (95% confidence interval)**	***P* value**
Trimmed ALOS	130.00 (81.85 – 178.14)	<0.001	0.36 (0.22 – 0.50)	<0.001
Illness severity score 3 or 4	933.45 (581.82 – 1285.08)	<0.001	2.44 (1.44 – 3.44)	<0.001
Number of referral to therapists	478.44 (322.20 – 634.69)	<0.001	1.43 (0.99 – 1.88)	<0.001
Referral to medical social worker	607.76 (16.99 – 1198.53)	0.044	2.59 (0.92 – 4.27)	0.003

ALOS: average length of hospital stay
Adjusted R^2 (for model predicting of cost of hospitalisation) = 0.30
Adjusted R^2 (for model predicting of actual length of hospital stay) = 0.31
*Adjusted for age, gender, admission Barthel Activities of Daily Living index and Abbreviated Mental Test score

shared common DRG codes were similar to that seen in the entire cohort.

The average cost of hospitalisation for the GRM cohort was S$1684.04 more than the GM cohort and the average LOS in the GRM cohort was 4.7 days longer than the GM cohort. Using the adjusted R^2 of a linear regression model, department factor alone accounted for only 4% and 6% of the variation seen in the cost of hospitalisation and actual LOS respectively. As shown in Table 6, the differences in cost of hospitalisation between the 2 departments were not statistically significant after adjusting for trimmed ALOS, illness severity score and the number of referral to therapists. Similarly, the differences in the actual LOS between the 2 departments were also not statistically significant after adjusting for trimmed ALOS, illness severity score, the number of referral to therapists and referral to the medical social worker.

There was no evidence of multicollinearity in all the above models as all the variables selected in the models had a VIF value of approximately 1, which is far below the threshold of 5. Thus, no further action was taken to address the issue of multicollinearity.

Table 6. Differences in Cost of Hospitalisation and Actual Length of Hospital Stay between 2 Medical Departments

	Cost of hospitalisation		Length of hospital stay	
	Coefficient (95% confidence interval)	***P* value**	**Coefficient (95% confidence interval)**	***P* value**
Department (GRM)	432.85 (-47.02 – 910.71)	0.077	0.95 (-0.43 – 2.34)	0.177
Trimmed ALOS	150.86 (81.49 – 220.23)	<0.001	0.41 (0.21 – 0.61)	<0.001
Illness severity score 3 or 4	716.89 (248.89 – 1184.90)	0.003	2.24 (0.89 – 3.58)	0.001
Number of referral to therapists	544.28 (314.88 – 773.68)	<0.001	1.49 (0.82 – 2.16)	<0.001
Referral to medical social worker			3.39 (1.00 – 5.78)	0.006

GRM: Department of Geriatric Medicine
Adjusted R^2 (for model explaining the differences in cost of hospitalisation between 2 medical departments) = 0.32
Adjusted R^2 (for model explaining the differences in actual length of hospital stay between 2 medical departments) = 0.37

Discussion

In this prospective cohort study, the DRG model alone is able to explain 21% of the variation in the cost of hospitalisation and actual LOS in hospitalised older patients. Other factors that determined the variation in the cost of hospitalisation and LOS include the degree of illness severity, the number of referral to therapists and referral to medical social worker.

The results of this study suggest that the DRG model alone does not adequately describe the cost of care in hospitalised older patients. The DRG model is largely organ-based and assumes that each category contains patients who are clinically similar and have similar pattern of resource use when given the appropriate care. The DRG assignment is based on the principal diagnosis, even though this may not be the most clinically important or the most resource intensive diagnosis.[17] Older patients do not constitute a homogenous group. They often have complex medical, functional and psychosocial problems. They are also more prone to adverse outcomes and their hospital stays are generally more complicated. The management of these patients involves more than just treating the underlying acute medical illness. Issues related to patients' functional and psychosocial status also need to be addressed.

The DRG model is no longer used to directly fund inpatient care in Singapore. Nevertheless, as the population ages and the utilisation of healthcare facilities increases, it is important to realise that resource utilisation in hospitalised, older persons does not depend on the principal diagnosis alone, for which the DRG is largely based on, but also on other factors such as the degree of illness severity and patients' underlying functional and social status. These factors need to be taken into account when allocating healthcare resources to ensure equity of medical care in older adults. Similarly, these factors also need to be taken into consideration when measuring and comparing outcomes such as LOS in hospitalised, older patients.

In clinical practice, the decision on whether or not to refer a patient to the therapists or medical social worker depends on the extent of functional decline in the patient and the rehabilitation potential of the patient. Patients who have changes in the functional and mental status, when compared to their premorbid status, are more likely to be referred to the therapists and medical social worker compared to those whose functional and mental status have remained stable even if the baseline function may already be impaired. In this study, referral to therapists and medical social worker were found to be significant predictors of resource utilisation but not the admission BADL index and AMT score. This suggests that changes in a patient's functional or mental status are more important in determining resource utilisation than the absolute functional and mental status determined at a single point in time.

The results of this study show that in addition to medical illnesses, underlying functional and social statuses also influence resource utilisation in hospitalised, older adults. However, once a patient is medically stable, the functional and social issues can be addressed in healthcare settings that are less costly such as the subacute and rehabilitation care settings. This study suggests a need to increase the availability of subacute and rehabilitation care settings to cater to the demands of an ageing population and to reduce the burden on acute hospitals.

The results of this study are consistent with that reported in previous studies performed elsewhere. The degree of illness severity,[9,12,18-20] patients' physical function and cognitive status[12-14,20-24] have all been shown to partially influence resource utilisation and LOS in hospitalised older patients. Cost of hospitalisation has been shown to be higher and LOS has been shown to be longer in patients who have more severe illnesses and poorer functional and cognitive status. Adjusting for illness severity has been shown to increase the ability of the DRG model to explain the variations seen in the cost of hospitalisation and LOS.[25,26] Similarly, incorporating a variable that reflects patients' functional status has been shown to increase the ability of the DRG

model to explain LOS in older patients.[6,24,27]

There are several limitations in this study. The multivariate models explained only 30% and 31% of the variation in the cost of hospitalisation and actual LOS, respectively. This suggests that there are many other variables, not captured in the study that can influence the cost of hospitalisation and the actual LOS in the older patients. Referral to therapists and referral to the medical social worker were used as proxies for change in patients' functional and social status. These may have resulted in a potential for bias as these variables may also reflect the different departmental practices, in addition to patients' functional and social status. However, the subgroup analysis evaluating the differences in the cost of hospitalisation and actual LOS between the 2 medical departments showed that department factor alone accounted for only 4% and 6% of the variations seen respectively, suggesting that factors other than different departmental practices have a greater influence on the cost of hospitalisation and LOS in older patients. Lastly, the study population comprised only of medical inpatients. It is unknown if these findings are applicable to older surgical inpatients.

Conclusion

In conclusion, in addition to the DRG groups, a simple, reliable and valid measure of illness severity, proxies for functional and social status can further explain the variation seen in the cost of hospitalisation and LOS in hospitalised, older patients. However, these factors inclusive of the DRG, could only explain 30% and 31% of the variation seen in the cost of hospitalisation and LOS, respectively.

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