

Variance Analysis Applied to a Stroke Pathway: How This Can Improve Efficiency of Healthcare Delivery

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Abstract

Introduction: Stroke is a complicated disease that requires a multidisciplinary approach for its management. We postulated that variance analysis applied to a stroke pathway, by identifying major problem areas and encouraging timely corrective actions, would lead to more efficient healthcare delivery to hospitalised stroke patients. **Materials and Methods:** Prospectively collected variance data from consecutive stroke patients discharged from a tertiary hospital in Singapore during a 3-month period in 2000 were used to identify the major variances causing increased length of stay. These were compared and contrasted to variance data collected during the same 3-month period in the subsequent year (2001), after the implementation of stroke pathway and the availability of monthly variance analysis reports. Patient characteristics and outcome measures were also compared between the two study periods. **Results:** The four major variances that accounted for increased length of stay were, in descending order of the number of patients affected, awaiting bed availability in step-down facilities, delay in head computed tomographic scan performance, awaiting family's decision on discharge plan and incomplete application submitted to step-down facilities. After implementation of the stroke pathway with ongoing variance analysis, all four variances showed different extent of improvements. There were no significant differences in patient characteristics between the two study periods, whereas the average length of stay significantly diminished in the late study period with a trend for decreased in-hospital mortality, compared to the early study period. **Conclusion:** Variance analysis applied in the context of a stroke pathway was effective in identifying major variances causing increased length of stay. This allowed targeted intervention to improve efficiency of healthcare delivery to stroke patients.

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Key words: Discharge planning, Hospitalisation costs, Length of stay

Introduction

Stroke is the fourth principal cause of death in Singapore,¹ and the leading cause of long-term disability amongst developed countries. Due to the spiralling increase in healthcare expenditure in recent years, many countries have implemented cost-containing measures in healthcare financing. In Singapore, reimbursement according to Diagnostic Related Groups (DRGs) has been commenced recently in public hospitals. At the same time, the general public has gained increased knowledge in health-related matters and demands better quality healthcare services. Disease management pathways are commonly used to improve quality of healthcare and efficient use of resources in the management of different disease entities, especially complicated diseases associated with long duration of

hospitalisation and high cost of management, such as stroke. Variance analysis is a useful tool to identify important deviations from the standard pathway, so that timely interventions may be applied to rectify the problem areas. The ultimate aim is to improve both the quality and efficiency of healthcare delivery to the patients.^{2,3}

Pathway variance is any development from the patient care activities outlined on the clinical pathway that alters the anticipated discharge date, the expected cost, or the expected length of stay.⁴ Alternatively, variance is defined as the difference between the planned, stable process for a homogeneous group of patients and the actual, individual, unique care delivery experience.⁵ These definitions tell a similar concept of variance, which is the deviation or difference between the expected and the actual process and

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outcomes in the care of patients afflicted with specific disease entities.

Variance can be positive or negative. Positive variance occurs when the patient achieves the final goal or intermediate outcomes sooner than expected, e.g. the patient is discharged 1 or 2 days earlier than expected from the pathway. Negative variance occurs when the patient is unable to achieve the expected outcomes under a specific time frame, with resultant increase in the length of stay, e.g., medical complications that require additional treatments and social economic problems that defer discharge planning. Negative variance may lead to increases in both the length of stay and hospitalisation costs. The documentation and analysis of variance in the context of a clinical pathway serves as a useful audit tool to monitor the healthcare delivery system and to provide continuous feedback for possible improvements.

A stroke pathway has been implemented at the National University Hospital, Singapore (NUH) since September 2000. All members of the multidisciplinary team involved in the care of hospitalised stroke patients (including physicians, nurses, rehabilitation therapists, medical social workers and pharmacists) have been involved in the development of the pathway. Variance data have been collected daily through review of in-patient charts and discussion with members of the stroke team.

We previously reported that implementation of a stroke pathway resulted in a significant decrease in the average length of stay in hospitalised stroke patients.⁶ The objective of the present study was to identify the major variances in stroke patients that accounted for the increase in length of stay and to determine whether variance analysis was able to improve efficiency of healthcare delivery by comparing these variances before and after implementation of the stroke pathway.

Materials and Methods

Variance data have been collected prospectively on a daily basis for stroke patients in NUH since February 2000. The categories of variances are shown in Table I and more detailed descriptions of the variances are given in Appendix I. Variances that account for increased length of stay occur when identifiable deviations from the normal process and delivery of care to an individual patient, which contribute to the eventual delay in discharge of the patient, are present. For example, the variance of awaiting bed availability in step-down facilities is counted from the day a patient is accepted by a community hospital or a nursing home, but is unable to be discharged on the same day because a bed in the particular step-down facility is not available until a later date. A head computed tomographic (CT) scan is usually performed within 24 hours of admission for all

TABLE I: CATEGORIES OF VARIANCES IN HOSPITALISED PATIENTS AT THE NATIONAL UNIVERSITY HOSPITAL

Patient variance	• Medical conditions requiring treatment • Awaiting consent for treatment • Reversal of consent for procedure/surgery • Request for extension of stay
Community or family variance	• No caregiver at home • Awaiting arrival of caregiver • Awaiting family's decision on discharge plan • Change of discharge plan from family • Awaiting bed availability in community hospitals/nursing homes • Unsuccessful application to step-down facilities • Resources not available
System variance	• Operation theatre delay/cancellation • Diagnostic investigation delay • Weekend delay
Healthcare provider variance	• Physician's decision to postpone procedure/operation • Delays in answering referrals • Incomplete application submitted to step-down facilities

stroke patients; any further delay will be counted as the variance of delay in head CT performance. Sources for variance identification included physician notes, nursing documentation, reports from Emergency Medicine Department, and referral letters, supplemented by discussions with members of the multidisciplinary stroke team. After implementation of the stroke pathway in September 2000, the main variances identified have been collated on a regular basis and brought to the attention of members of the stroke team in the form of monthly reports. The head of the Neurology Division would discuss these findings with the multidisciplinary stroke team and followed up on corrective actions during the weekly division ward round.

The four major variances involving the highest numbers of stroke patients discharged during the period 1 April 2000 to 30 June 2000 (early study period), before implementation of the stroke pathway, were identified. These were compared and contrasted to data on the same four variances of stroke patients discharged during the period 1 April 2001 to 30 June 2001 (late study period), after implementation of the stroke pathway with ongoing variance analysis. Variance data were prospectively entered from consecutive stroke patients discharged from NUH over the study periods.

Patient characteristics during the two study periods, including demographic data and underlying medical conditions, were compared for possible confounding effects. Outcome measures, such as average length of stay, in-hospital mortality and complication rates, were also compared between the two periods. Student's *t*-test and

chi-square test were used to compare continuous and categorical data, respectively, when appropriate. *P* values of less than 0.05 were considered statistically significant. As the stroke pathway had not been implemented in the early study period, data collection was incomplete during this period compared to the late study period.

Results

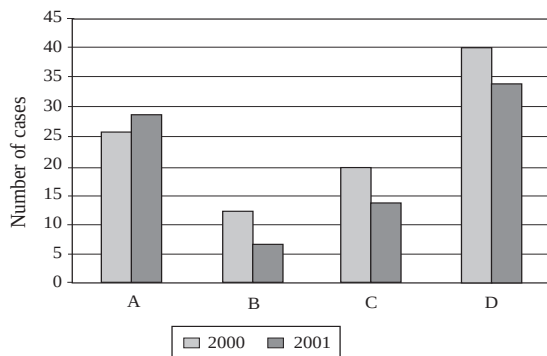
Patient Characteristics

One hundred and thirty two stroke patients discharged from 1 April to 30 June 2000 (early study period), and 125 patients discharged from 1 April to 30 June 2001 (late study period) were included in the study. Comparison of patient characteristics between the two study periods in terms of sex distribution, mean age, proportion of ischaemic versus haemorrhagic strokes and underlying medical conditions (hypertension, diabetes mellitus, and hypercholesterolaemia) did not reveal any significant difference (Table II).

Major Variances

The four major variances that accounted for increased length of stay during the early study period were (Table II and Fig. 1):

1. Awaiting bed availability in step-down facilities (community hospitals and nursing homes), which caused a total delay in discharge of 278 days in 40 patients (6.95 days per patient).
2. Delay in head CT scan performance, which contributed to a delay of 41 days in 26 patients (1.58 days per patient).
3. Awaiting family's decision on the patient's discharge plan in 13 cases, usually in determining whether the patient would be discharged home directly or to a step-down facility.



A = Delay in head CT performance
 B = Awaiting family's decision on discharge plan
 C = Incomplete application for step-down facilities
 D = Awaiting bed availability in step-down facilities

Fig. 1. Comparison of the four major variances of hospitalised stroke patients for the periods 1 April 2000 to 30 June 2000 and 1 April 2001 to 30 June 2001.

4. Incomplete application (e.g., incomplete application forms, lack of certain laboratory results) submitted to step-down facilities in 20 patients. During this period, the durations of delay associated with the latter two variances were not recorded in the stroke pathway.

Other variances identified, which were less important in causing increased length of stay, included delay in the availability of formal radiologist's report of head CT, change of family's decision concerning the discharge plan, medical conditions that required additional treatment (e.g., infections, stabilisation of clotting times for patients on warfarin therapy), awaiting the arrival of a domestic helper from a foreign country to care for the patient at home and awaiting the performance of diagnostic tests (e.g., echocardiography and gastroscopy). As the identifiable variances usually occurred during different time points throughout the entire period of hospitalisation, it is unlikely that doubling-counting of the days in delayed hospital discharge occurred to a significant extent.

TABLE II: COMPARISON OF CHARACTERISTICS OF PATIENTS

	2 nd quarter 2000	2 nd quarter 2001	Level of significance
No. of patients	132	125	
Male (%)	47.72	56	<i>P</i> = 0.185
Mean age (y)	65.3	65.5	<i>P</i> = 0.896
Ischaemic stroke (%)	83.3	90.4	<i>P</i> = 0.095
Haemorrhagic stroke (%)	16.7	9.6	<i>P</i> = 0.095
Hypertension (%)	70.5	69.6	<i>P</i> = 0.881
Diabetes mellitus (%)	42.4	34.4	<i>P</i> = 0.186
Hypercholesterolaemia (%)	25.8	31.2	<i>P</i> = 0.334
In-hospital mortality (%)	12.1	5.6	<i>P</i> = 0.067
Urinary tract infection (%)	16.7	12.8	<i>P</i> = 0.383
Pneumonia (%)	9.8	8	<i>P</i> = 0.604
Average length of stay (days)	16.39	9.73	<i>P</i> <0.001
Total variance (days)	NA	330	
Delay in head CT performance			
No. of patients	26	28	
No. of days	41	34	
% total variance	NA	10.3	
Awaiting family's decision			
No. of patients	13	7	
No. of days	NA	21	
% total variance	NA	6.4	
Incomplete application			
No. of patients	20	13	
No. of days	NA	19	
% total variance	NA	5.8	
Awaiting placement			
No. of patients	40	33	
No. of days	278	163	
% total variance	NA	49.4	

NA: These results were not available due to incomplete data collection during the early study period.

Improvements in Variances

Substantial improvements were observed in the four major variances during the late study period compared to the early study period (Table II and Fig. 1). Awaiting bed availability in step-down facilities accounted for a delay of 163 days in 40 patients (4.08 days per patient), awaiting family's decision on the patient's discharge plan accounted for a delay of 21 days in 7 patients (3 days per patient) and incomplete application submitted to step-down facilities accounted for a delay of 19 days in 13 patients (1.46 days per patient). Although the number of patients experiencing delay in head CT performance slightly increased to 28, the total number of days delayed due to this variance decreased to 34 (1.21 days per patient).

Outcomes Measures

A statistically significant decrease in the average length of stay from 16.4 days during the early study period to 9.73 days during the late study period was found ($P < 0.001$). There was also a trend towards lower in-hospital mortality in the late study period compared to the early study period (5.6% vs 12.12%; $P = 0.067$). Although the complication rates in urinary tract infection and pneumonia were lower in the late study period, these differences did not reach statistical significance (Table II).

Discussion

Stroke management involves the expertise of many disciplines, which can result in poor coordination and inefficiencies in patient management.⁷ Clinical pathways are care plans that detail the essential steps and interventions required for the management of patients suffering from specific disease entities at different time points of hospitalisation. They are usually evidence-based, taking into consideration the international and national guidelines, local protocols and resource availability, and are designed so that quality healthcare can be provided in a timely and efficient manner. The design and implementation of a stroke pathway has been described in detail elsewhere.⁸

Variances are deviations from agreed practice as depicted in the clinical pathway. They need to be identified, recorded and acted upon, in order to optimise both the quality and the efficiency of healthcare delivery to the patients. Variance analysis is a tool to achieve these objectives by highlighting variances in a clinical pathway, so that members of the multidisciplinary team can understand every single deviation from the expected outcomes and intervene accordingly in the earlier stage.⁹ Interested readers may refer to relevant articles on collecting, recording, analysing and reporting on variance data.^{10,11}

We reported that in a tertiary hospital in Singapore, the most important variances that accounted for increased

length of stay in stroke patients were, in descending order of the number of patients affected, awaiting bed availability in step-down facility, delay in head CT scan performance, awaiting family's decision on discharge plan and incomplete application submitted to step-down facilities.

After identification of these variances, multiple corrective actions were taken. For example, the time required to obtain a bed in a step-down facility could be shortened by early discussion with the patient and family for discharge planning so that the application process could be initiated sooner after hospitalisation, and frequent contacts between the staff of the hospital and the step-down facilities would expedite transfer of the patient at short notice when a bed is available. Similarly, delay in head CT scan performance could be minimised after mutual discussion and agreement of both the physicians and radiologists on the principle that all acute stroke patients would have a head CT performed within 24 hours of admission. Delays associated with awaiting family's decision on discharge plan could be diminished by early discussion with relatives on the patient's prognosis and discharge options by a stroke-care nurse with special training in the area, so that comprehensive information could be provided to the family at an early stage and thus decreasing uncertainties and the time to make this important decision. Increased vigilance was taken on the part of house staff, staff nurses, rehabilitation therapists and medical social workers, which resulted in diminished delay due to incomplete application materials submitted to the step-down facilities.

Compared to the early study period, data on the four major variances in the late study period, after implementation of the stroke pathway with monthly feedback of variance data to the stroke team members, showed substantial improvements. These results strongly support our hypothesis that implementation of a stroke pathway with ongoing variance analysis is associated with more efficient healthcare delivery to patients. However, it is of note that our patients still spent an extra 163 days awaiting for bed availability in step-down facilities during the late study period, which accounted for half of the total variance in the increased length of stay of all hospitalised stroke patients during the period. This is mainly explained by the fact that our hospital does not have a step-down or rehabilitation ward and thus has been entirely dependent on other convalescent hospitals or rehabilitation centres to accept our stroke patients for further in-patient rehabilitation therapy. As intra-institutional transfer of patients is expected to be more efficient than inter-institutional transfer, there may be a strong case for setting up an in-patient rehabilitation ward in our hospital in the coming future if this particular category of variance remains significant despite all corrective measures.

Furthermore, when compared to the early study period, a significant decrease in the length of stay together with a trend towards diminished in-patient mortality were noted in the late study period, although the baseline patient characteristics were similar in the two study periods. One possible explanation is that the improvements in the major variances resulted in not only more efficient care of the patient (decreased length of stay), but also better quality of care delivered (diminished mortality). However, we were unable to completely exclude the possibility that patients discharged during the late study period suffered from milder strokes and thus confounded the outcome measures.

The present study highlights the important role of discharge planning for the efficient use of healthcare resources for hospitalised stroke patients.¹² Three of the four major variances associated with increase in the average length of stay (except delay in head CT performance) concern discharge planning. Our stroke pathway did specify that a discharge plan had to be decided by the managing doctor (discharge to home, nursing home, community hospital or rehabilitation unit), and that the nursing team had to commence the process of discharge planning, both within the first week of hospitalisation. However, these provisions were proven to be insufficient to facilitate efficient discharge planning, especially with the significant number of patients and accompanying delays in hospital discharge related to the variance of awaiting placement. Variance analysis had been useful in highlighting these problem areas, and corrective measures as described above were effective in reducing the average length of stay during the late study period, as compared to the early study period. A further application of the results of variance analysis would be the stipulation of specific targets to be achieved in the stroke pathway (e.g., discharge planning should be initiated by the second day of hospitalisation for all stroke patients with mild to moderate disability, whereas this process should be commenced by the end of the first week for severely disabled patients).

Previous studies have consistently demonstrated that the length of stay is the most important predictor of total hospitalisation costs for stroke patients,^{13,14} and implementation of a stroke pathway is able to reduce hospital costs mainly through decrease in the length of stay.^{15,16} Although a detailed cost-effectiveness analysis is beyond the scope of this paper, we believe that the practice of variance analysis applied to a stroke pathway is highly likely to result in substantial reduction in hospitalisation costs for stroke patients in the local setting. As the major component of hospital costs in Singapore, as in many developed countries, is the room rate that is charged on a daily basis, reduction in the average length of stay will lead to decrease in hospital costs.

This study is limited by incomplete collection of some categories of variance data during the early study period (e.g. the number of days of prolonged hospitalisation attributed to some categories of variances), and lack of data on stroke severity and the distribution of different stroke subtypes in ischaemic stroke patients. However, these are unlikely to invalidate our findings, as a comparison of the baseline characteristics of the stroke patients between the two study periods did not reveal any significant difference. We suggest that further research focused on cost-effectiveness analysis can be performed to validate that variance analysis for clinical pathways can indeed lead to improved efficiency in the utilisation of healthcare resources associated with cost saving.

Conclusion

In a prospective cohort of hospitalised stroke patients, implementation of a stroke pathway with ongoing variance analysis was associated with substantial improvements in the major variances identified, significant decrease in the average length of stay and a trend towards diminished in-patient mortality. We conclude that variance analysis applied in the context of a stroke pathway is a useful tool for achieving improved efficiency while maintaining quality of healthcare delivery to patients.

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APPENDIX I: CATEGORIES AND DESCRIPTIONS OF VARIANCES IN PATIENTS ADMITTED TO NUH

1. Patient Variance

- Medical conditions requiring treatment: Complications (e.g. infections, deep vein thrombosis), co-morbidities (e.g. atrial fibrillation, poorly-controlled diabetes) or other medical conditions that require additional treatment that prolong the length of stay.
- Awaiting consent for treatment/intervention: The patient occasionally requires a prolonged period of time to consent to or refuse treatment recommended by the physician (e.g., long-term anticoagulation, percutaneous gastrostomy).
- Reversal of consent for procedure/surgery: Withdrawal of the consent given earlier.

- Request for extension of stay: The patient or family may request for a few more days to stay in the hospital until the home situation and the family are ready, although the patient is already medically fit for discharge.

2. Community or Family Variance

- No caregiver at home: For patients who are dependent in their activities of daily living, a full-time caregiver is usually required when the patient is discharged home.
- Awaiting arrival of caregiver: It is a common practice for the family to employ a domestic helper from a foreign country to work as the main caregiver to an elderly disabled family member.
- Awaiting family's decision on discharge plan: The family is sometimes indecisive in choosing a community hospital or a nursing home amongst the available options.
- Change of discharge plan from family: When the family changes their preference for step-down facility, delay is caused as another application has to be processed.
- Awaiting bed availability in a community hospital/rehabilitation centre: Although the patient is already accepted by a community hospital, immediate transfer cannot be effected until a bed is available for the patient.
- Awaiting bed availability in a nursing home: As above.
- Unsuccessful application for step-down facility: Community hospitals or nursing homes may reject the application due to a number of reasons, e.g., no rehabilitation potential, co-morbid medical conditions, isolation of antibiotic-resistant organisms.
- Resource not available: When there is no suitable step-down facility available for the patients because of restrictions in age, disability, co-morbidities, demand for nursing care or financial requirements.

3. System Variance

- Operation theatre delay/cancellation.
- Diagnostic investigation delay (CT, magnetic resonance imaging (MRI), echocardiography, etc): All investigations should usually be performed within 24 hours of requisition; delays beyond this time period are, however, not uncommon due to the busy schedules.
- Weekend delay: This occurs mainly for patients admitted before or during the weekends, as some services are not available on Saturdays and Sundays.

4. Healthcare Provider Variance

- Physician's decision to postpone procedure/operation.

- Delays in answering referrals (physicians, therapists, medical social workers, etc): All referrals to other disciplines are usually answered within 24 hours.
- Incomplete application submitted to step-down facilities: Incomplete application forms, lack of key laboratory results, no primary caregiver identified, etc.

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