The SOAR Stroke Score Predicts Hospital Length of Stay in Acute Stroke: An External Validation Study

Running head: Usefulness of SOAR stroke score in predicting hospital LOS

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Abstract

Aims: The objective of this study is to externally validate the SOAR stroke score (Stroke subtype, Oxfordshire Community Stroke Project Classification, Age, and pre-stroke modified Rankin score) in predicting hospital length of stay (LOS) following an admission for acute stroke.

Methods: We conducted a multi-centre observational study in eight National Health Service hospital trusts in the Anglia Stroke & Heart Clinical Network between September 2008 and April 2011. The usefulness of the SOAR stroke score in predicting hospital LOS in the acute settings was examined for all stroke and then stratified by discharge status (discharged alive or died during the admission).

Results: A total of 3,597 patients (mean age 77 years) with first-ever or recurrent stroke (92% ischaemic) were included. Increasing LOS was observed with increasing SOAR stroke score ($p<0.001$ for both mean and median) and the SOAR stroke score of 0 had the shortest mean LOS (12±20 days) while the SOAR stroke score of 6 had the longest mean LOS (26±28 days). Among participants who were discharged alive, increasing SOAR stroke score had a significantly higher mean and median LOS ($p<0.001$ for both mean and median) and the LOS peaked among participants with score value of 6 (mean (sd) 35±31 days, median (IQR) 23 (14-48) days). For participants who died as in-patient, there was no significant difference in mean or median LOS with increasing SOAR stroke score ($p=0.68$ & $p=0.79$ respectively).

Conclusion: This external validation study confirms the usefulness of the SOAR stroke score in predicting LOS in patients with acute stroke especially in those who are likely to survive to discharge. This provides a simple prognostic score useful for clinicians, patients and service providers.

What's known?

- Previous studies have identified predictors of length of stay (LOS) in acute stroke.
- Currently, there has yet to be a system that is routinely implemented to predict LOS in acute stroke.
- We previously developed the SOAR stroke score to predict mortality and LOS among stroke patients but this score has not been externally validated for LOS outcome.

What's new?

- We have confirmed the usefulness of the SOAR stroke score in predicting LOS.Higher scores were associated with prolonged hospital stay among patients who survived to discharge.
- The SOAR stroke score can be routinely implemented to provide likely LOS of acute stroke admissions for service providers, healthcare staff and patients and relatives particularly in lower range where the chance of survival to discharge is greater.

Introduction

Stroke is a major cause of mortality and morbidity in Westernized societies[1] and the delivery of stroke care poses a major economic burden.[2] Among the factors that contribute to the total costs of hospitalization, length of stay (LOS) is highly predictive of inpatient costs.[3] One study suggested that LOS accounted for 43% of the variance in total cost in ischaemic stroke.[4] Accurate predictions of LOS provides useful prognostic information for clinicians which may affect clinical decision making and patients and families may benefit from a better understanding of what to expect. Furthermore, it provides useful information to service providers in managing their services to meet the potential demands. Consequently, accurate prediction of LOS has become increasingly important for the patients, hospital administrators and healthcare systems including commissioning and purchasing organizations.

Previous studies have identified some predictors of LOS in acute stroke. The NIHSS score has been evaluated for prediction of LOS after first-ever ischemic stroke.[3] The PLOS score (which includes stroke severity, stroke type, decrease level of consciousness on admission, history of congestive heart disease and prior atrial fibrillation) has been shown to be predictive of LOS in both derivation and validation cohorts (c statistic 0.69 and 0.68, respectively).[5] Other studies have identified other independent predictors of LOS after stroke such as prestroke dementia, smoking, diabetes and atrial fibrillation.[6,7] While it may be interesting to identify factors that are associated with increased LOS, for clinicians a scoring system which is highly predictive of LOS and that could be implemented easily in daily clinical practice would be ideal. Currently, there has yet to be a system that is both validated and routinely implemented to predict LOS in acute stroke.

We previously developed and internally validated the SOAR stroke score which predicts mortality and LOS among stroke patients in a large dataset involving 12,355 patients with acute stroke.[8] This simple prognostic score based on Stroke subtype, Oxfordshire Stroke Community Project classification, Age and pre-stroke modified Rankin has the advantage of including variables which are relative fixed (unlike NIHSS which may change rapidly), easy to remember and easily collectable by the clinical team. This score has been subsequently validated for its usefulness in predicting in-hospital and early (within 7-day) mortality using an independent dataset.[9] Whilst the score was developed with the view of predicting mortality based on predictors of mortality outcome, we also found that it predicted in-hospital LOS.[8] If this was verified in an independent sample, the SOAR stroke score will have added value over other scores which either predicts mortality or LOS alone. Therefore, in this study, we aimed to validate the SOAR stroke score for LOS prediction using an independent patient cohort.

Methods

Participants

The study sample was drawn from the Anglia Stroke & Heart Clinical Network (AS&HCN) database which routinely collected data on consecutive stroke admissions between September 2008 and April 2011 in eight NHS hospital trusts in the East of England across three counties, Norfolk, Suffolk and Cambridgeshire with the catchment population of ~2.5 million. The East of England Strategic Health Authority (SHA) set up the AS&HCN to support the development of stroke services within the region and to monitor the progress in the East of England. Data collection for AS&HCN began at the point of admission to the acute hospital and terminated at the point of patient's discharge from the acute hospital. Anglia Stroke Clinical Network Evaluation Study (ASCNES) was set up with the data sharing agreement with AS&HCN and the study methodology & robustness of study methods have been previously reported. [PKM1]

Selection criteria

Patients included were confirmed stroke cases (either ischaemic or haemorrhagic stroke) based on clinical history and neuroradiological investigations (CT and/or MRI) and therefore transient ischemic attacks and other vascular causes of neurological deficits presenting with stroke-like symptoms (e.g. subdural hematoma and subarachnoid haemorrhages) were excluded. We also excluded patients who were admitted to Norfolk and Norwich University Hospital prior to February 2010 because they were included in the original SOAR stroke score derivation cohort study.[8]

Data collection

Stroke cases were identified prospectively by the clinical teams caring for the patients. Anonymised data from each hospital were sent on a monthly basis to the AS&HCN which collates the data on clinical service activities of the eight hospitals within the network in order to monitor and evaluate the services in relation to National targets and acute stroke management guidelines of the Royal College of Physicians and National Institute of Health & Clinical Excellence.[10]

The follow up time started at baseline for this study (date of study enrolment) and ended at end of March 2009 for CVD events and end of December 2011 for mortality outcome.

SOAR stroke score

We previously derived the SOAR stroke score with score values ranging from 0 to a maximum of 7 that included Stroke subtype (ischaemic or haemorrhagic), OCSP (Oxfordshire Community Stroke Project) classification, Age and prestroke modified Rankin which are measured at the time of admission. For stroke subtype, 1 point is assigned for haemorrhagic stroke. For the OCSP classification, 1 point is assigned for posterior circulation stroke and 2 points for total anterior circulation stroke. For age, 1 point is assigned for age 66-85 years and 2 points for age greater than 85 years. For prestroke modified Rankin, 1 point is assigned for a score of 3 or 4 and 2 points for a score of 5. The overall SOAR stroke prognostic score was the sum of the points designated for these four variables.

Statistical analysis

Statistical anaysis was performed using STATA 13.0 (College Station, USA). The score value for an individual was calculated as per the SOAR scoring system (Appendix 1). The frequency distritbution of baseline characteristics of subjects in the cohort, mean and standard deviation of LOS and median and interquartile range of LOS were also calculated for each value of SOAR stroke score. The cohort was then stratified by discharge status (discharged alive or died during the admission) and LOS was evaluated for each score. Comparisons of LOS and SOAR stroke score values were performed using a one-way analysis of variance for comparison of means and the nonparametric K-sample test on equality of medians for comparison of medians. In addition, we compared the LOS for the derivation and validation studies graphically and in table format.

Results

A total of 3,597 patients with first-ever or recurrent stroke who were admitted between September 2008 and April 2011 (from Feb 2010 in Norwich to avoid overlap with the derivation study of SOAR score)[8] were included in the current study. Their characteristics with regard to the SOAR variables are shown in Table 1. The mean age of the patients was 77 years (SD 12 years) and 92% of them had an ischaemic stroke, with 38% having an OCSP diagnosis of a partial anterior circulation stroke . Half of the patients in this study did not have any disability prior to stroke and a total of 15% of them died during the admission. The SOAR score and crude death rate has been previously reported in this cohort by our group.[9] The characteristics of the patients with missing values who were not included in the analysis are shown in Appendix 2.

SOAR score and mortality

The mortality rate and 95% confidence interval is shown in Appendix 3. The mortality rate ranged from 1.2% to 61% with higher mortality with increasing score from SOAR score of 0 to 6. We observed no patients who had a SOAR score of 7 in this validation cohort. The detailed results of the validation study of SOAR stroke in predicting mortality have been previously reported.[9]

SOAR score and length of stay

For the derivation and validation (current) study, the mean and median LOS for the full cohort and then stratified by discharge status are presented in Table 2. For the validation study there was an increasing LOS with increasing score for the full cohort ($p<0.001$ for both mean and median) and the SOAR stroke score of 0 had the shortest mean LOS (12±20 days) while the SOAR stroke score of 6 had the longest mean LOS (26±28 days). Among participants who were discharged alive, increasing SOAR stroke score had a significantly higher mean and median LOS ($p<0.001$ for both mean and median) and the LOS peaked among participants with score value of 6 (mean (sd) 35±31 days, median (IQR) 23 (14-48) days). For participants who died as in-patient, there was no significant difference in LOS with increasing SOAR stroke score ($p=0.68$ for mean, $p=0.79$ for median) and the mean LOS ranged from 8 to 22 days. Similar results were present for the derivation cohort. A comparison of the LOS of the derivation and validation cohort was shown graphically in Figures 2 and 3 for comparison of mean and median, respectively.

Discussion

This validation study confirms that the SOAR stroke score is also useful in predicting LOS in patients with acute stroke in addition to mortality prediction. The SOAR stroke score performed as expected as higher scores were associated with prolonged hospital stay among patients who are discharged alive but the performance was inconsistent for patients[PKM2] who died as an inpatient. The inconsistency for predicting LOS in patients who died may be due to the fact that the score was derived to predict in-hospital death and thus may not perform as well for LOS in those who died. Nonetheless, the performance of the SOAR stroke score score is very good for those who are discharged alive albeit with some inconsistency at the very high scores perhaps due to small sample size in this category.

Predicting length of stay in stroke is complex. Stroke patients are heterogeneous in terms of baseline function and severity of stroke. Furthermore, whilst the majority of stroke occurs in older age, there is wide age range as it also affects younger people. Some patients present with mild stroke while others present with very severe disabiling stroke and this has a strong influence on length of stay as well as inpatient mortality or survival to discharge. This could be further complicated by the fact that some very severe stroke (e.g. who scored 6) may be discharged alive for palliation in the community with expected death occuring shortly after the discharge. Nevertheless, this may not concern the health system management in term of secondary care resource use. It should be noted that the SOAR stroke score was designed based on predictors of mortality. Of note the length of stay in stroke may be influenced by the aggressiveness of management and the individual patient's susceptibility to complications. For patients with good baseline function and mild stroke who eventually are discharged the score has very good predictive value as there is a higher certainty that the patient will be discharged alive.

While many demographic, clinical and functional factors have been reported to influence LOS in acute stroke, there are inconsistencies among the studies. In a population based study of 346 stroke patients, initial stroke severity was the only significant predictor of length of stay in hospital.[11] A Swedish study found that independent predictors of acute LOS were stroke severity, lacunar stroke, dementia and smoking. In addition, a Chinese study of over 5000 patients found that stroke type has been reported to influence LOS.[12] An Australian study of over 6000 patients with first-ever stroke found that hospital stays were longer for females and those who were admitted to specialist stroke units.[13] In-hospital complications have also to be shown to be associated with longer LOS in acute stroke.[14] Higher quality of care during the early phase of stroke has also been reported as associated with reduced LOS among patients with stroke.[15] Some of the differences in findings may reflect different measures evaluated in each study. No study to date has attempted to develop an easy score that correlated very well with the LOS outcome.

The predictive accuracy of the SOAR stroke score may relate to the fact that the individual variables included in this scoring system are important prognostic indicators of stroke. Stroke type has been shown to be predictive of LOS.[12] Age has been shown to have prognostic impact as very old age has been shown to be a strong predictor of outcome and mortality after stroke.[16] In the SOAR score, stroke severity is captured by OSCP classification. More severe stroke according to the OSCP classification[17,18] and high pre-morbid Rankin scores[19,20] in stroke are associated with poor outcomes which may influence patient LOS.

The SOAR stroke score has several strengths. In contrast to other suggested stroke prognostic scores to date, our score contains only four variables, which are easy to obtain thus makes it much simpler and user friendly. In addition, it can be easily implemented by any clinician at the point of stroke diagnosis. The score is universally applicable as the parameters included in the score are readily available which increases the likelihood of the score being adopted by clinicians in their routine clinical practice. In addition, the score can be calculated by non-clinical staff for administrative purposes once a clinical assessment has been made. An important advantage of the SOAR score is that the variables included are mainly fixed at time of assessment unlike variables such as glucose, blood pressure of NIHSS score which are subject to variation over time. Another strength of the study is that it is derived from 8 hospitals in the UK from 3 counties which would capture variations in stroke services, thus results are more likely to be generalizable. Unlike other scores which are specific to ischaemic stroke[21] and stroke patients who received intravenous thrombolysis,[22] this score can be applied to predict LOS outcome for both stroke subtypes.

Our study has some limitations. Variables such as age, stroke subtype, OSCP classification and premorbid Rankin were statistically significantly different between the included and excluded patients. The excluded group has a much higher rate of hemorrhagic stroke and this may suggest that there was a greater extent of missing data for patients with more severe stroke subtypes, e.g. unable to ascertain pre-stroke modified Rankin. For age and the pre-stroke modified Rankin score, the patients excluded had slightly higher proportion of patients who were in the youngest and oldest groups and in the least disabled and most disabled groups. The truncation of distribution however would only attenuate the associations. Furthermore, the internal relationship between the score and outcomes examined would not have been affected by the missing data. Furthermore, the data showed expected results, i.e.

the higher the score, the higher the mortality outcomes, and thus has internal validity. Furthermore we have shown that the score performance score is reproducible in both derivation (internal validation) and the currently reported external validation cohorts. The score was validated using hospital based data and thus did not capture patients with mild strokes and patients who died in the community due to severe stroke who were not admitted to the hospital. Nonetheless, the majority of patients with stroke are admitted to hospital making the score relevant to stroke prognosis.

One of the potential limitations is the possibility of inter-rater variability in the measurement of prestroke modified Rankin score which was collected from medical documents, nursing records or from a proxy, usually relatives or carers. However, the way the SOAR score is categorized for aggregated scores for the prestroke modified Rankin (0-2, 3-4 and 5) minimizes the impact of inter-rater variability on the score value. Finally, the OCSP classification can be difficult to measure acurately because the patients' condition may change in some cases e.g. from total anterior circulation to partial anterior circulation stroke depending on the exact timing of stroke onset and assessment. Nonetheless, major neurological fluctuations are less likely to happen compared to other biochemical parameters or physiological variables such as blood pressure or glucose levels.

Future studies should test the usefulness of SOAR score in predicting hospital length of stay in different healthcare settings (community and hospital based) as well as in different ethnic groups to examine the generalisability of its clinical utility. The outcome of stroke is invariably linked to the quality and efficiency of services hence the SOAR score can serve as a benchmarking tool to determine the efficiency and outcome of services. This will provide a valuable assessment tool for service users and care service commissioners to use to determine services to buy, and for service providers to ensure the expected standards are met. Further studies should also be undertaken to evaluate how clinical judgement compares to the SOAR score in predicting length of hospital stay.

Conclusions

In summary, this validation study found that the SOAR score acurrately predicts LOS in acute stroke. This four variable score is simple and can be implemented at time of diagnosis to provide service users, healthcare staff and commisioners about likely LOS of acute stroke admissions. The score also has the potential to be utilized as a benchmarking tool to evaluate if service providers meet the expected standards.

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Disclosures

We have no financial conflicts of interest, personal conflicts of interest or potential conflicts of interest. The authors have no disclosures to declare.

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Institutional Approval

The individual Institutional approvals were obtained to use AS&HCN data as part of the Anglia Stroke Clinical Network Evaluation Study (ASNES) funded by the NIHR Research for Patient Benefit Programme.

Sponsor's Role

The funders of this research (NIHR Research for Patient Benefit (RfPB) programme (Grant Reference Number PB-PG-1208-18240), National Health Service Improvement Program, Cambridge NIHR Biomedical Research Grant) were not directly involved in the design, methods, analysis and preparation of this paper. The sponsor's provided funding that was necessary for subject recruitment and data collection but were not directly involved in these processes.

List of Figure and Tables

Figure 1: Mean length of stay (corresponding 95% CI) of patients scoring 0-6 by SOAR Stroke Score in derivation and validation (current) study according to discharge status

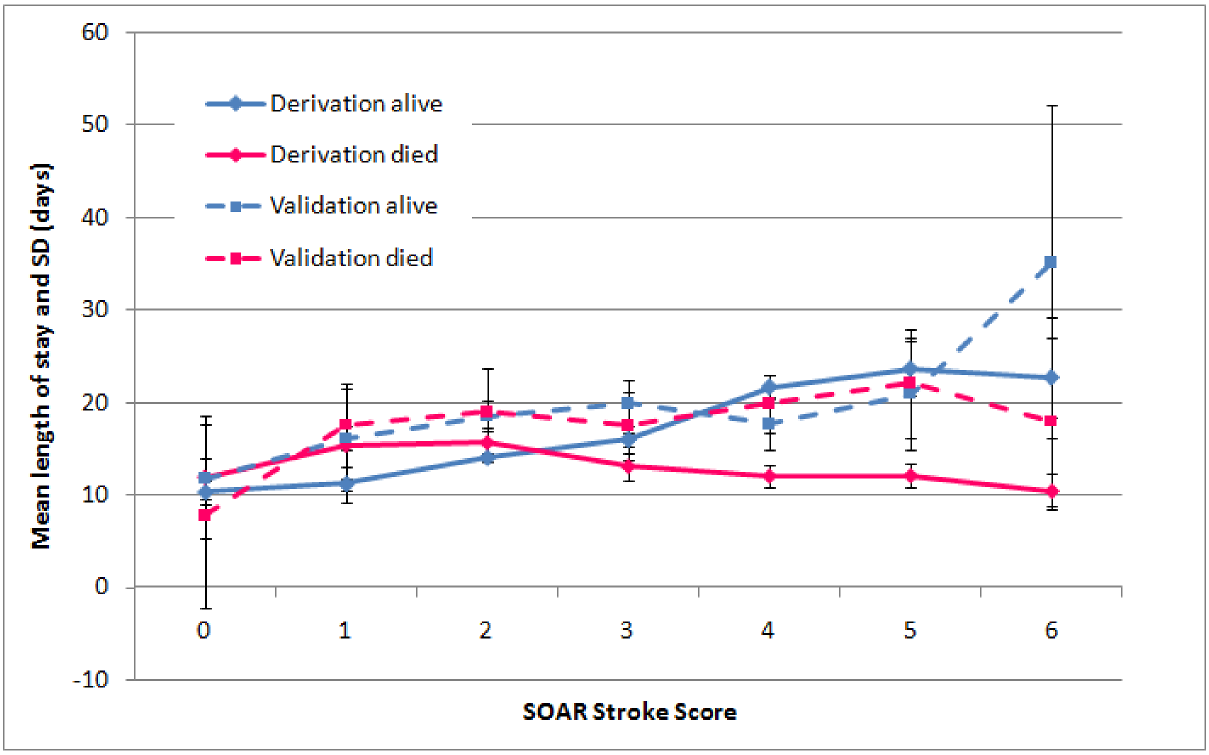


Figure 2: Median length of stay (IQR) of patients scoring 0-6 by SOAR Stroke Score in derivation and validation (current) study according to discharge status

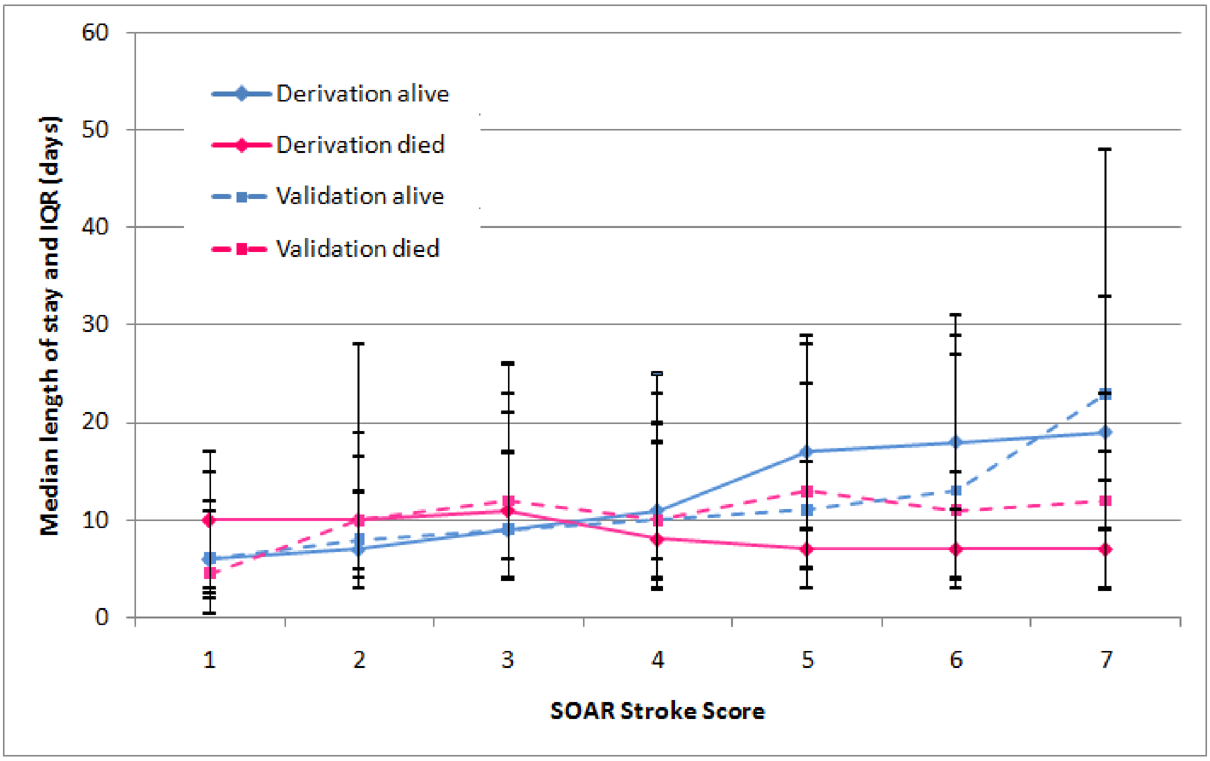


Table 1: Demographic data of patients

Variable	N	%/SD
Age (mean / SD)	3597	77 (±12)
Female	1822	51%
Male	1775	49%
Ischaemic	3308	92%
Haemorrhage	289	8%
mRs		
0	1809	50%
1	607	17%
2	460	13%
3	412	11%
4	236	7%
5	72	2%
6	1	0.03%
Bamford classification		
LACS	929	26%
PACS	1361	38%
POCS	542	15%
TACS	765	21%
Discharge status		
Alive	3001	85%
Dead	536	15%

SD = standard deviation, mRs = modified Rankin score, LACS = lacunar stroke, PACS = partial anterior circulation stroke, POCS = posterior circulation stroke, TACS = total anterior circulation stroke.

Table 2: Length of stay by SOAR Stroke Score in derivation and validation study

SOAR Score	Derivation study			Validation study (current study)		
	N	Mean (SD)	Median (IQR)	N	Mean (SD)	Median (IQR)
0	766	10 (±19)	6 (3-12)	340	12 (±20)	6 (2-12)
1	2313	11 (±17)	7 (4-13)	1221	16 (±22)	8 (3-19)
2	4130	14 (±16)	10 (5-17)	905	18 (±24)	9 (4-24)
3	2588	15 (±17)	10 (6-19)	621	19 (±26)	10 (4-24)
4	1766	17 (±19)	12 (5-24)	334	20 (±29)	12 (5-25)
5	668	16 (±19)	11 (5-22)	142	21 (±26)	12 (4-28)
6 or 7	124	13 (±13)	9 (4-19.5)	34	26 (±28)	16 (5-32)
Alive at discharge						
0	754	10 (±19)	6 (3-11)	333	12 (±20)	6 (2-12)
1	2220	11 (±16)	7 (4-13)	1149	16 (±22)	8 (3-19)
2	3690	14 (±16)	9 (6-17)	813	18 (±24)	9 (4-23)
3	2034	16 (±17)	11 (6-20)	468	20 (±28)	10 (4-25)
4	943	22 (±20)	17 (9-29)	170	18 (±19)	11 (5-24)
5	249	24 (±24)	18 (11-29)	55	21 (±23)	13 (4-31)
6 or 7	30	23 (±18)	19.5 (9-33)	13	35 (±31)	23 (14-48)
Dead at discharge						
0	12	12 (±12)	10 (2.5-17)	4	8 (±10)	4.5 (0.5-15)
1	93	15 (±30)	10 (5-16.5)	55	18 (±17)	10 (5-28)
2	440	16 (±17)	11 (4-21)	81	19 (±22)	12 (4-26)
3	554	13 (±18)	8 (3-18)	139	17 (±22)	10 (3-23)
4	823	12 (±16)	7 (3-16)	153	20 (±20)	13 (5-28)
5	419	12 (±14)	7 (3-15)	85	22 (±28)	11 (4-27)
6 or 7	94	10 (±10)	7 (3-17)	19	18 (±20)	12 (3-23)

SD=standard deviation, IQR=interquartile range

Appendix 1: The SOAR Stroke Score described in tabular form

SOAR Stroke Prognosis Score				
Point	**Age**	**Stroke subtype**	**OCSP**	**Pre-stroke disability**
0	≤65	Infarct	LACS/PACS	mRs 0-2
1	66-85	Haemorrhage	POCS	mRs 3-4
2	>85	-	TACS	mRs 5
Score for each factor				
Total				

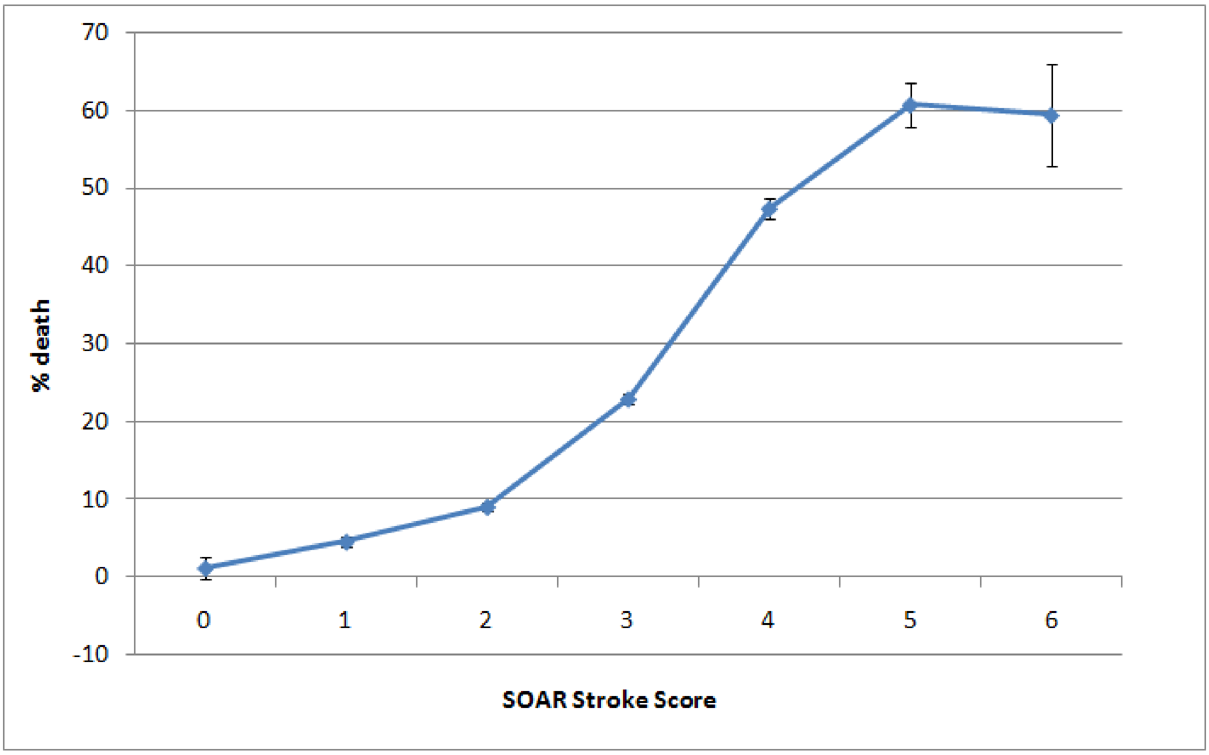
mRs = modified Rankin score

Appendix 2: Demographic data of patients excluded due to missing data

Variable	Mean/N	SD/%
Age (mean / SD)	5325	76 (±13)
Female	2685	52%
Male	2521	48%
Ischaemic	3769	83%
Haemorrhage	766	17%
MRs		
0	949	54%
1	306	17%
2	155	9%
3	190	11%
4	135	8%
5	34	2%
6	1	0.06%
Bamford classification		
LACS	375	23%
PACS	697	43%
POCS	209	13%
TACS	351	22%
Discharge status		
Alive	3649	79%
Dead	995	21%

Appendix 3: SOAR Stroke Score and risk of mortality ([PKM4]corresponding 95% CI) in current study

The in-hospital mortality rate (95%CI) for each point of SOAR Stroke Score in the current cohort



References

1. Stroke Association. Stroke Statistics 2013. Available at http://www.stroke.org.uk/resource-sheet/stroke-statistics. Accessed December 24, 2013.

2. Di Carlo A. Human and economic burden of stroke. Age Ageing 2009;38:4-5.

3. Chang KC, Tseng MC, Weng HH, et al. Prediction of length of stay of first-ever ischemic stroke. Stroke 2002;33:2670-2674.

4. Diringer MN, Edwards DF, Mattson DT, et al. Predictors of acute hospital costs for treatment of ischemic stroke in an academic center. Stroke 1999;30:724-8.

5. Koton S, Bornstein NM, Tsabari R, et al; NASIS Investigators. Derivation and validation of the prolonged length of stay score in acute stroke patients. Neurology 2010;74:1511-6.

6. Appelros P: Prediction of length of stay for stroke patients. Acta Neurol Scand 2007;116:15–19.

7. Huang YC, Hu CJ, Lee TH, et al. The impact factors on costs and length of stay among acute ischemic stroke. J Stroke Cerebrovasc Dis 2013;22:e152-8.

8. Myint PK, Clark AB, Kwok CS, et al. A simple 8-point score strongly predicts early outcomes in acute stroke. Int J Stroke 2014;9:278-83.

9. Kwok CS, Potter JF, Dalton G, et al; On behalf of the Anglia Stroke Clinical Network Evaluation Study (ASCNES) Group. The SOAR Stroke Score Predicts Inpatient and 7-Day Mortality in Acute Stroke. Stroke 2013;44:2010-2012.

10. National clinical guidelines for stroke. 4th edition. Incorporating the recommendations from Stroke: national clinical guidelines for diagnosis and initial management of acute stroke and transient ischaemic attack (TIA) by the National Institute for Health and Clinical Excellence. Available at http://www.rcplondon.ac.uk/publications/stroke-national-clinical-guideline-diagnosis-and-initial-management-acute-stroke-and-tr. Accessed December 24, 2013.

11. Luengo-Fernandez R, Gray AM, Rothwell PM. Population based study of determinants of initial secondary care costs of acute stroke in the United Kingdom. Stroke 2006;37:2579–2587.

12. Li Y, Liu H, Wang J, Li Y et al. Variable lengths of stay among ischemic stroke types in Chinese general teaching hospitals. PLoS One 2012;7:e45101.

13. Somerford PJ, Lee AH, Yau KK. Ischemic stroke hospital stay and discharge destination. Ann Epidemiol 2004;14:773-7.

14. Ingeman A, Andersen G, Hundborg HH, et al. In-hospital medical complications, length of stay, and mortality among stroke unit patients. Stroke 2011;42:3214-8.

15. Svendsen ML, Ehlers LH, Andersen G, et al. Quality of care and length of hospital stay among patients with stroke. Med Care 2009;47:575–582.

16. Kammersgaard LP, Jorgensen HS, Reith J, et al; Copenhagen Stroke Study. Short- and long-term prognosis for very old stroke patients. The Copenhagen Stroke Study. Age Ageing 2004; 33:149–154.

17. Tei H, Uchiyama S, Ohara K, et al. Deteriorating ischemic stroke in 4 clinical categories classified by the Oxfordshire Community Stroke Project. Stroke 2000;31:2049-54.

18. Paci M, Nannetti L, D'Ippolito P, et al. Outcomes from ischemic stroke types classified by the Oxfordshire Community Stroke Project: a systematic review. Eur J Phys Rehabil Med 2011;47:19-23.

19. Kwok CS, Clark A, Ford GA, et al. Association between pre-stroke disability and in-patient mortality and length of acute hospital stay following acute stroke. J Am Geriatr Soc 2012;60:726-32.

20. Huybrechts KF. Caro JJ, Xenakis J, et al. The prognostic value of the modified Rankin scale score for long-term survival after first-ever stroke. Cerebrovasc Dis 2008;26:381-387.

21. Lee J, Morishima T, Kunisawa S, et al. Derivation and validation of in-hospital mortality prediction models in ischaemic stroke patients using administrative data. Cerebrovasc Dis 2013;35:73-80.

22. Giralt-Steinhauer E, Rodriguez-Campello A, Cuadrado-Godia E, et al. External validation of the DRAGON score in elderly Spanish population: prediction of stroke prognosis after IV thrombolysis. Cerebrovasc Dis 2013;36:110-4.