Addition of sodium criterion to SOAR stroke score

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Abstract

Objectives: To examine the usefulness of including sodium (Na) levels as a criterion to the SOAR stroke score in predicting inpatient and 7-day mortality in stroke.

Materials & Methods: Data from the Norfolk and Norwich University Hospital Stroke & TIA register (2003-2015) were analysed. Univariate and then multivariate models controlling for SOAR variables were used to assess the association between admission sodium levels and inpatient and 7-day mortality. The prognostic ability of the SOAR and SOAR-Na score for mortality outcomes at both time points were then compared using Area Under the Curve (AUC) values from Receiver Operating Characteristics.

Results: A total of 8,493 cases were included (male=47.4%, mean (s. d.) 77.7 (11.6) years). Compared to normonatraemia (135-145mmol/L), hypernatraemia (>145mmol/L) was associated with inpatient mortality and moderate (125-129mmol/L) and severe hypontraemia (<125mmol/L) with 7-day mortality after adjustment for stroke type, Oxfordshire Community Stroke Project classification, age, pre-stroke modified Rankin score and sex. The SOAR and SOAR-Na scores both performed well in predicting inpatient mortality with AUC values of 0.794(0.78-0.81) and 0.796(0.78-0.81), respectively. 7-day mortality showed similar results. Both scores were less predictive in those with chronic kidney disease (CKD) and more so in those with hypoglycaemia.

Conclusion: The SOAR-Na did not perform considerably better than the SOAR stroke score. However, the performance of SOAR-Na in those with CKD and dysglycaemias requires further investigation.

Key Words: Acute stroke, dysnatraemia, mortality, prognosis

Introduction

Acute stroke mortality remains high (1) with most deaths occurring early as inpatient deaths (2). Numerous prognostic scores previously developed are limited by various factors including complexity (3) and prediction limited to either ischaemic or haemorrhagic stroke (4-7). We developed the SOAR stroke score as a simple 8 point (score values 0-7) prognostic score that predicts inpatient and 7-day mortality for both stroke subtypes. It takes into account four readily available variables: **S**troke subtype, **O**xfordshire Community Stroke Project (OCSP) Classification, **A**ge and pre-stroke modified **R**ankin score (pre-stroke mRs; indicative of pre-stroke disability). Haemorrhagic, and total anterior circulation stroke (TACS), older age and extensive pre-stroke disability are weighted with a higher score and are associated with greater risk for early mortality (8). Supplementary Table 1 demonstrates how values for these variables are scored (along with the proposed scores for sodium categories). Though not currently in clinical use, external validation of the SOAR stroke score has shown that it is accurate in predicting mortality (9).

Dysnatraemia, either hypo- or hypernatraemia, is the commonest electrolyte abnormality in hospitalised patients (10). Indeed, both hypo- and hypernatraemia have been shown to increase inpatient mortality in various settings including intensive care units and emergency departments (10-12). Recently, studies have established that hyponatraemia increases both short and long term mortality in stroke patients (13-15). We hypothesise that the addition of sodium levels would improve the performance of SOAR stroke score.

The current study aimed to examine if the addition of sodium levels (forming the SOAR-Na score) would considerably better the prognostic ability of the SOAR stroke score. Also of interest was to explore the performance of the SOAR-Na score in comparison to the SOAR stroke score in patient populations characterised by conditions that may particularly influence sodium handling and levels - those with or without chronic kidney disease (CKD) and those with or without hyperglycaemia, respectively.

Materials & Methods

The participants were drawn from the Norfolk and Norwich University Hospital Stroke & TIA register (NNUSTR) which has a catchment population of ~750,000. This register has recorded consecutive stroke patients since its inception in 1996 and blood results were available from electronic records from 2003. For this study purpose we included patients consecutively admitted between January 2003 and May 2015. The Newcastle and Tyneside National Health Service Research Ethics Committee granted ethical approval (12/NE/0170).

The variables included in this study were sex, plasma sodium levels on admission (same day or closest to admission), status at discharge (dead or alive), dates of admission and discharge. In addition to this were all variables needed to calculate the SOAR stroke score: age, pre-stroke mRs, stroke subtype and OCSP classification. The outcomes of interest were inpatient and 7-day mortality. Inpatient mortality refers to patients who die before discharge from hospital, while 7-day mortality refers to death within 7 days regardless of status at discharge. Sodium levels on admission were split into five categories based on standard cut off points used in clinical practice. These were severe hyponatraemia (<125mmol/L), moderate hyponatraemia (125-129mmol/L), mild hyponatraemia (130-134mmol/L), normonatraemia (135-145mmol/L) and hypernatraemia (>145mmol/L). Cases were excluded for various reasons, these are summarised in Figure 1.

Statistical Analysis

Analysis was performed using SPSS V.23.0 (Chicago, Illonois, US). Univariate and then multivariate logistic regression models were constructed for both inpatient and 7-day mortality outcomes. The results of the multivariate model that adjusted for SOAR variables were used to assign score values for sodium categories. Then, a separate logistic regression model was constructed to check the value of points assigned to sodium categories. This analysis adjusted for a calculated SOAR stroke score as opposed to actual values of individual variables. Based on the results of these models, both severe hyponatraemia and hypernatraemia were assigned one point each and added to the SOAR stroke score, forming the SOAR-Na stroke score (Supplementary Table 1).

Due to relatively small numbers of patients who scored very high scores, those with scores 5 and 6 were combined for SOAR and those who were scoring 5, 6 and 7 were combined for

the SOAR-Na score. The diagnostic ability of the SOAR and SOAR-Na score for both inpatient and 7-day mortality was determined by sensitivity, specificity, negative predictive value (NPV) and positive predictive value (PPV) for each increment of the score point. Then the discriminating ability of SOAR and SOAR-Na was compared using receiver operating characteristic (ROC) curves. An analysis was also run stratifying those whose sodium level were taken at the same day of admission and those whose level was measured afterwards.

Sub-analyses were conducted using STATA (Version 14.0). This analysis involved stratifying each of the ROC curves by diagnosis of chronic kidney disease or by glucose levels: Glucose categories were hypoglycaemia (<4.0mmol/L), normoglycaemia (4.0-7.8mmol/L), borderline hyperglycaemia (7.9-11.0mmol/L) and hyperglycaemia (>11.0mmol/L). Some had missing data for glucose levels at admission, thus for glucose analysis the sample consisted of 6,550 patients.

Results

The NNUSTR had a total of 11,886 entries between January 2003 and May 2015. Of them, 3393 records were excluded from the current study (see Figure 1 for exclusions).The included cases had similar characteristics compared to the whole sample (Supplementary Table 2). A total of 8,493 patients with acute stroke were included in the study. The sample mean age was 77.7 years (SD ±11.6 years), 47.4% were male. Approximately 19.5% of cases died as inpatients and 9.5% died within 7 days of admission. Table 1 shows the sample characteristics. 88.4% of the sample had an ischaemic stroke and the most common OCSP classification was partial anterior circulation stroke (35.7%). 63.7% of the patients had no pre-stroke disability (pre-stroke mRs=0) and the majority of cases (84.3%) had normal sodium levels on admission. The baseline point prevalence of hypernatraemia was 1.8%. The prevalences for mild, moderate and severe hyponatraemia were 10.6%, 2.6% and 0.7%, respectively.

Univariate analysis showed that all levels of dysnatraemia had increased odds of both inpatient and 7-day mortality. Hypernatraemia appeared to have the largest impact on inpatient mortality, OR 3.04 (95% CI: 2.18-4.24) while severe hyponatraemia had the largest impact for 7-day mortality OR 3.00 (1.61-5.60). Multivariate analysis controlling for SOAR stroke score variables showed that those with hypernatraemia were more likely to die as an inpatient in comparison to those with normal sodium levels (OR 2.56 (1.71-3.84)). In contrast, moderate and severe hyponatraemia showed statistical significance for predicting 7-day mortality, the latter appearing to have the highest risk: ORs 2.00 (1.33-3.01) and 3.13 (1.56-6.29), respectively (Table 2). Analysis utilising the SOAR stroke score as a single categorical variable revealed similar results (Supplementary Table 3).

When predicting inpatient mortality the SOAR stroke and SOAR-Na scores achieved AUC values of 0.794 (95% CI: 0.78-0.81) and 0.796 (95% CI: 0.78-0.81) respectively. Similar values were observed for 7-day mortality: respective AUC values were 0.784 (0.77-0.80) and 0.785 (0.77-0.80). A statistically significant difference between the two scores was observed when predicting in-patient mortality (p value = 0.04), though the absolute improvement was minimal. Sodium levels were measured on the same day for the majority of the sample (84.7%). Repeating the analysis stratifying those whose sodium level was taken at the same

day of admission and those whose level was measured afterwards showed little difference in the predictive ability of the either the SOAR or SOAR-Na score (data not shown).

The sensitivities, specificities, PPVs and NPVs for each increment of score point for the SOAR stroke and SOAR-Na scores are shown for both mortality outcomes in Table 3. Both scores performed better in those without CKD compared with those with CKD for both mortality time points. In relation to glucose categories, both scores' predictive ability for inpatient and 7-day mortality are statistically significantly higher in patients with hypoglycaemia. Both scores also performed better in those with normoglycaemia when predicting 7-day mortality (though to a lesser degree) (Table 4).

Discussion

Our findings support previously observed associations between dysnatraemia and early mortality in stroke (13-15). A U-shaped relationship is present with severe and moderate hyponatraemia and hypernatraemia showing statistical significance once other variables relevant to the SOAR stroke score were adjusted for. Increased odds of mortality displayed in those with hyponatraemia may be attributed to osmotic changes causing cerebral oedema and increased intracranial pressure leading to a subsequent increase in cell dysfunction and death (13). Excess mortality observed in those with hypernatraemia may be due to neurological impairment (12), but is more likely to be a marker of dehydration and advanced frailty (15). Hypernatraemia has also been associated with early neurological worsening (16).

In comparison to preceding literature, the models utilised to predict mortality outcomes had a much smaller degree of adjustment (13-15).The aim of the models used within this paper was to establish if sodium levels perform independently of the variables used within the SOAR stroke score. Considerably fewer variables were therefore controlled for. This is important to note in respect to hypernatraemia's association with mortality. Soiza et al's (15) sample is comparable to the one in this study (theirs is taken from the same register but from an earlier time point). Although Soiza et al. (15) also showed this association, this was lost when serum urea, another measure of dehydration, was controlled for along with other haematological and biochemistry variables.

The addition of sodium to the SOAR stroke score does not appear to make a noteworthy impact on the score's predictive ability. While there is a statistically significant difference when predicting inpatient mortality, the minor difference in absolute terms means this is unlikely to be a useful tool over SOAR. Similarly, the SOAR-Na score was not superior to the SOAR stroke score with regard to 7-day mortality prediction. The minor increase in performance observed may be partly attributed to the fact that higher scores were combined in both indices (due to their small numbers), perhaps reducing the discriminative ability of the SOAR-Na score. An alternative possible explanation is the presence of a mechanistic link between the SOAR stroke score and dysnatraemias. Dysnatraemias could possibly mediate the poor outcome in patients with characteristics fulfilling a high SOAR stroke score (e.g. older age, higher pre-stroke mRs, more severe stroke).

Myint et al. (8) have shown that the SOAR stroke score accurately predicts length of stay, this has been validated by the same group (17).While not examined within this study, the addition of sodium may be more useful in predicting length of stay as opposed to early mortality outcomes. Hyponatraemia has not only been independently associated with an increased length of stay within an unselected population (18-19) but also increased use of hospital resources and cost (18-19).

The SOAR-Na score appears to perform poorly in those with CKD (though still marginally better than the SOAR stroke score). Within this sub-group, renal function is the main determinant of outcome (20) and compromised water homeostasis means that dysnatraemias are more likely (20-22). It is worth noting that the sample size was small when we confined analysis to those with history of CKD. Additional research with a larger sample would be required to confirm or refute the current study findings.

Both the SOAR and SOAR-Na score's predictive ability was considerably increased in those with hypoglycaemia for both mortality outcomes. An unexpected finding was the SOAR stroke score actually performed slightly better. This finding, however, could be influenced by the small number of cases (N=56) within this category. While the overall sample size is reasonable (>6,500 cases) individual categories held small numbers of cases possibly contributing to non-significant results. As glucose concentration rises, sodium concentration falls due to water shifts from the intracellular to extracellular compartment. Examining how this could impact the performance of the SOAR-Na score in a larger sample would be of interest.

In conclusion, this study further supports that sodium is an independent predictor of mortality after stroke. The addition of sodium levels as a criterion to the SOAR stroke score, however, does not make a substantial increase in the score's predictive ability with regard to 7- day and inpatient mortality outcomes. Nonetheless, the performance of the SOAR-Na score may still be of interest in particular groups, namely those with dysglycaemia and CKD and other patient related outcomes.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Contributions of Authors

PKM is the PI of the NNUSTR. PKM conceived the study. JHBS performed data linkages. IA-O and SJM analysed the data. JFP, KMB and AKM are co-I of NNUSTR. IA-O and PKM drafted the manuscript. All authors contributed in writing the paper. PKM is the guarantor. registers.

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Table 1: Sample characteristics by total sample, those who died as in-patient and within 7 days of admission

		Total sample n	Inpatient Death	7-Day Mortality
			n=1652	n=808
Age category	≤65	1267 (14.9)	84 (5.1)	60 (7.4)
	66-85	4937(58.1)	864 (52.3)	446 (55.2)
	≥86	2289 (27.0)	704 (42.6)	302 (37.4)
Sex	Male	4025 (47.4)	672 (40.7)	322 (39.9)
	Female	4468 (52.6)	980 (59.3)	486 (60.1)
Stroke Type	Ischaemic	7508 (88.4)	1306 (79.1)	581 (71.9)
	Haemorrhagic	985 (11.6)	346 (20.9)	227 (28.1)
OCSP Classification	TACS	1847 (21.7)	921 (55.8)	498 (616.6)
	PACS	3033 (35.7)	355 (21.5)	119 (14.7)
	LACS	2087 (24.6)	114 (6.9)	41 (2.1)
	POCS	1526 (18.0)	262 (15.9)	150 (18.6)
Pre-stroke modified Rankin score	0	5406 (63.7)	784 (47.5)	424 (52.5)
	1	1021 (12.0)	215 (13.0)	94 (11.6)
	2	716 (8.4)	191 (11.6)	86 (10.6)
	3	805 (9.5)	232 (14.0)	101 (12.5)
	4	388 (4.6)	153 (9.3)	72 (8.9)
	5	157 (1.8)	77 (4.7)	31 (3.8)
Sodium level (mmol/L)	Severe hyponatraemia (<125)	58 (0.7)	18 (1.1)	13 (1.6)
	Moderate hyponatraemia (125-129)	223 (2.6)	54 (3.3)	36 (4.5)
	Mild hyponatraemia	900 (10.6)	219 (13.3)	106 (13.1)

	(130-134)			
	Normonatraemia (135-145)	7163 (84.3)	1301 (78.8)	628 (77.7)
	Hypernatraemia (>145)	149 (1.8)	60 (3.6)	25 (3.1)

Abbreviations: OCSP - Oxfordshire Community Stroke Project Classification, TACS – total anterior circulation stroke, PACS- partial anterior circulation stroke, LACS- lacunar stroke, POCS – posterior circulation stroke. Data presented are number (%).

Table 2: Odds Ratios and corresponding 95% Confidence Intervals (95%CI) for inpatient and 7-day mortality (Multiple regression model)*

		Inpatient mortality			7-day mortality		
		OR	95% CI	P	OR	95% CI	P
Sodium level** (mmol/L)	Normonatraemia (135-145)	1.00			1.00		
	Mild hyponatraemia (130-134)	1.17	[0.96-1.41]	0.11	1.16	[0.91-1.47]	0.24
	Moderate hyponatraemia (125-129)	1.29	[0.90-1.84]	0.17	2.00	[1.33-3.01]	=0.001
	Severe hyponatraemia (<125)	1.84	[0.97-3.49]	0.06	3.13	[1.56-6.29]	=0.001
	Hypernatraemia (>145)	2.56	[1.71-3.84]	<0.001	1.59	[0.97-2.59]	0.06
Age category	≤65	1.00			1.00		
	66-85	2.46	[1.92-3.15]	<0.001	1.59	[1.19-2.13]	<0.001
	≥86	4.42	[3.41-5.74]	<0.001	2.06	[1.51-2.82]	<0.001
OCSP Classification	LACS	1.00			1.00		
	TACS	16.02	[12.90-19.91]	<0.001	15.24	[10.97-21.18]	<0.001
	PACS	2.15	[1.72-2.69]	<0.001	1.84	[1.28-2.65]	=0.001
	POCS	3.48	[2.74-4.43]	<0.001	4.52	[3.16-6.47]	<0.001
Pre-stroke modified Rankin score	0	1.00			1.00		
	1	1.56	[1.29-1.88]	<0.001	1.18	[0.92-1.52]	0.20
	2	2.01	[1.63-2.49]	<0.001	1.51	[1.15-1.98]	<0.001
	3	2.09	[1.71-2.55]	<0.001	1.50	[1.16-1.94]	<0.001
	4	3.03	[2.35-3.92]	<0.001	2.16	[1.59-2.95]	<0.001
	5	3.98	[2.72-5.82]	<0.001	1.90	[1.21-2.99]	0.01
Stroke type	Haemorrhagic	1.00			1.00		

	Infarct	0.41	[0.34-0.48]	<0.001	0.33	[0.28-0.40]	<0.001

Abbreviations: OCSP - Oxfordshire Community Stroke Project Classification, TACS – total anterior circulation stroke, PACS- partial anterior circulation stroke, LACS- lacunar stroke, POCS – posterior circulation stroke.

*All variables were included in the model simultaneously

**Additional adjustment of sodium concentration respective to glucose concentration did not affect mortality outcomes.

Table 3: The sensitivity, specificity, positive predictive value, negative predictive value and corresponding 95% confidence intervals of the SOAR stroke and SOAR-Na score for inpatient and 7 day mortality

Inpatient mortality											
	No.	Cum %	Total with score	Sensitivity	95% CI	Specificity	95% CI	PPV	95% CI	NPV	95% CI
SOAR stroke score											
0	20	1.2	676								
≥1	1632	11.2	7817	98.79	[98.14-99.26]	9.59	[8.90-10.31]	20.88	[19.98-21.80]	97.04	[95.47-98.18]
≥2	1467	28.4	5021	88.80	[87.18-90.28]	48.05	[46.86-49.24]	29.22	[27.96-30.50]	94.67	[93.87-95.40]
≥3	1183	57.6	2813	71.61	[69.37-73.77]	76.17	[75.15-77.18]	42.05	[40.22-43.90]	91.74	[91.00-92.45]
≥4	700	85.7	1177	42.37	[39.98-44.80]	93.03	[92.40-93.62]	59.47	[56.61-62.29]	86.99	[86.19-87.75]
≥5	235	99.9	335	14.23	[12.58-16.00]	98.54	[98.22-98.81]	70.15	[64.94-75.00]	82.63	[81.79-83.45]
SOAR-Na score											
0	17	1.0	661								
≥1	1635	10.7	7832	98.97	[98.36-99.40]	9.41	[8.73-10.13]	20.88	[19.98 21.79]	97.43	[95.91-98.49]
≥2	1474	27.6	5062	89.23	[87.63-90.68]	47.55	[46.36-48.74]	29.12	[27.87 30.39]	94.81	[94.02-95.53]
≥3	1194	56.1	2864	72.28	[70.05-74.42]	75.59	[74.55-76.60]	41.69	[39.88 43.52]	91.86	[91.12-92.56]
≥4	724	84.5	1231	43.48	[41.42-46.26]	92.59	[91.94-93.20]	58.81	[56.01 61.58]	87.22	[86.43-87.98]
≥5	255	99.9	364	15.44	[13.73-17.27]	98.41	[98.08-98.69]	70.05	[65.06 74.72]	82.81	[81.98-83.63]
7-day mortality											

	No.	Cum %	Total with score	Sensitivity	95% CI	Specificity	95% CI	PPV	95% CI	NPV	95% CI
SOAR stroke score											
0	11	1.4	676								
≥1	797	8.9	7817	98.64	[97.58-99.32]	8.65	[8.03-9.30]	10.20	[9.53-0.89]	98.37	[97.11-99.18]
≥2	736	24.6	5021	91.09	[88.91-92.96]	44.24	[43.13-45.36]	14.66	[13.69-15.67]	97.93	[97.40-98.37]
≥3	609	55.2	2813	75.37	[72.25-78.31]	71.32	[70.30-72.33]	21.65	[20.14-23.22]	96.50	[95.99-96.96]
≥4	362	83.7	1177	44.80	[41.34-48.31]	89.39	[88.69-90.07]	30.76	[28.13-33.48]	93.90	[93.33-94.44]
≥5	132	100	335	16.34	[13.85-19.07]	97.36	[96.97-97.71]	39.40	[34.14-44.86]	91.71	[91.09-92.30]
SOAR-Na score											
0	9	1.1	661								
≥1	799	8.6	7832	98.89	[97.90-99.49]	8.48	[7.87-9.13]	10.20	[9.54-10.89]	98.64	[97.43-99.38]
≥2	738	23.9	5062	91.34	[89.18-93.18]	43.73	[42.62-44.85]	14.58	[13.62-15.58]	97.96	[97.43-98.41]
≥3	614	53.6	2864	75.99	[72.89-78.90]	70.72	[69.69-71.74]	21.44	[19.95-22.99]	96.55	[96.04-97.01]
≥4	374	82.4	1231	46.29	[42.81-49.80]	88.85	[88.12-89.54]	30.38	[27.82-33.04]	94.02	[93.45-94.56]
≥5	141	99.9	364	17.45	[14.89-20.25]	97.10	[96.70-97.46]	38.74	[33.70-43.95]	91.79	[91.18-92.38]

Abbreviations: No. = number of deaths, Cum% = cumulative percentage of those who died, PPV = positive predictive value, NPV = negative predictive value.

Table 4: Comparison of predictive ability of SOAR stroke and SOAR-Na scores for 7-day and inpatient mortality in all patients and stratified by presence of chronic kidney disease and by glucose categories

	N	SOAR stroke score		SOAR-Na score	
		AUC value	95% CI	AUC value	95% CI
Inpatient mortality					
All cases	8493	0.794	[0.78-0.81]	0.796	[0.78-0.81]
CKD Diagnosis					
No	8229	0.798	[0.79-0.81]	0.800	[0.79-0.81]
Yes	264	0.704	[0.63-0.77]	0.707	[0.64-0.78]
Glucose category					
Normoglycaemia	4851	0.783	[0.77-0.80]	0.786	[0.77-0.80]
Hypoglycaemia	56	0.899	[0.80-1.00]	0.889	[0.79-0.99]
Borderline hyperglycaemia	1083	0.780	[0.75-0.81]	0.778	[0.75-0.81]
Hyperglycaemia	560	0.778	[0.73-0.82]	0.780	[0.74-0.82]
7-day mortality					
All cases	8493	0.784	[0.77-0.80]	0.785	[0.77-0.80]
CKD Diagnosis					
No	8229	0.787	[0.77-0.80]	0.788	[0.77-0.80]
Yes	264	0.702	[0.61-0.79]	0.702	[0.62-0.79]
Glucose category					
Normoglycaemia	4851	0.787	[0.76-0.81]	0.790	[0.77-0.81]
Hypoglycaemia	56	0.832	[0.67-1.00]	0.825	[0.66-0.99]
Borderline hyperglycaemia	1083	0.732	[0.69-0.77]	0.731	[0.69-0.77]

Hyperglycaemia	560	0.748	[0.69-0.80]	0.749	[0.70-0.80]

Abbreviations: CKD – chronic kidney disease.

Supplementary Table 1: Scoring System for SOAR-Na index

Patient Variables		Score	Variable		Score
Age categories	≤60	0	Pre-stroke mRS	0	0
	61-65	0		1	0
	66-70	1		2	0
	71-75	1		3	1
	76-80	1		4	1
	81-85	1		5	2
	86-90	2			
	91>	2			
OCSP classification	TACS	2	Sodium level	Normonatraemia	0
	PACS	0		Mild hyponatraemia	0
	LACS	0		Moderate hyponatraemia	0
	POCS	1		Severe hyponatraemia	1
				Hypernatraemia	1
Stroke type	Ischaemic	0			
	Haemorrhagic	1	Gender	Male	0
				Female	0

Abbreviations: OCSP - Oxfordshire Community Stroke Project Classification, TACS – total anterior circulation stroke, PACS- partial anterior circulation stroke, LACS- lacunar stroke, POCS – posterior circulation stroke.

Supplementary Table 2: Comparison of sample characteristics and whole NNSTR characteristics

	NNSTR 2015 Dataset *	Sample
Number (n)	10688	8493
Age	77.7 (11.99)	77.7 (11.76)
Female	5591 (52.3)	4468 (52.6)
Male	5097 (47.7)	4025 (47.4)
Ischaemic stroke type	9248 (86.5)	7508 (88.4)
Haemorrhagic stroke type	1440 (13.5)	985 (11.6)
Transient Ischaemic Attack	309 (2.9)	237 (2.9)
Dementia	490 (4.6)	348 (4.1)
Previous Myocardial Infarction	519 (4.9)	409 (4.8)
Peripheral Vascular Disease	274 (2.6)	220 (2.6)
Chronic Kidney Disease	346 (3.2)	264 (3.1)
Congestive Heart Failure	906 (8.5)	733 (8.6)
Diabetes Mellitus	1056 (9.9)	846 (10.0)
Atrial Fibrillation	1645 (15.4)	1300.3)

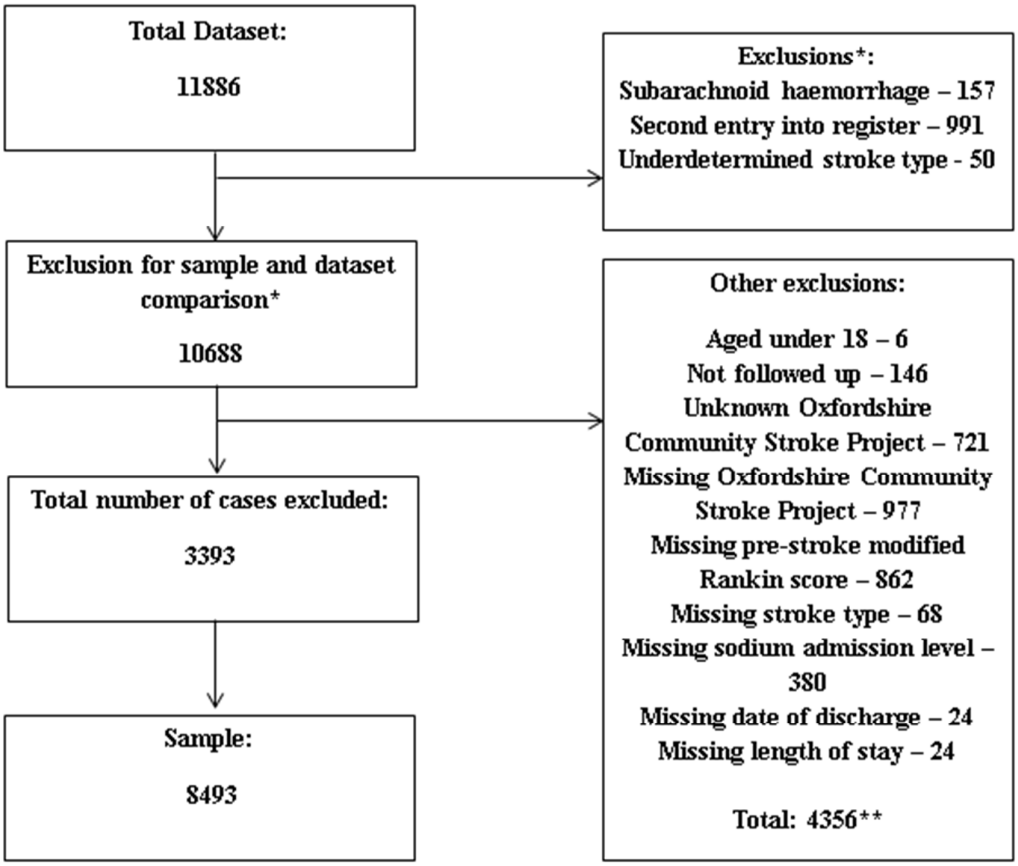
*To be comparable to study sample, those with SAH, undetermined type of stroke (i.e. not ischaemic, haemorrhagic or SAH) and second entries into the dataset are excluded.

Brackets indicate standard deviation for continuous data and percentage for categorical data.

Supplementary Table 3: Odds Ratios and corresponding 95%Confidence Intervals (95%CI) for inpatient and 7-day mortality (model using SOAR score)

		Inpatient death			7 Day Mortality		
		OR	95% CI	P	OR	95% CI	P
Sodium level	Normonatraemia	1			1		
	Mild hyponatraemia	1.15	[0.95-1.39]	0.15	1.09	[0.86-1.37]	0.50
	Moderate hyponatraemia	1.28	[0.90-1.82]	0.17	1.85	[1.25-2.75]	<0.001
	Severe hyponatraemia	1.7	[0.91-3.18]	0.10	2.60	[1.33-5.10]	0.01
	Hypernatraemia	2.45	[1.66-3.63]	<0.001	1.44	[0.90-2.32]	0.13
SOAR stroke score	0	1					
	1	2.07	[1.29-3.32]	<0.001	1.34	[0.70-2.56]	0.38
	2	4.80	[3.02-7.63]	<0.001	3.58	[1.92-6.67]	<0.001
	3	13.59	[8.60-21.48]	<0.001	10.49	[5.69-19.33]	<0.001
	4	40.05	[25.14-63.81]	<0.001	22.21	[12.01-41.10]	<0.001
	5	77.15	[46.01-129-36]	<0.001	40.38	[21.20-76.92]	<0.001
	6	66.14	[33.03-132.43]	<0.001	29.32	[13.28-64.72]	<0.001

Figure 1. Flow diagram for selection of cases



*These indicate exclusions made to make data between sample and dataset comparable when comparing the characteristics of the two (Supplementary Table 2).

**Exclusions total exceeds total number of cases excluded as some cases have more than one variable missing or removed from sample.