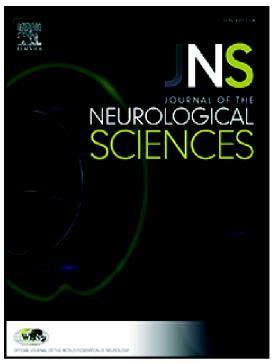

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Impact of Anaemia on Acute Stroke Outcomes Depends on the Type of Anaemia: Evidence from a UK Stroke Register

Raphae S. Barlas MA(Hons)[1*], Stephen J. McCall MSc (Oxon)[1,2*], Joao H Bettencourt-Silva PhD[5], Allan B. Clark PhD[4], Kristian M. Bowles PhD[4], Anthony K. Metcalf MBChB[3], Mamas A. Mamas DPhil[6], John F. Potter DM[4], Phyo K. Myint MD [1,3,4]

[1]Epidemiology Group, Institute of Applied Health Sciences, University of Aberdeen, Aberdeen, UK

[2]Nuffield Department of Population Health, University of Oxford, Oxford, UK

[3]Stroke Research Group, Norfolk and Norwich University Hospital, Norwich, UK

[4]Norwich Medical School, University of East Anglia, Norwich, UK

[5]Clinical Informatics, Department of Medicine, University of Cambridge, Cambridge, UK

[6]Keele Cardiovascular Research Group, Institutes of Science and Technology in Medicine and Primary Care and Health Sciences, Keele University, Stoke-on-Trent, UK

*Joint first authors

Correspondence to:

Phyo Kyaw Myint
Room 4:013, Polwarth Building,
School of Medicine, Medical Sciences and Nutrition
University of Aberdeen
Foresterhill
AB25 2ZD
Aberdeen, Scotland, UK
Tel: +44 (0) 1224 437841
Fax: +44(0) 1224 437911
Mail to: phyo.myint@abdn.ac.uk

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Abstract

Background: Previous research has demonstrated an association between anaemia and poor outcomes in acute stroke. This study aimed to assess the impact of anaemia on stroke by anaemia subtype.

Methods: Data from a prospective UK Regional Stroke Register were used to assess the association between hypochromic microcytic and normochromic normocytic anaemia on inpatient-mortality, length of stay (LOS) and discharge modified Rankin scale (mRS). Analysis was stratified by stroke subtypes and multivariable logistic regression, adjusting for potential confounders, was used to quantify this association. Patients who were not anaemic were the reference category.

Results: A total of 8,167 stroke patients (admitted between 2003 – 2015) were included, mean age (SD) 77.39 ± 11.90 years. Of these, 3.4% (n=281) had hypochromic microcytic anaemia and 15.5% (n=1,262) had normochromic normocytic anaemia on admission. Normochromic normocytic anaemia was associated with increased odds of in-patient mortality OR 1.48 (1.24 –1.77), 90-day mortality OR 1.63 (1.38 - 1.92), longer LOS OR 1.21 (1.06 – 1.40), defined as >7 days, and severe disability defined as discharge mRS≥3 OR 1.31 (1.06 – 1.63), in patients with ischaemic stroke. Hypochromic microcytic anaemia was associated with 90-day mortality OR 1.90 (1.40 – 2.58) and a longer LOS OR 1.57 (1.20 – 2.05) in patients with ischaemic stroke.

Conclusions: Hypochromic microcytic and normochromic normocytic anaemia are associated with differing outcomes in terms of inpatient mortality and post stroke disability. While it is unclear if anaemia per se or another underlying cause is responsible for adverse outcomes, subtype of anaemia appears to be relevant in stroke prognosis.

Keywords: Stroke, anaemia, outcome, prognosis

1. Introduction

The impact of comorbidities on stroke is an issue of increasing salience as the population continues to age. Anaemia is common among community-dwelling adults aged over 64 years [1] and has an estimated prevalence exceeding 20% in those aged over 84 years [2]. Anaemia is also relatively common among stroke patients and has a prevalence ranging from 15-30% [3]. A recent systematic review and meta-analysis has demonstrated an association between anaemia and poor outcomes subsequent to stroke [4]. Furthermore, anaemia has been shown to be associated with poor outcomes in other cardiovascular conditions such as heart failure [5] and acute coronary syndromes [6]. Finally, the presence of anaemia in patients with malignancy or chronic kidney disease also leads to poorer outcomes compared to those without anaemia [7, 8].

Following stroke adequate cerebral oxygenation is required to prevent further hypoxic cerebral damage. Adequate cerebral oxygenation depends on cerebral perfusion pressure, oxygen saturation and haemoglobin levels. Reduced haemoglobin levels are therefore thought to increase the severity of hypoxic injury resulting in poorer outcomes in stroke [3, 9]. However, anaemia is a heterogeneous condition and has several underlying pathological mechanisms. This is reflected morphologically between the different subgroups of anaemia, the two most common being normochromic normocytic and hypochromic microcytic anaemia, which are typically caused by chronic disease and iron deficiency, respectively [10].

Differences in the aetiology of anaemia may influence the relationship between anaemia and adverse stroke outcomes. While previous research has shown an association between anaemia and poor acute stroke outcomes, the impact of the different subtypes of anaemia on stroke outcome has not been previously examined.

We therefore aimed to examine the association between anaemia type and in-patient mortality, 90-day mortality, length of hospital stay and disability outcome as indicated by the modified Rankin scale (mRS).

2. Methods

The study population of patients with acute stroke were drawn from a UK Regional Stroke register in the East Anglia Region, UK (with a catchment population of ~750,000 people) during January 2003 to May 2015. The register received research database ethical approval form the Newcastle and Tyneside National Health Service (NHS) Research Ethics Committee (12/NE/0170) and the study protocol was approved by the Steering Committee of the Register. The data collection methods have previously been described [11]. Briefly, data was entered from paper and electronic records onto the stroke register database prospectively, under the supervision of a clinical team. Patients were included if they had a confirmed ischaemic or haemorrhagic stroke. This was ascertained by a clinical examination and neuroimaging results. Specialist stroke nurses ascertained the pre-stroke modified Rankin score (mRS) from medical records or discussion with relatives. The electronic database was linked up with other electronically held data on comorbidities and biochemistry data and the linkage of these data sources are updated annually. Linkage with the Office of National Statistics (ONS) for mortality data ensures near complete follow-up for this outcome.

Variables for this study were chosen *a priori* using the literature to identify those shown to be associated with acute stroke mortality. These were age, sex, stroke type (ischaemic or haemorrhagic), pre-stroke disability mRS (0 – 5), Oxfordshire Community Stroke Project (OCSP) classification (Total Anterior Circulation Stroke,

Partial Anterior Circulation Stroke, Posterior Circulation Stroke, Lacunar Stroke), haemoglobin levels at admission, pre-stroke co-morbidities (Coronary Heart Disease, Congestive Heart Failure, Atrial Fibrillation, Hypertension, Hyperlipidaemia, Previous Stroke, Diabetes Mellitus, Peripheral Vascular Disease, Chronic Obstructive Pulmonary Disease, Chronic Kidney Disease, Falls, Malignancy, Dementia), prior use of antithrombotic drugs.

The primary outcomes were inpatient and 90-day mortality. Secondary outcomes were longer length of stay (LOS) defined as > 7 days and poor composite functional and mortality outcome defined as discharge mRS 3-6. In-patient mortality status was assessed using the mortality status at discharge. Mortality at 90-days was derived using data acquired by linkage with the ONS, which specified date of death. The date of admission and discharge was recorded allowing the calculation of length of hospital stay. The exposure variables were two types of anaemia based on their microscopic appearance, namely, normochromic normocytic anaemia and hypochromic microcytic anaemia. These two types of anaemia were chosen as these are the most common types of anaemia in the elderly and thus there was a large enough power to study them. The World Health Organization's criteria was used to define anaemia; anaemia was defined as Hb <12.0 g/dL in females and <13.0 g/dL in males [12]. Normochromic normocytic anaemia was defined as a Mean Corpuscular Volume (MCV) of 80 – 100 fL and a Mean Corpuscular Haemoglobin (MCH) of 27 – 32 pg. Hypochromic microcytic anaemia was defined as a MCV of <27 and a MCH <80. Each type of anaemia was compared to the non-anaemic patients unless otherwise stated.

The analyses were undertaken using SPSS Version 24.0 (SPSS Inc., Chicago, Illinois, USA). Chi-square tests were used to assess the differences between patient

characteristics, comorbidities and outcomes between the anaemic groups (hypochromic microcytic and normochromic normocytic anaemia) and the non-anaemic group. Further Chi square tests were used to examine the differences in patient characteristics between each type of anaemia. The odds of having hypochromic microcytic or normochromic normocytic anaemia for each study outcome were assessed using logistic regression. For each outcome, the unadjusted and the fully adjusted models are presented. Adjustments were made for sex, age, Oxford Community Stroke Project (OCSP) classification, prior antithrombotic therapy status, stroke type, and co-morbidities listed above. In inpatient mortality, interactions between both types of anaemia and malignancy, chronic kidney disease and cardiovascular comorbidities were tested. The fully adjusted models were repeated for ischaemic and haemorrhagic stroke separately. A sensitivity analysis was completed examining the association between inpatient mortality and both types of anaemia stratified by level of comorbidity burden. All analyses used complete case analysis.

3. Results

Between January 2003 and May 2015 the registry recorded 11,886 patients were admitted to stroke services during the study period (911 episodes of stroke were excluded as they were a repeated event during the study period). After further exclusion of 3,719 patients that did not meet the study inclusion criteria (see Figure 1), a total of 8,167 patients were included in the current study. The mean age (SD) of the sample was 77.4 ± 11.9 years of whom 46.9% were male, and 86.9% had ischaemic stroke. A majority of patients (64.3%) had a pre-stroke mRS of 0 and Partial Anterior Circulation Stroke (PACS (33.4%) was the most common subtype. Inpatient mortality for the sample population was 20.8% (N=1,696) and

approximately a fifth (18.9%) had anaemia on admission. The mean LOS was 13.8 (SD ± 16.9) days. The mean haemoglobin (Hb) level was 13.7 (SD ± 1.8) for the whole population, 10.2 (SD ± 1.5) in those with hypochromic microcytic anaemia and 11.3 (SD ± 1.1) in those with normochromic normocytic anaemia. Hypochromic microcytic anaemia was present in 3.4% (N=281) of patients and normochromic normocytic anaemia was present in 15.5% (N=1,262).

Figure 1. Patient Inclusion Chart

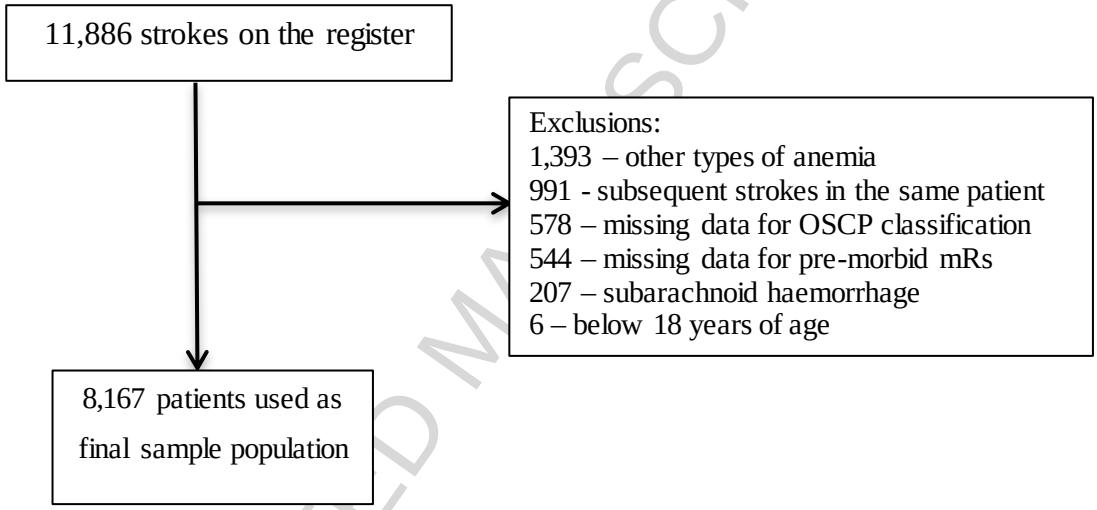

Table 1 illustrates the distribution of the sample characteristics according to anaemia status. The hypochromic microcytic anaemia group had a significantly higher proportion of females, those aged 81-90 years old, higher pre-stroke modified Rankin scores, higher proportions of ischaemic strokes, PACS and higher comorbidity burden than non-anaemic patients. However, there were non-significant differences in the prevalence of atrial fibrillation, chronic kidney disease and dementia. Furthermore, patients with hypochromic microcytic anaemia compared to those with patients with no anaemia had higher inpatient mortality rates, a higher proportion of patients whose hospital stay was longer than 7 days and 59.2% had a discharge Rankin score of 3-6, which were statistically significant.

Table 1. Study population characteristics by anaemia status compared to the non-anaemic group

Variable	No Anaemia	Hypochromic Microcytic	P-Value*	Normochromic Normocytic	P-Value*	P-Value**
Total	6,624	281		1,262		
Sex			0.001		<0.001	<0.001
Female	3,563 (53.8)	180 (64.1)		589 (46.7)		
Male	3,061 (46.2)	101 (35.9)		673 (53.3)		
Age			<0.001		<0.001	0.338
≤ 60	700 (10.6)	15 (5.3)		44 (3.5)		
61 – 70	1,095 (16.5)	23 (8.2)		86 (6.8)		
71 - 80	1,937 (29.2)	75 (26.7)		338 (26.8)		
81 - 90	2,318 (35.0)	126 (44.8)		630 (49.9)		
≥ 91	574 (8.7)	42 (6.8)		164 (13.0)		
Pre-stroke Rankin Score			<0.001		<0.001	0.825
0	4,499 (67.9)	132 (47.0)		618 (49.0)		
1	729 (11.0)	40 (14.2)		193 (15.3)		
2	488 (7.4)	33 (11.7)		138 (10.9)		
3	530 (8.0)	43 (15.3)		176 (13.9)		
4	277 (4.2)	24 (8.5)		86 (6.8)		
5	101 (1.5)	9 (3.2)		51 (4.0)		
Stroke Type, n (%)			0.002		0.028	0.035
Ischaemic	5,716 (86.3)	261 (92.9)		1,118 (88.6)		
Haemorrhagic	908 (13.7)	20 (7.1)		144 (11.4)		
Bamford Classification, n (%)			0.013		<0.001	0.174
LACS	1,593 (24.0)	65 (23.1)		252 (20.0)		
PACS	2,202 (33.2)	103 (36.7)		421 (33.4)		
POCS	1,182 (17.8)	29 (10.3)		197 (15.6)		
TACS	1,301 (19.6)	65 (23.1)		301 (23.9)		
Undefined	346 (5.2)	19 (6.8)		91 (7.2)		
Prior Antithrombotic therapy			0.357		<0.001	0.108
No	3,321 (50.1)	133 (47.3)		531 (42.1)		

Yes	3,303 (49.9)	148 (52.7)		731 (57.9)		
Pre-stroke Comorbidity						
Stroke/TIA	1,568 (23.7)	75 (26.7)	0.244	372 (29.5)	<0.001	0.352
CHD/MI	962 (14.5)	59 (21.0)	0.004	351 (27.8)	<0.001	0.019
Congestive Heart Failure	395 (6.0)	34 (12.1)	<0.001	176 (13.9)	<0.001	0.414
Hypertension	1,780 (26.9)	105 (37.4)	<0.001	524 (41.5)	<0.001	0.200
Hyperlipidemia	240 (3.6)	17 (6.0)	0.035	66 (5.2)	0.007	0.582
Atrial Fibrillation	1,916 (28.9)	90 (32.0)	0.262	428 (33.9)	<0.001	0.545
Diabetes Mellitus	499 (7.5)	45 (16.0)	<0.001	210 (16.6)	<0.001	0.798
COPD	238 (3.6)	22 (7.8)	<0.001	93 (7.4)	<0.001	0.791
Chronic Kidney Disease	107 (1.6)	8 (2.8)	0.114	100 (7.9)	<0.001	0.003
Malignancy	585 (8.8)	44 (15.7)	<0.001	223 (17.7)	<0.001	0.420
Dementia	166 (2.5)	13 (4.6)	0.028	73 (5.8)	<0.001	0.444
Falls	764 (11.5)	72 (25.6)	<0.001	257 (20.4)	<0.001	0.052
Inpatient Mortality			<0.001		<0.001	0.319
Alive	5,400 (81.5)	202 (71.9)		869 (68.9)		
Dead	1,224 (18.5)	79 (28.1)		393 (31.1)		
Length of Stay (Days)			<0.001		<0.001	0.221
1 – 7	3,252 (49.1)	104 (37.0)		517 (41.0)		
Over 7 Days	3,372 (50.9)	177 (63.0)		745 (59.0)		
Discharge Rankin Score* **			<0.001		<0.001	0.262
0	593 (17.4)	19 (11.7)		77 (11.4)		
1	674 (19.8)	25 (15.4)		88 (13.0)		
2	421 (12.3)	21 (13.0)		72 (10.7)		
3	513 (15.0)	19 (11.7)		120 (17.8)		
4	478 (14.0)	19 (11.7)		112 (16.6)		
5	207 (6.1)	12 (7.4)		39 (5.8)		
6	499 (14.6)	46 (28.4)		161 (23.9)		

*Test for difference between type of anaemia group and no anaemia group **Test for difference between microcytic and normocytic anaemia
***n = 4,215

However, patients with normochromic normocytic anaemia compared to patients with no anaemia had a higher proportion of males, older aged patients, higher pre-stroke Rankin scores, higher proportions of ischaemic stroke, TACS type and higher burden of comorbidities, which were statistically significant at the 5% level. Table 1 also presents a comparison of patient characteristics between normochromic normocytic and hypochromic microcytic anaemia groups. Hypochromic microcytic anaemia had higher proportions of females, haemorrhagic strokes and previous coronary heart disease or myocardial infarction compared to normochromic normocytic anaemia. Normochromic normocytic anaemia was associated with a higher prevalence of CKD.

Table 2 shows the univariable and multivariable logistic regression analysis results which examined the likelihood of inpatient mortality, 30-day mortality, 1-year mortality, longer length of stay (> 7 days) and a high discharge modified Rankin score of 3-6, in both normochromic normocytic and hypochromic microcytic compared to no anaemia. Results were stratified by stroke type (ischaemic/ haemorrhagic). In the unadjusted analysis, there was a significant association between all the acute outcomes and both anaemia subtypes compared to those without anaemia.

After full adjusting for confounders, normochromic normocytic anaemia was associated with poorer outcomes in ischaemic stroke for every outcome under assessment. Odds ratios for inpatient mortality, 90-day mortality, long length of stay and high discharge Rankin score were; 1.48 (95% CI 1.24 – 1.77), 1.63 (95% CI 1.38 – 1.92), 1.21 (95% CI 1.06 – 1.40) and 1.31 (95% CI 1.06 – 1.63) respectively. Hypochromic microcytic anaemia was also associated with higher odds of 90-day mortality and long length of stay with odds ratios of 1.90 (95% CI 1.40 - 2.58), and 1.57 (95% CI 1.20 – 2.05). Regarding haemorrhagic stroke, neither sub-type of

Table 2: Logistic regression models examining the association between types of anaemia and acute stroke outcomes

	Unadjusted model	Fully adjusted model*	Ischaemic stroke only*	Haemorrhagic stroke only*
Inpatient Mortality				
No Anaemia	1.00	1.00	1.00	1.00
Hypochromic Microcytic	1.73 (1.32 – 2.25)	1.37 (0.99 – 1.89)	1.37 (0.97 – 1.93)	1.40 (0.52 – 3.81)
Normochromic Normocytic	2.00 (1.74 – 2.28)	**1.42 (1.20 – 1.67)**	**1.48 (1.24 – 1.77)**	1.23 (0.81 – 1.88)
90-Day Mortality				
No Anaemia	1.00	1.00	1.00	1.00
Hypochromic Microcytic	2.16 (1.69 – 2.77)	**1.90 (1.56 – 2.30)**	**1.90 (1.40 – 2.58)**	1.01 (0.37 – 2.73)
Normochromic Normocytic	2.19 (1.93 – 2.48)	**2.54 (2.05 – 3.15)**	**1.63 (1.38 – 1.92)**	1.28 (0.84 – 1.94)
Long Length of Stay †				
No Anaemia	1.00	1.00	1.00	1.00
Hypochromic Microcytic	1.64 (1.28 – 2.10)	**1.41 (1.09 – 1.82)**	**1.57 (1.20 – 2.05)**	0.48 (0.18 – 1.27)
Normochromic Normocytic	1.39 (1.23 – 1.57)	**1.15 (1.02 – 1.33)**	**1.21 (1.06 – 1.40)**	0.88 (0.59 – 1.30)
Discharge Rankin Score‡				
No Anaemia	1.00	1.00	1.00	1.00
Hypochromic Microcytic	1.47 (1.07 – 2.03)	1.09 (0.75 – 1.60)	1.15 (0.78 – 1.70)	0.53 (0.13 – 2.19)
Normochromic Normocytic	1.81 (1.53 – 2.15)	**1.28 (1.04 – 1.57)**	**1.31 (1.06 – 1.63)**	1.06 (0.53 – 2.11)

*Adjusted for Sex, Age, OSCE Classification, Pre-Stroke Rankin Score, Stroke Type, Antithrombotic Therapy Status, Co-Morbidities (all of them). However, the ischaemic and haemorrhagic strokes only did not adjust for stroke type.

† Over 7 days vs. Under 7 days.

‡ Discharge modified Rankin Scale: 0 – 2 vs 3 - 6

anaemia was associated with worse outcomes.

Table 3 depicted the association between anaemia subtype, comorbidity and odds of 90-day mortality in patients with ischaemic stroke, stratified by comorbidity burden. The magnitude of this association increases for those with over 3 comorbidities compared to those with no comorbidities. However, the magnitude of association is slightly lower for those with 2-3 comorbidities compared to those with no comorbidities.

4. Discussion

To the knowledge of the authors, this is the first study to examine the relationship between anaemia and acute stroke outcomes by the specific morphological type of anaemia. Our retrospective analysis of a prospectively collected dataset observed that normochromic normocytic anaemia was associated with increased odds of inpatient mortality, 90-day mortality, longer length of stay and higher post-stroke disability in patients with ischaemic stroke. Furthermore, hypochromic microcytic anaemia was associated with increased odds of 90-day mortality and long length of stay in patients with ischaemic stroke. Neither sub-type of anaemia was associated with higher odds of poor outcomes in haemorrhagic stroke.

Previous research has shown an association between anaemia, low haemoglobin and low haematocrit levels with poor outcomes in stroke [4, 13, 14]. However, no previous studies examined the relationship between the specific type of anaemia and stroke outcome. Our study illustrates that normochromic normocytic

Table 3. The association between 90-day mortality and anaemia status by level of comorbidity burden in ischaemic stroke

No of comorbidities	No anaemia	Hypochromic microcytic	Normocytic normochromic
0	1.00	1.64 (0.89 – 3.00)	1.51 (1.15 – 2.25)
1	1.00	1.47 (0.74 – 2.91)	1.49 (1.05 – 2.01)
2-3	1.00	1.28 (0.61 – 2.21)	1.38 (1.03 – 2.21)
Over 3	1.00	1.59 (0.82 – 3.07)	1.63 (1.11 – 2.17)

Adjusted for: Age, Sex, OCSP Classification, Prior Antithrombotic Use and Pre-Stroke Modified Rankin Score. Included comorbidities: Coronary heart disease, congestive heart failure, atrial fibrillation, hypertension, hyperlipidaemia, previous stroke, diabetes mellitus, peripheral vascular disease, chronic obstructive pulmonary disease, chronic kidney disease, falls, malignancy and dementia

anaemia was associated with inpatient mortality, 90-day mortality, higher discharge disability score and longer length of stay. The pathogenesis of normochromic normocytic in these patients is likely to be the result of anaemia of chronic disease (ACD) [15, 16]. Previous research has shown that anaemia in patients with chronic heart disease was associated with longer length of hospital stay and mortality [17]. While this study was unable to typify the type of anaemia, the authors have stated that anaemia in chronic heart disease is mainly caused by ACD.

Indeed, ACD is associated with a number of chronic diseases and is a common cause of anaemia in older individuals [18]. A number of biological mechanisms have been suggested for ACD. These include the detrimental effect of cytokines on haematopoiesis mediated by hepcidin [19] and the direct impact of ACE inhibitor medication [20]. However, the biological mechanisms linking normochromic normocytic anaemia and poor outcomes after an acute stroke event are not fully understood. Normochromic normocytic anaemia is itself the result of common medical comorbidities, which are independently associated with prognosis in elderly populations [21, 22]. We therefore attempted to evaluate the relationship between co-morbidity burden and increased odds of mortality in ischaemic stroke patients with normochromic normocytic anaemia.

It was found that the relationship between normochromic normocytic anaemia and poor outcomes in ischaemic stroke persisted despite adjustment for multiple comorbidities (Table 2). On further analysis, the odds of inpatient mortality were slightly higher in those with over 3 morbidities compared to those with 1, in normochromic normocytic anaemia. However, the odds did not increase in a linear manner as the number co-morbidities increased (Table 3). It is possible that a higher number of comorbidities leads to increased frailty and this therefore explains the relationship between normochromic normocytic anaemia and worse outcomes in ischaemic stroke. However, the interaction between inflammation,

medical comorbidities and anaemia with poor stroke outcomes is complex and remains unknown.

This study also found an association between hypochromic microcytic anaemia and higher odds of 90-day mortality, and long length of stay. Previous research has suggested that stroke patients with anaemia have a higher rate of complications [23]. This may therefore explain why both sub-types of anaemia are associated with longer length of stay in patients with ischemic stroke. We did not find an association between both anaemia types and poor outcomes in haemorrhagic stroke. Alternatively, haemorrhagic strokes are more likely to have poor outcomes so the effect of anaemia on outcomes may be minimal. Further research using a larger sample size is required to assess this association to eliminate the possibility of Type II error.

Our study had some strengths. Due to a relatively large sample size, which enabled us to evaluate the association between acute stroke outcomes and specific subtypes of anaemia. We were also able to account for a large number of confounders in the analysis including numerous co-morbidities. Co-morbidity data was derived from the hospital Patient Administrative System (PAS) which records patient information based on referral letters (known diagnosis as described by the patients' General Practitioner) and newly found diagnoses.

Our study also had some limitations. Firstly, this study did not adjust for baseline NIHSS (National Institutes of Health Stroke Scale) score, as it was only available in <15% of the study population. However, the models contained age, stroke subtype, OSCP score and pre stroke Rankin score which are all shown to predict acute stroke outcomes, [24] the inclusion of the NIHSS would have only moderately improved the predictive ability of the model [25]. It is therefore unlikely that residual confounding from NIHSS substantially alters the findings within the current study. Secondly, a lack of statistical power may explain why

there was not an observed relationship between either anaemia sub-type and poor outcomes in intracerebral haemorrhage. Further studies, with a larger sample size are required in order to mitigate the chances of Type II error occurring. Finally, there was a substantial amount of missing data for the discharge modified Rankin score variable. However, this was because the NNUH Stroke Register began recording this variable in January 2009 and is therefore unlikely to lead to biased findings.

As the population continues to age, the impact of comorbidities on patient outcomes is an issue of increasing salience. This cohort study demonstrated that both normochromic normocytic and hypochromic microcytic anaemia were associated with poor outcomes after a stroke event. Future trials are therefore required to gauge appropriate thresholds for transfusion in stroke patients with anaemia. Furthermore, clinicians may benefit from factoring in the impact of anaemia on stroke outcomes when prognosticating stroke patients.

Contributions of Authors

PKM is the PI of NNUSTR. PKM and RSB conceived the study. JBHS performed data linkages. RSB analysed the data. SJM, RSB, JFP, MM and PKM interpreted the data. JFP, KMB and AKM are co-I of NNUSTR. SJM wrote the first draft of the manuscript. All authors contributed in interpretation of results and in making an important intellectual contribution to the manuscript. PKM is the guarantor.

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Conflicts of Interest

PKM received small honorarium <£1000 from ViForPharma as an advisory panel member on one occasion.

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Highlights

- Normochromic normocytic anaemia was associated with higher post-stroke disability.
- Hypochromic microcytic anaemia was associated with long length of stay.
- Both sub-types of anaemia were associated with higher odds of mortality.