Knowledge of acute stroke management and the predictors among Malaysian healthcare professionals

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Background. Despite rapid advances in acute ischaemic stroke (AIS) management, many healthcare professionals (HCPs) might not be aware of the latest recommended management of AIS patients. Therefore, we aimed to determine the level and factors associated with AIS management knowledge among Malaysian HCPs.

Methods. This cross-sectional online questionnaire study was conducted nationwide among 627 HCPs in Malaysia using the Acute Stroke Management Questionnaire (ASMaQ). Multiple logistic regression was used to predict the relationship between the independent variables (age, gender, years of service, profession, work setting, work sector, seeing stroke patients in daily practice, and working with specialists) and the outcome variable (good versus poor knowledge).

Results. About 76% (95% CI: 73%, 79%) of HCPs had good overall knowledge of stroke. The highest proportion of HCP with good knowledge was noted for General Stroke Knowledge (GSK) [88.5% (95% CI: 86%, 91%)], followed by Advanced Stroke Management (ASM) [61.2% (95% CI: 57%, 65%)] and Hyperacute Stroke Management (HSM) [58.1% (95% CI: 54%, 62%)]. The odds of having poor knowledge of stroke were significantly higher among non-doctor HCPs [adjusted OR = 3.46, (95% CI: 1.49, 8.03), P = 0.004]; among those not seeing stroke patients in daily practice [adjusted OR = 2.67, (95% CI: 1.73, 4.10), $P < 0.001$]; and among those working without specialists [adjusted OR = 2.41, (95% CI: 1.38, 4.18), P = 0.002].

Conclusions. Stroke education should be prioritised for HCPs with limited experience and guidance. All HCPs need to be up-to-date on the latest AIS management and be able to make a prompt referral to an appropriate facility. Therefore, more stroke patients will benefit from advanced stroke care.

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Abstract

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Introduction

Seventy-five percent of all stroke-related deaths globally occurred in low- and middle-income countries, and Asian countries had the highest lifetime stroke risk from 1990 to 2016 [1]. In Malaysia, stroke is the second leading cause of morbidity and the third leading cause of mortality [2].

Despite rapid advances in acute ischaemic stroke (AIS) management, many stroke patients do not receive treatment at the appropriate time [3]. Healthcare professional (HCP) related factors might lead to suboptimal stroke care [3]. Although a new clinical practice guideline (CPG) on AIS management was available in Malaysia in 2021, there had been a ten-year gap since the last CPG was published, which may have led to a lack of awareness of the latest management [4].

There have been very few studies published in the past five years on AIS management knowledge among HCPs, and none from Malaysia. The target population of the studies has mainly been general practitioners, paramedics, and emergency nurses. Previous studies had a wide variation in HCPs' responses to the stroke knowledge questions, and most of them recommended stroke education to improve their knowledge [5-10].

Years of clinical experience [5] [8-10], profession [11], working in stroke-related specialities [12], the number of beds [7], and the number of stroke cases [9] were known to be associated factors of stroke management knowledge. However, previous studies did not explore factors such as the work sector (government versus private), work settings (hospital versus primary care clinic), and the presence of guidance from specialists.

Therefore, the researchers aimed to determine the level and factors associated with AIS management knowledge among Malaysian HCPs.

Materials & Methods

Study setting

This study involved both public and private healthcare facilities in Malaysia. As of December 2019, there are 154 public hospitals, 208 private hospitals, 1114 government health clinics, and 7988 private medical clinics in Malaysia [13].

The healthcare system in Malaysia comprises primary, secondary, and tertiary care. Primary care focuses on general health services such as health promotion, disease prevention, health maintenance, counselling, patient education, diagnosis, and treatment of acute and chronic illnesses as an outpatient. It is also the basis for referral to secondary and tertiary care hospitals if highly specialised equipment and expertise are required. Primary care providers, especially in the public sector, usually consist of family medicine specialists, medical doctors, and other allied health professionals, whereas in the private sector, they consist of doctors and clinic assistants.

There are two types of secondary care services provided in Malaysia, namely basic and full secondary care. The basic secondary care services are general medicine, general surgery, obstetrics and gynaecology, and paediatrics. They are available at district hospitals and overseen by resident medical officers and visiting specialists. Full secondary care services include additional services such as orthopaedics, anesthesiology, psychiatry, dermatology, medical rehabilitation, pathology, imaging, dental, otorhinolaryngology, opthalmology, and geriatrics. They are available in some district and general hospitals and are overseen by resident specialists and medical officers.

Tertiary care is highly specialised and provides services such as cardiology, cardiothoracic surgery, paediatric surgery, neurology, neurosurgery, respiratory medicine, urology, nephrology, plastic surgery & burns, maxilofacial, haematology, radiotherapy, oncology, and endocrinology. They are mainly available at private hospitals, university hospitals, and some general hospitals [14].

Study design

A cross-sectional online questionnaire study was conducted nationwide among HCPs in Malaysia from February until July 2021. HCPs are defined as medical practitioners and allied healthcare professionals from various medical disciplines. A convenience sampling method followed by the snowball sampling method was used to recruit participants. The online questionnaire link was emailed to all HCPs registered for the Stroke e-learning Module on the Docquity platform. The interested participants were informed to fill in the online questionnaire before accessing the module to get the baseline knowledge scores.

Ethical approval

This study was approved by the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia (*NMRR-20-2706-57567*). Informed consent was obtained from all participants.

Data measurement

The online questionnaire link consisted of two sections. Section 1 (Demographic information) collected data on independent variables such as age, gender, years of service, profession, work setting (primary care versus hospital), work sector (private versus government), seeing stroke patients in daily practice, and working with specialists. Section 2 [Acute Stroke Management Questionnaire (ASMaQ)] measures the outcome variables. The ASMaQ was used to measure the knowledge of AIS management among HCPs. It consisted of 29 items and had three domains: General Stroke Knowledge (GSK), Hyperacute Stroke Management (HSM), and Advanced Stroke Management (ASM). Cronbach's alpha for the overall ASMaQ was 0.82 [15]. The items were scored using a five-point Likert scale ranging from 1 to 5.

Outcome variable

The outcome variable, knowledge scores, was categorised into good and poor. The cutoff point was determined based on expert opinions from stroke neurologists, internal medicine physicians, and family medicine specialists actively involved in stroke management. Marks were converted to positive scores for those negative answers as the desired response, with a higher score

indicating better knowledge. The scores of 1 to 3 were categorised into poor knowledge, and 4 to 5 were categorized into good knowledge. Therefore, a score of 3.5 was considered a cutoff point for good and poor knowledge, and the score range for the level of knowledge of each domain was classified accordingly under Table S1.

Statistical methods

We used IBM SPSS Version 20 for statistical analysis. We estimated the proportion of good and poor knowledge on stroke with a 95% confidence interval (CI). We performed a binary logistic regression analysis to predict the relationship between independent variables and knowledge outcomes. First, we ran simple logistic regression on each independent variable, followed by multiple logistic regression to control for confounding effects. Variabls aree selected based on automatic Forward and Backward Likelihood Ratio (LR) methods. The preliminary model was checked for possible two-way interactions and multicollinearity problems. The goodness-of-fit assessment was done using the Hosmer-Lemeshow test, based on the classification table and area under the Receiving Operating Characteristics curve (AUC) methods. All the hypotheses involved were two-sided tests. Independent variables with a *P* value of less than 0.05 in the final model were considered statistically significant predictors of poor knowledge. We also analysed the 95% CI of odds ratios.

Study size

We set $\alpha = 0.05$ and $\rho = 2$ [standard deviation that would include all possible values for two levels categorical variable (good versus poor knowledge)] [16]. With the estimated HCP population size of 200,000, the minimum returned sample size required at 95% CI and a margin of error of 0.05 was 384. The total number of participants who answered the questionnaire during the study period was 627; which was the final sample size.

Results

A total of 627 participants who answered the online questionnaire were included in the study. The median (inter-quartile range) for age and years of service were 32 (7) and 7 (8), respectively. Both variables were skewed to the right; therefore, they were grouped into three-level categories using quantiles. Table 1 describes the baseline characteristics of participants. The participants were predominantly female (63%), medical officers (65.6%), working in the hospital (66.8%), in the government sector (82.6%), seeing stroke patients in daily practice (77.8%), and working with specialists (80.5%).

Healthcare professionals' level of stroke knowledge

Table 2 shows the proportion of participants with good and poor knowledge and the total mean scores. About 76% (95% CI: 73%, 79%) of HCPs had good overall knowledge of stroke. The highest proportion of HCP with good knowledge was noted for General Stroke Knowledge (GSK) [88.5% (95% CI: 86%, 91%)], followed by Advanced Stroke Management (ASM) [61.2% (95% CI: 57%, 65%)] and Hyperacute Stroke Management (HSM) [58.1% (95% CI: 54%, 62%)]. The overall knowledge total mean score was 107.2 (SD = 9.29) and the total mean scores for GSK, HSM, and ASM were 39.18 (3.4), 32.43 (3.67), and 36.32 (5.35), respectively.

For GSK among HCPs, the highest proportion of poor responses (undesired and neutral responses) was noted for item GSK-10 [*Acute stroke management education should be conducted regularly for healthcare professionals*] (99.9%) and followed by GSK-8 [*A full neurological examination must be performed immediately in patients presenting acutely with symptoms suggestive of stroke*] (96.3%); see Figure 1; Table S2.

For HSM, poor knowledge was noted for item HSM-8 [*All acute stroke patients must have a 12 leads ECG before thrombolysis*] (93.1%), HSM-7 [*Coagulation profile must be screened before thrombolysis*] (87.7%), and HSM-1 [*Stroke is a medical emergency only within 4.5 hours of stroke onset]* (70%); see Figure 2; Table S2.

For ASM, the poor response was for item ASM-6 [My hospital is equipped with mechanical thrombectomy service] (85.1%), ASM-10 [*Wake up strokes are not eligible for thrombolysis nor mechanical thrombectomy*] (73.2%), ASM-8 [Mechanical thrombectomy can be performed after thrombolysis therapy] (62%) and ASM-3 [How would you rate your knowledge of acute stroke management?] (50.2%); see Figure 3; Table S2.

The factors associated with knowledge of stroke among healthcare professionals

Overall Knowledge of Stroke

Multiple logistic regression showed that the professions, not seeing stroke patients in daily practice, and working without specialists were significant predictors of poor overall stroke knowledge among HCPs. Compared to a specialist, non-doctor HCPs had 3.46 times the odds of poor knowledge ($P = 0.004$). However, the odds of poor knowledge were not statistically significant among general practitioners, house officers, medical officers, and specialists. Those not seeing stroke patients in daily practice had 2.67 times the odds of poor knowledge than those seeing stroke patients ($P < 0.001$). Those not working with specialists in their workplace had 2.41 times the odds of poor knowledge than those without specialists ($P = 0.002$) (Table 3).

There was no significant interaction found between the predictors. There was no multicollinearity problem identified (variance-inflation-factor less than 10), which indicated a statistically stable model. The Hosmer-Lemeshow test was insignificant ($P = 0.932$), which showed that the dataset fits well with the logistic model. The classification table showed that 77% of cases are predicted correctly, whether they have poor knowledge or not, with 97.3% specificity and 13.2% sensitivity. The AUC was 0.66 (95% CI: 0.61, 0.71), and it was an acceptable fit to discriminate against poor versus good knowledge (Fig. S1). All methods of goodness-of-fit showed a good model fit. Cook's influential statistic showed no influential outlier present (all the data points were below the cutoff point of 1.0). The Nagelkerke R square showed 10.3% of the variation in the outcome variable was explained by the model.

General Stroke Knowledge (GSK)

The profession was a significant predictor of poor GSK knowledge ($P < 0.001$). Other non-doctor HCPs had 6.67 times the odds of poor knowledge compared to specialists (Table 4).

Hyperacute Stroke Management (HSM)

For HSM, those without or unsure of the availability of thrombolysis services in their workplace had 9.52 times the odds of poor knowledge than those working in a workplace with thrombolysis services ($P < 0.001$). Other factors were not statistically significant (Table 5).

A*dvanced Stroke Management (ASM)*

For ASM, significant factors for poor knowledge were gender ($P < 0.001$), service group ($P = 0.015$), seeing stroke patients in daily practice ($P < 0.001$), workplace with specialists ($P < 0.001$), and availability of thrombectomy services in the workplace ($P < 0.001$). Female HCPs had 1.98 times the odds of poor knowledge than males. Those in service for less than five years had 1.73 times the odds of poor knowledge than those over 11 years ($P = 0.02$). However, the odds of poor knowledge were insignificant among those with 5-10 years and more than 10 years of service ($P = 0.959$). Those not seeing stroke patients in daily practice had 2.55 times the odds of poor knowledge than those seeing stroke patients. Those not working with specialists had 2.68 times the odds of poor knowledge than those without specialists. Those not having or unaware of thrombectomy services in their workplace had 24.78 times the odds of poor knowledge than those workplaces without the services (Table 6).

Discussion

Comprehensively, this is the first study to use ASMaQ as a tool to assess HCPs' knowledge of AIS management. Unfortunately, most tool items were not similar to other studies to compare

our findings, especially on the HSM and ASM responses. For GSK, HSM, and ASM discussion, the items with the negative answer as the desired response were italicized in the brackets.

General Stroke Knowledge (GSK)

The majority of poor responses to the GSK domain were noted on GSK-10 and GSK-8. The negative answer was the desired response for GSK-10 [*Acute stroke management education should be conducted regularly for healthcare professionals*]. Item GSK-10 was created to assess the adequacy of stroke knowledge among respondents indirectly, and low scores indicated a lack of stroke knowledge, thus requiring regular education [15]. Our study reported that almost all participants agreed with this item.

For GSK-8 [*A full neurological examination must be performed immediately in patients presenting acutely with symptoms suggestive of stroke*], 96% of HCPs wrongly perceived that a full neurological examination was required. NIHSS is sufficient for the initial assessment of acute stroke patients [4] [17]. Therefore, poor knowledge regarding this assessment might cause a delay in managing stroke patients.

Responses to GSK-9 [*High blood pressure must be lowered to normal values in acute stroke*] showed that 25.5% of HCPs were still not aware or perceived that high blood pressure (BP) should be lowered to normal values in acute stroke. Elevated BP after a stroke should be carefully lowered to at or below 185/110 mmHg before the initiation of acute therapy; otherwise, it should not be treated in acute stroke patients below 220/120 mmHg [4]. Previously, it was reported that 80% of paramedics were not managing hypertension according to guidelines [9]. Another study reported that 62.6% of stroke patients were over-treated with anti-hypertensive [18]. In a study done among GPs, 27% wanted a drastic BP reduction that could be harmful to acute stroke patients, and 14% of GPs were unsure of the ideal BP target [6]. Even though the majority of our participants are aware of proper blood pressure management in AIS and it is better than in previous studies, it should be further improved as it is one of the absolute contraindications for the initiation of acute reperfusion therapy.

Almost 90% of our participants had good knowledge of items GSK-1 to GSK-7 and were well aware of the signs and symptoms of stroke. Our finding was also compared with previous studies, whereby 85% of nurses were able to recognise stroke symptoms [7], while among GPs, knowledge of the signs and symptoms of a stroke ranged from 79% to 99% [8]. The previous study among GPs and nurses with similar items to GSK-3, GSK-4, and GSK-5 reported a much lower percentage of knowledge, which was 15.4%, 66.8%, and 13.6%, respectively [19].

The profession was associated with the GSK level in our study, whereby non-doctor HCPs had the poorest knowledge, mainly as they were not on the front line of stroke management.

Hyperacute Stroke Management (HSM)

The responses to items HSM-8, HSM-7, and HSM-1 were poor. About 93% answered incorrectly or were unsure about item HSM-8 [*All acute stroke patients must have a 12 leads ECG before thrombolysis*]. About 88% answered incorrectly or were unsure about HSM-7 [*Coagulation profile must be screened before thrombolysis*]. Our finding showed that most HCPs had poor knowledge of the investigations indicated for the initiation of thrombolysis. Twelve-lead ECG and coagulation profiles are required in all stroke patients, but they are not compulsory and should not delay the initiation of thrombolysis in AIS patients [4] [17].

For HSM-1 [*Stroke is a medical emergency only within 4.5 hours of stroke onset*], 70% of our participants were unaware of thrombolysis above 4.5 hours. Intravenous thrombolysis can also be considered for acute stroke onset more than 4.5 hours up to 9 hours or in wake-up stroke or stroke of uncertain onset assisted by CT/MR perfusion (significant penumbra mismatch) or MRI (DWI-FLAIR mismatch) [4]. Our finding is similar to that reported previously, especially regarding the treatment of extended hours of stroke; most participants were unaware of stroke treatment beyond 4.5 hours [9]. Thus, potentially treatable stroke patients could be missed due to poor knowledge.

For HSM-6 [My hospital is equipped with thrombolysis treatment], 32.9% do not have thrombolysis treatment in their workplace, and 13.6% were unaware of it. Our study identified that those HCPs had significantly poor knowledge of HSM as they might not have experience managing hyperacute stroke. There were about 362 hospitals (154 public and 208 private) in Malaysia [13], but only 48 hospitals (24 public and 24 private) offered thrombolysis service [20]. Thus, the actual percentage of HCPs with poor knowledge of HSM in Malaysia might be higher than that reported in this study.

Advanced Stroke Management (ASM)

The majority of poor responses within the ASM domain were for ASM-6, ASM-10, and ASM-8. About 66% of HCPs stated that thrombectomy services were unavailable in their workplace. Our findings from HSM-6 and ASM-6 suggest that Malaysia needs more facilities with thrombolysis and thrombectomy services. Thus, HCPs can increase their knowledge and experience in managing acute strokes, which will benefit many stroke patients.

For item ASM-10 [*Wake up strokes are not eligible for thrombolysis nor mechanical thrombectomy*], half of the HCPs were unsure of the eligibility of AIS therapy in wake-up strokes, and 27% had wrongly perceived that it was not eligible for treatment. Again, this brings up the issue of HCPs not being aware of stroke treatment in the extended window period.

For item ASM-8 [Mechanical thrombectomy can be performed after thrombolysis therapy], 62% of HCPs were unaware of combination therapy of thrombolysis and thrombectomy. Thrombectomy can be performed after thrombolysis in eligible AIS patients who arrive within 4.5 hours of stroke onset [4]. Previously, it was reported that 86% of physicians were unaware of the possibility of thrombectomy with thrombolysis, which was higher compared to our study [21].

For ASM, predictors of poor knowledge were short duration of services, not seeing stroke patients in daily practice, working without specialists, and unavailability or being unaware of thrombectomy services in the workplace. This could lead to poor knowledge and would be a barrier to proper stroke management. A systematic review showed that organisational factors such as lack of stroke specialists and health professionals' lack of awareness, knowledge, and skills in acute management were the common barriers to stroke care practise [22]. Gender was also found to be a significant factor affecting ASM knowledge in our study. This might be due to the unequal distribution of male and female participants in this study. Besides, this association might be due to other confounding factors that were not explored in this study.

Overall Knowledge of Stroke

Generally, most of our HCPs had good knowledge of stroke, but it could be further improved, especially on HSM and ASM aspects. The majority of them were not up-to-date on the current indications of thrombolysis and thrombectomy, particularly regarding the extended hours.

This study found that HCPs who saw stroke patients in daily practice, especially doctors and those working with specialists, had better overall knowledge of stroke, showing that experience and proper guidance are the determinant factors of stroke knowledge. Similarly, previous studies reported that being a physician [11], working in a stroke-related speciality [12], and seeing more stroke cases [9], are significantly associated with higher stroke knowledge. Furthermore, training, skill, and expertise in acute stroke care were significantly associated with higher thrombolysis rates [23]. Thus, having a better knowledge of stroke management will lead to a better outcome for stroke patients.

Training HCPs on stroke management is one of the strategies to improve the quality of care for stroke patients [11] [24]. As a part of a nationwide initiative to improve stroke care in Malaysia, an online stroke e-learning module was launched to raise awareness of AIS management among HCPs [25]. The module was developed based on the latest Malaysian clinical practice guideline in collaboration with the ANGELs Initiative. This module may help our HCPs to improve their knowledge of stroke management; however, further research is needed to assess the module's effectiveness.

Limitations

This study has several limitations. Firstly, response bias could influence the estimation of the proportion of poor knowledge among HCPs. Those who responded are more likely to be involved in stroke management and might have better knowledge than non-responders. Secondly, our study does not have an equal representation of HCPs due to the non-probability sampling methods used in this study. Therefore, future research should consider probability sampling for less bias and more generalizable findings. Thirdly, ASMaQ has certain limitations. Most of the items in the questionnaire are general. It did not include the thrombolytic medication dosages and contraindications for AIS treatment. However, highly specific questions were omitted during the validation of this questionnaire to keep the instrument relevant throughout time [15]. Finally, even though most of our HCPs were found to have good knowledge of AIS management, this might not reflect their actual practice. Therefore, further research is needed to evaluate their practice in AIS management.

Conclusions

About one-fourth of HCPs had poor knowledge of AIS management, particularly in hyperacute and advanced stroke management. Mostly, they were not aware of the AIS treatment during extended hours. Stroke knowledge was significantly poor among HCPs who do not see stroke patients on a daily basis, do not work with specialists, and work in facilities that do not offer thrombolysis and thrombectomy services. Our findings reinforce the need for stroke education on the current recommended AIS management, especially for HCPs with limited experience and guidance in managing stroke patients. All HCPs need to be aware of the latest AIS management and make a prompt referral to an appropriate facility. Therefore, more stroke patients will benefit from advanced stroke care. Getting appropriate healthcare fast is crucial, and knowing where to find those resources quickly is of utmost importance.

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Table 1(on next page)

Baseline characteristics.

1 **Table 1: Baseline characteristics.**

Variables	Total *n* (%)	
Age group (years)		
≤30	217 (34.6)	
31-35	209 (33.3)	
≥36	201 (32.1)	
Gender		
Female	395 (63.0)	
Male	232 (37.0)	
Service group (years)		
<5	210 (33.5)	
5-10	241 (38.4)	
>10	176 (28.1)	
Professions		
Others§	40 (6.4)	
General practitioner (GP)	57 (9.1)	
House officer (HO)	20 (3.2)	
Medical officer (MO)	411 (65.6)	
Medical based dept.¥		263 (64.0)
Surgical based dept.		27 (6.6)
Primary care		121 (29.4)
Specialist	99 (15.8)	
Medical based dept.¥		68 (68.7)
Surgical based dept.		15 (15.2)
Primary care		16 (16.2)
Work setting		
Primary care	208 (33.2)	
Government health clinic		138 (66.3)
Private clinic		70 (33.7)
Hospital	419 (66.8)	
Private hosp.		39 (9.3)
General hosp.		202 (48.2)
District hosp.		134 (32.0)
University hosp.		44 (10.5)
Work sector		
Private	109 (17.4)	
Government	518 (82.6)	

Seeing stroke patients in daily practice	
No	139 (22.2)
Yes	488 (77.8)
Workplace with specialists	
No	122 (32.1)
Yes	505 (80.5)

[§]Others: medical assistants, nurses, pharmacists and allied health professionals

[¥]Medical based department was mostly involved the General Medicine and Emergency department.

Table 2(on next page)

The proportion of participants with good and poor knowledge and the total mean scores.

Table 2: The proportion of participants with good and poor knowledge and the total mean scores.

Knowledge	Good knowledge		Poor knowledge		Total mean scores	
	n	% (95% CI)	*n*	% (95% CI)	Mean (SD)	95% CI
General Stroke Knowledge (GSK)	555	88.5 (86, 91)	72	11.5 (9, 14)	39.18 (3.40)	38.9, 39.4
Hyperacute Stroke Management (HSM)	364	58.1 (54, 62)	263	41.9 (38, 46)	32.43 (3.67)	32.1, 32.7
Advanced Stroke Management (ASM)	384	61.2 (57, 65)	243	38.8 (35, 43)	36.32 (5.35)	35.9, 36.7
Overall	476	75.9 (73, 79)	151	24.1 (21, 27)	107.20 (9.29)	106, 108

Abbreviations:CI= Confidence Interval; SD= Standard deviation

Table 3(on next page)

Predictors of poor knowledge of stroke among healthcare professionals.

1 **Table 3: Predictors of poor knowledge of stroke among healthcare professionals.**

Variables	Knowledge		Simple Logistic Regression			Multiple Logistic Regression		
	Good *n* (%)	Poor *n* (%)	Crude OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]	Adjusted OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]
Age group (years)				0.492 (2)	0.782			
≤30	162 (74.7)	55 (25.3)	1.05 (0.68,1.64)	0.052 (1)[b]	0.819[b]	-	-	-
31-35	162 (77.5)	47 (22.5)	0.90 (0.57,1.42)	0.204 (1)[b]	0.651[b]			
≥36	152 (75.6)	49 (24.4)	1					
Gender								
Female	295 (74.7)	100 (25.3)	1.20 (0.82,1.77)	0.896 (1)	0.344	-	-	-
Male	181 (78.0)	51 (22.0)	1					
Service group (years)				1.9 (2)	0.387			
<5	153 (72.9)	57 (27.1)	1.19 (0.75,1.89)	0.539 (1)[b]	0.463[b]	-	-	-
5-10	189 (78.4)	52 (21.6)	0.88 (0.55,1.40)	0.304 (1)[b]	0.581[b]			
>10	134 (76.1)	42 (23.9)	1					
Professions				13.974 (4)	0.007		12.371 (4)	0.015
Others[§]	22 (55.0)	18 (45.0)	3.95 (1.75,8.90)	10.956 (1)[b]	0.001[b]	3.46 (1.49,8.03)	8.313 (1)[b]	0.004[b]
GP	39 (68.4)	18 (31.6)	2.23 (1.04,4.78)	4.208 (1)[b]	0.04[b]	0.76 (0.29,1.97)	0.323 (1)[b]	0.570[b]
HO	17 (85.0)	3 (15.0)	0.85 (0.22,3.23)	0.056 (1)[b]	0.813[b]	0.96 (0.25,3.74)	0.002 (1)[b]	0.962[b]
MO	316 (76.9)	95 (23.1)	1.45 (0.82,2.57)	1.630 (1)[b]	0.202[b]	1.40 (0.77,2.54)	1.23 (1)[b]	0.267[b]
Specialist	82 (82.8)	17 (17.2)	1			1		
Work setting								
Primary care	140 (67.3)	68 (32.7)	1.97 (1.35,2.87)	12.238 (1)	<0.001	-	-	-
Hospital	336 (80.2)	83 (19.8)	1					
Work sector						-	-	-
Private	78 (71.6)	31 (28.4)	1.32 (0.83,2.10)	1.33 (1)	0.249			

Government	398 (76.8)	120 (23.2)	1					
Seeing stroke patients in daily practice								
No	83 (59.7)	56 (40.3)	2.79 (1.86,4.19)	23.737 (1)	<0.001	2.67 (1.73,4.10)	19.49 (1)	<0.001
Yes	393(80.5)	95 (19.5)	1			1		
Workplace with specialists								
No	76 (62.3)	46 (37.7)	2.31 (1.51,3.53)	14.275 (1)	<0.001	2.41 (1.38,4.18)	9.364 (1)	0.002
Yes	400 (79.2)	105 (20.8)	1			1		

Abbreviations: GP= General Practitioner; HO= House Officer; MO= Medical Officer; OR=Odds Ratio; CI= Confidence Interval; *df*= Degree of freedom

[a] Likelihood Ratio test

[b] Wald test

[§]Others: medical assistants, nurses, pharmacists and allied health professionals

Table 4(on next page)

Predictors of poor knowledge of General Stroke Knowledge (GSK).

Table 4: Predictors of poor knowledge of General Stroke Knowledge (GSK).

Variables	Knowledge		Simple Logistic Regression			Multiple Logistic Regression		
	Good *n* (%)	Poor *n* (%)	Crude OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]	Adjusted OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]
Age group (years)				2.734 (2)	0.255			
≤30	188 (86.6)	29 (13.4)	1.09 (0.61,1.93)	0.080 (1)[b]	0.778[b]	-	-	-
31-35	191 (91.4)	18 (8.6)	0.66 (0.35,1.26)	1.581 (1)[b]	0.209[b]			
≥36	176 (87.6)	25 (12.4)	1					
Gender								
Female	350 (88.6)	45 (11.4)	0.93 (0.59,1.62)	0.009 (1)	0.926	-	-	-
Male	205 (88.4)	27 (11.6)	1					
Service group (years)				0.252 (2)	0.881			
<5	187 (89.0)	23 (11.0)	0.86 (0.46,1.60)	0.222 (1)[b]	0.637[b]	-	-	-
5-10	214 (88.8)	27 (11.2)	0.88 (0.49,1.61)	0.165 (1)[b]	0.685[b]			
>10	154 (87.5)	22 (12.5)	1					
Profession*				28.465 (4)	<0.001		28.465 (4)	<0.001
Others[§]	24 (60.0)	16 (40.0)	6.67 (2.62,16.94)	15.898 (1)[b]	<0.001[b]	6.67 (2.62,16.94)	15.898 (1)[b]	<0.001[b]
GP	47 (82.5)	10 (17.5)	2.13 (0.81,5.60)	2.341 (1)[b]	0.126[b]	2.13 (0.81,5.60)	2.341 (1)[b]	0.126[b]
HO	17 (85.0)	3 (15.0)	1.77 (0.43,7.20)	0.627 (1)[b]	0.428[b]	1.77 (0.43,7.20)	0.627 (1)[b]	0.428[b]
MO	377 (91.7)	34 (8.3)	0.90 (0.42,1.95)	0.069 (1)[b]	0.793[b]	0.90 (0.42,1.95)	0.069 (1)[b]	0.793[b]
Specialist	90 (90.1)	9 (9.1)	1			1		
Work setting*								
Primary care	177 (85.1)	31 (14.9)	1.62 (0.98,2.66)	3.458 (1)	0.063	-	-	-
Hospital	378 (90.2)	41 (9.8)	1					
Work sector*								
Private	94 (86.2)	15 (13.8)	1.29 (0.70,2.38)	0.646 (1)	0.422	-	-	-
Government	461 (89.0)	57 (11.0)	1					

Seeing stroke patient in daily practice*						-	-	-
No	116 (83.5)	23 (16.5)	1.78 (1.04,3.04)	4.175 (1)	0.041			
Yes	439 (90.0)	49 (10.0)	1					
Workplace with specialist*						-	-	-
No	104 (85.2)	18 (14.8)	1.45 (0.81,2.57)	1.508 (1)	0.207			
Yes	451 (89.3)	54 (10.7)	1					

Abbreviations: GP= General Practitioner; HO= House Officer; MO= Medical Officer; OR=Odds Ratio; CI= Confidence Interval; *df*= Degree of freedom

[a] Likelihood Ratio test

[b] Wald test

[§]Others: medical assistants, nurses, pharmacists and allied health professionals

Table 5(on next page)

Predictors of poor knowledge of Hyperacute Stroke Management (HSM).

Table 5: Predictors of poor knowledge of Hyperacute Stroke Management (HSM).

Variables	Knowledge		Simple Logistic Regression			Multiple Logistic Regression		
	Good *n* (%)	Poor *n* (%)	Crude OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]	Adjusted OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]
Age group (years)				1.326 (2)	0.515			
≤30	122 (56.2)	95 (43.8)	1.02 (0.69,1.50)	0.01 (1)[b]	0.919[b]	-	-	-
31-35	128 (61.2)	81 (38.8)	0.83 (0.56,1.23)	0.868 (1)[b]	0.352[b]			
≥36	114 (56.7)	87 (43.3)	1					
Gender								
Female	223 (56.5)	91 (39.2)	1.20 (0.86,1.66)	1.123 (1)	0.289	-	-	-
Male	141 (60.8)	172 (43.5)	1					
Service group (years)				5.101(2)	0.078			
<5	112 (53.3)	98 (46.7)	1.13 (0.75,1.68)	0.329 (1)		-	-	-
5-10	153 (63.5)	88 (36.5)	0.74 (0.50,1.10)	2.222 (1)				
>10	99 (56.2)	77 (43.8)	1					
Profession				7.246 (4)	0.123			
Others[§]	26 (65.0)	14 (35.0)	1.08 (0.40,2.33)	0.035 (1)	0.851[b]			
GP	28 (49.1)	29 (50.9)	1.06 (1.06,4.03)	4.59 (1)	0.032[b]	-	-	-
HO	9 (45.0)	11 (55.0)	0.92 (0.92,6.48)	3.23 (1)	0.072[b]			
MO	235 (57.2)	176 (42.8)	0.94 (0.94,2.38)	2.95 (1)	0.086[b]			
Specialist	66 (66.7)	33 (33.3)	1					
Work setting								
Primary care	99 (47.6)	109 (52.4)	1.90 (1.35,2.65)	13.9 (1)	<0.001	-	-	-
Hospital	265 (63.2)	154 (36.8)	1					
Work sector								
Private	52 (47.7)	57 (52.3)	1.66 (1.10,2.51)	5.734 (1)	0.017	-	-	-
Government	312 (60.2)	206 (39.8)	1					

Seeing stroke patient in daily practice						-	-	-
No	71 (58.1)	68 (48.9)	1.44 (0.99,2.10)	3.539 (1)	0.06			
Yes	293 (60.0)	195 (40.0)	1					
Workplace with specialist						-	-	-
No	48 (39.3)	74 (60.7)	2.58 (1.72,3.87)	21.527 (1)	<0.001			
Yes	316 (62.6)	189 (37.4)	1					
Workplace with thrombolysis services								
No/Unsure	91 (31.3)	200 (68.7)	9.52 (6.58,13.78)	167.0 (1)	<0.001	9.52 (6.58,13.78)	167.0 (1)	<0.001
Yes	273 (81.2)	63 (18.8)	1			1		

Abbreviations: GP= General Practitioner; HO= House Officer; MO= Medical Officer; OR=Odds Ratio; CI= Confidence Interval; *df*= Degree of freedom

[a] Likelihood Ratio test

[b] Wald test

[§]Others: medical assistants, nurses, pharmacists and allied health professionals

Table 6(on next page)

Predictors of poor knowledge of Advanced Stroke Management (ASM).

1 **Table 6: Predictors of poor knowledge of Advanced Stroke Management (ASM).**

Variables	Knowledge		Simple logistic regression			Multiple logistic regression		
	Good *n* (%)	Poor *n* (%)	Crude OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]	Adjusted OR (95% CI)	X^2 stat. (*df*)[a]	*P*-value[a]
Age group (years)				5.211 (2)	0.074			
≤30	121 (55.8)	96 (44.2)	1.28 (0.86,1.89)	1.511 (1)	0.219[b]	-	-	-
31-35	139 (66.5)	70 (33.5)	0.81 (0.54,1.22)	1.032 (1)	0.310[b]			
≥36	124 (61.7)	77 (38.3)	1					
Gender								
Female	224 (56.7)	172 (43.3)	1.70 (1.21,2.39)	9.382 (1)	0.002	1.98 (1.35,2.90)	12.72 (1)	<0.001
Male	160 (69.0)	72 (31.0)	1			1		
Service group (years)				5.823 (2)	0.054		8.39 (2)	0.015
<5	115 (54.8)	95 (45.2)	1.41 (0.94,2.12)	2.715 (1)	0.099[b]	1.73 (1.09,2.74)	5.42[b] (1)	0.02[b]
5-10	158 (65.6)	83 (34.4)	0.90 (0.60,1.34)	0.276 (1)	0.599[b]	0.99 (0.63,1.55)	0.003[b] (1)	0.959[b]
>10	111 (63.1)	65 (36.9)	1			1		
Profession				17.859 (4)	0.001			
Others[§]	22 (55.0)	18 (45.0)	2.56 (1.18,5.55)	5.649 (1)	0.017[b]			
GP	25 (43.9)	32 (56.1)	4.00 (1.99,8.03)	15.222 (1)	<0.001[b]	-	-	-
HO	14 (70.0)	6 (30.0)	1.34 (0.46,3.87)	0.291 (1)	0.589[b]			
MO	248 (60.3)	163 (39.7)	2.05 (1.25,3.39)	7.95 (1)	0.005[b]			
Specialist	75 (75.8)	24 (24.2)	1					
Work setting								
Primary care	102 (49.0)	106 (51.0)	2.14 (1.52,3.01)	19.328 (1)	<0.001	-	-	-
Hospital	282 (67.3)	137 (32.7)	1					
Work sector								
Private	57 (52.3)	52 (47.7)	1.56 (1.03,2.37)	4.377 (1)	0.036	-	-	-
Government	327 (63.1)	191 (36.9)	1					

Seeing stroke patient in daily practice								
No	63 (45.3)	76 (54.7)	2.32 (1.58,3.40)	18.676 (1)	<0.001	2.55 (1.65,3.94)	18.01 (1)	<0.001
Yes	321 (65.8)	167 (34.2)	1			1		
Workplace with specialist								
No	50 (41.0)	72 (59.0)	2.81 (1.88,4.22)	25.574 (1)	<0.001	2.68 (1.70,4.20)	18.83 (1)	<0.001
Yes	334 (66.1)	171 (33.9)	1			1		
Workplace with thrombectomy services								
No/Unsure	294 (55.1)	240 (44.9)	24.49 (7.66,78.34)	75.91 (1)	<0.001	24.78 (7.62,80.66)	69.15 (1)	<0.001
Yes	90 (96.8)	3 (3.2)	1			1		

Abbreviations: GP= General Practitioner; HO= House Officer; MO= Medical Officer; OR=Odds Ratio; CI= Confidence Interval; *df*= Degree of freedom

[a] Likelihood Ratio test

[b] Wald test

[§]Others: medical assistants, nurses, pharmacists and allied health professionals

Figure 1

Participants' responses (%) to General Stroke Knowledge

*Asterisk sign denotes negative answer as desired response.

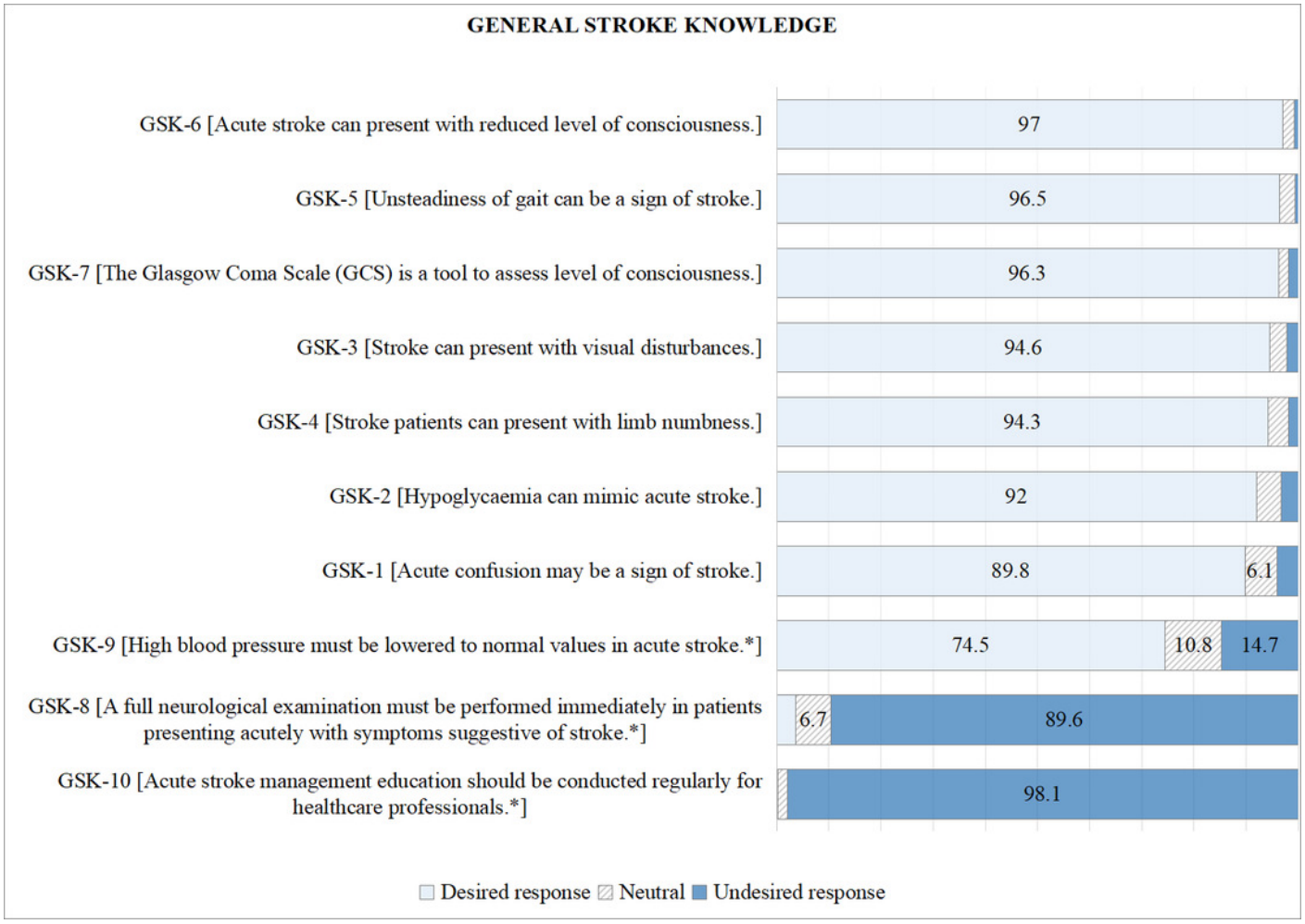


Figure 2

Participants' responses (%) to Hyperacute Stroke Management

*Asterisk sign denotes negative answer as desired response.

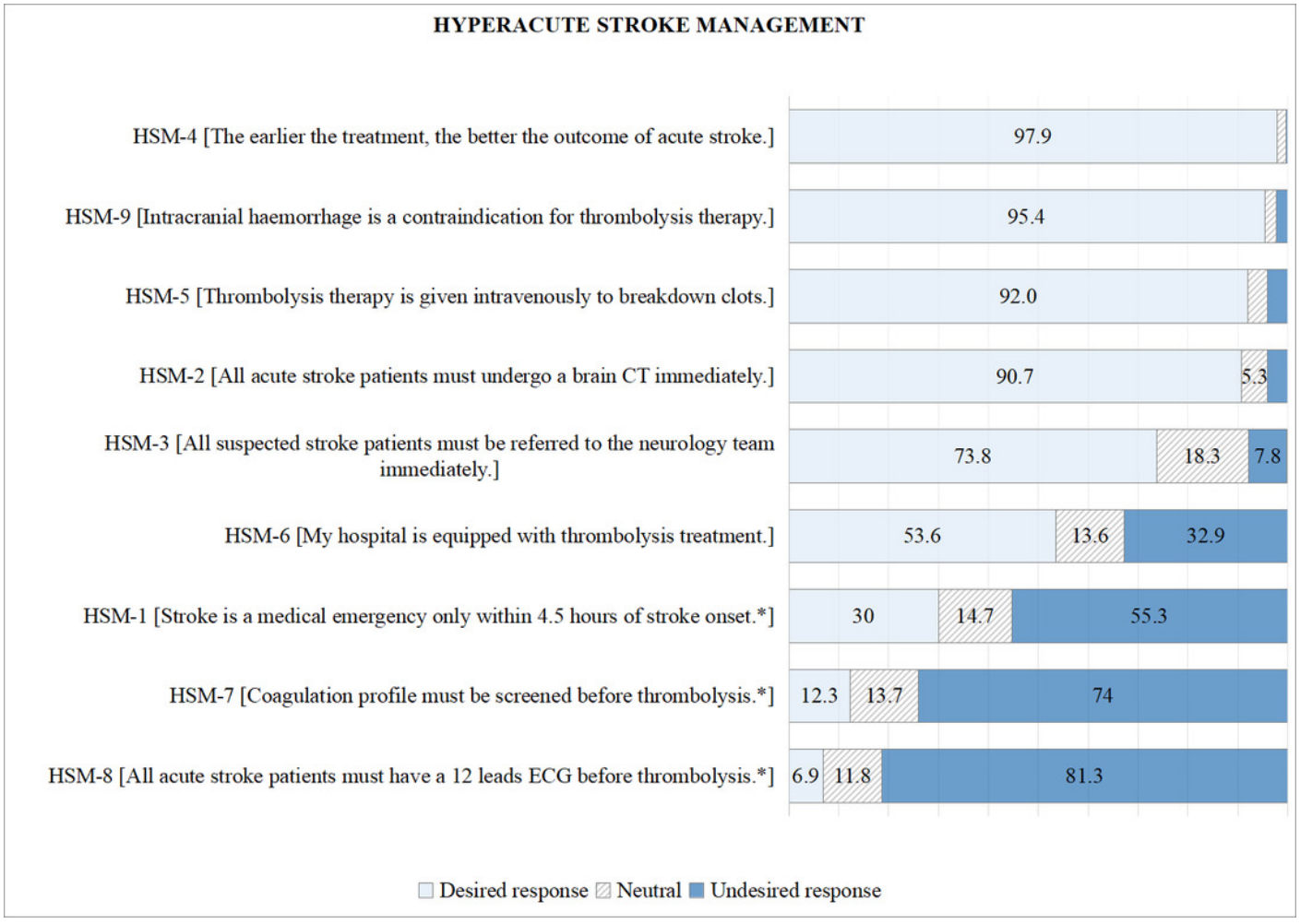
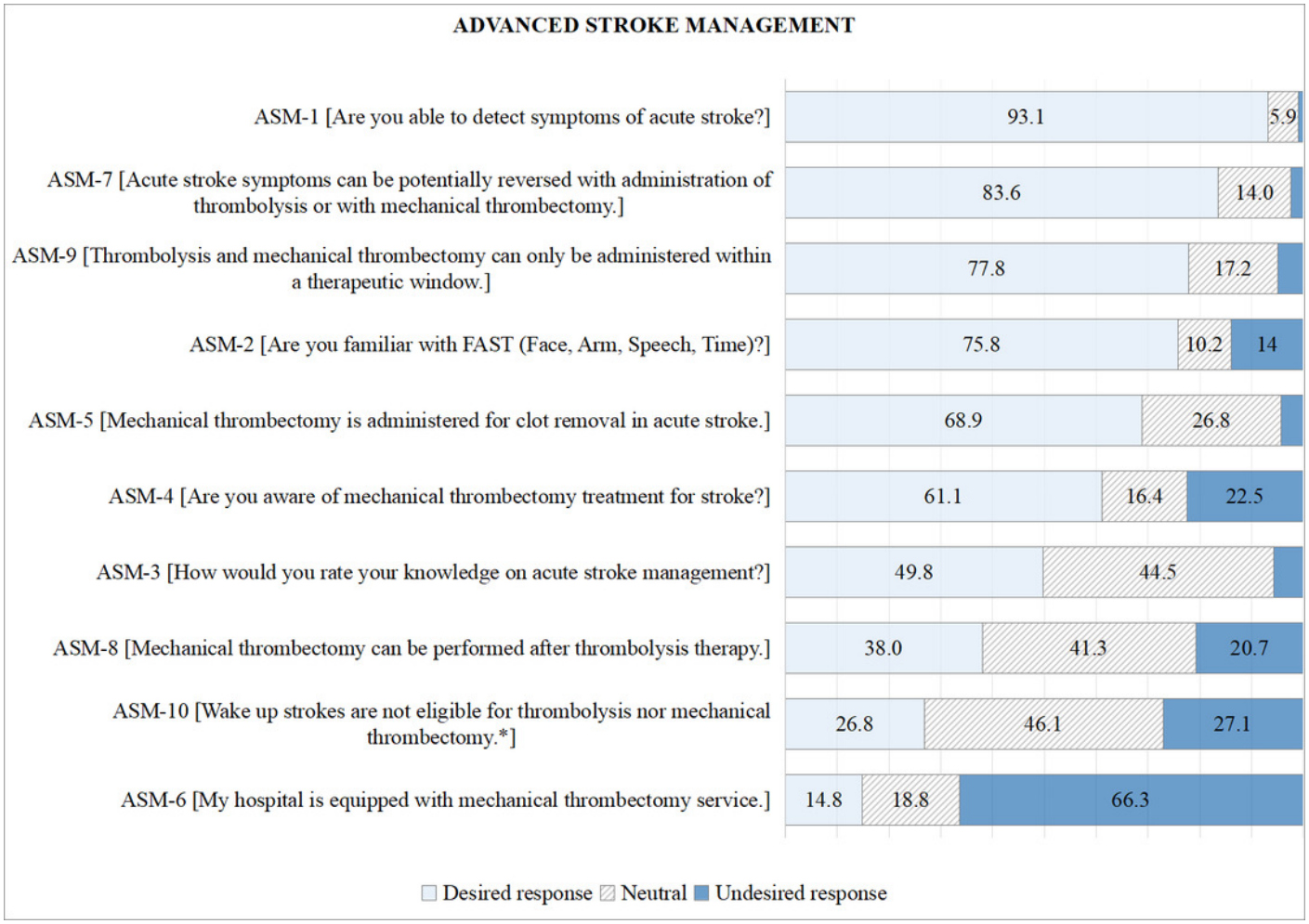


Figure 3

Participants' responses (%) to Advanced Stroke Management

*Asterisk sign denotes negative answer as desired response.