Ekurhuleni District Junior Doctors' Accuracy Rate in Neuro-Emergency CTB Interpretation.

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Enrolled for MMed (Rad D)

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In the fulfilment of the requirements of the degree of Master of Medicine (Radiology)

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Declaration by candidate

I, Ramatsemela Mumsy Gololo student number 831451, declare this research report is my effort. It is being submitted for the MMed (RAdD) degree at the University of the Witwatersrand in Johannesburg. It has not previously been submitted for a degree or examination at this or any other university.

I recognised all sources and noted them in the references section.

There are no conflicts of interest while writing the study paper.

This work was written in a "submissible" style in accordance with the standards of the South African Journal of Radiology.

22 September 2025

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Declaration by Supervisors

The following individuals served as supervisors for the candidate, Ramatsemela Mumsy Gololo, student number 831451, as part of their research paper titled "Ekurhuleni District Junior Doctors' accuracy rate Neuro-emergency CTB interpretation" to fulfil the requirements for the degree of FC Rad Diag (SA) MMed.

Details about the candidate and supervisors (including % contributions):

- Candidate: Ramatsemela Mumsy Gololo (60%).
- Supervisor 1: Gopolang Mndebele (20%).
- Supervisor 2 Besley Mojapelo is the supervisor (20%).

Supervisor and candidate contributions to the study paper:

- Ramatsemela Gololo wrote the protocol and final research article for this study. Supervisors evaluated versions of the protocol and research article, offering criticism on methodology, content, execution, and ideas.
- The proposal and manuscript were submitted to Turnitin for plagiarism assessment.
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Dr Gopolang Mndebele — 22/09/2025 Date

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Acknowledgements

The acknowledgement section follows the conclusions section and addresses formal, required statements of gratitude and required disclosures. It includes listing those who contributed to the work but did not meet authorship criteria, with the corresponding description of the contribution. Acknowledge anyone who provided intellectual assistance, technical help (including with writing and editing), or special equipment and/or materials. Authors are responsible for ensuring that anyone named in the Acknowledgements agrees to be named.

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1. Abstract

Background: Brain neurologic emergencies are among the top causes of disabilities, frequently causing irreversible brain damage. In neuro-emergencies, immediate management is essential, as early neurological deterioration commonly occurs within the first few hours. Therefore, early imaging and prompt interpretation are crucial.

Objectives: This study assesses the ability of junior medical doctors to identify important emergency findings in CT brain neuroimaging.

Method: A prospective observational cross-sectional study was conducted in three hospitals in the Ekurhuleni District from 30th August to 03 September 2024. Participants were involved in structured training on interpreting neuro-emergency CTB scans. Before and after training, surveys were employed to evaluate the changes in diagnostic accuracy.

Results: Post-training, the mean accuracy improved from 69.3% to 72.9%, representing a statistically significant increase of 3.24% with P-value 0.006. The most notable improvements were observed in detecting diffuse axonal, space-occupying lesions and subarachnoid haemorrhages. While a decrease in the accuracy of identifying subdural haemorrhages was noted.

Conclusion: The study highlights the advantages and improvements that the targeted training programs may have in enhancing junior doctors' skills in reading CTB images in emergency settings. It also emphasises the importance of continuous training initiatives and multidisciplinary meetings to assist in the enhancement of diagnostic accuracy and ultimately patient management.

Contribution: This research contributes to the pool of literature by addressing a substantial void in medical education and training, demonstrating the effectiveness of a focused intervention to improve diagnostic precision in neuro-emergencies. The findings suggest that juniors' interpretation of essential neuroimaging may be significantly improved by concise, organised training programs, thereby improving patient outcomes in emergency rooms.

Keywords: Neuro-emergencies, CT brain imaging, junior medical doctors, neuroimaging, diagnostic accuracy, diagnostic skills, radiological interpretation, clinical decision-making

Abbreviations: Computed tomography of the brain (CTB), Computed Tomography (CT), emergency department (ED), Picture Archiving and Communication System Radiology Information System (PACS-RIS), Thelle Mogoerane Regional Hospital (TMRH), traumatic brain injury (TBI). Emergency physicians (EP), Health Professional Council of South Africa (HPCSA)

2. Introduction

Brain injuries are responsible for the majority of health issues and functional impairments worldwide (1,2). Numerous survivors of brain trauma endure significant disability, adversely affecting both society and the economy (1,2). The effective management of these medical conditions requires prompt evaluation, timely administration of the appropriate treatments, and quick transfer to the most suitable healthcare facility to improve survival rates, reduce morbidity, and prevent disability (3). The efficient management of various medical conditions requires immediate assessment, timely provision of adequate treatments, and quick transfer to the most appropriate healthcare institution to improve survival rates, decrease morbidity, and prevent impairment (4). Therefore, early imaging and swift interpretation are crucial (5–7).

Computed tomography of the brain (CTB) is a frequently used imaging method for evaluating emergencies affecting the brain, detecting both traumatic and non-traumatic injuries (2–4,8–11). The use of CTB in emergency departments (EDS) is common due to its prompt imaging capabilities, which increase efficiency (5). Due to the time-sensitive nature of trauma cases, non-radiology doctors often need to interpret the CT scan and initiate patient treatment before the radiological report is available (2,11,12).

The workload in radiology divisions has seen a significant increase recently (13). The availability of diagnostic radiologists often does not match the demand, particularly when it comes to offering emergency imaging services outside standard operating hours (12,13). Along with the increase in ED visits, there has been a corresponding rise in the use of imaging modalities (5).

In most health institutions in high-income countries, radiology residents provide preliminary readings of the radiology examinations done after hours (14). The discrepancies between the radiology registrar’s and the radiologist's final reports are usually minimal (14). In contrast, low-income countries face a considerable challenge in having enough trained healthcare professionals across various levels of expertise.

(15) South Africa is classified as an upper-middle-income country by the World Bank; however, it remains one of the most unequal nations globally, with the triple challenge of high poverty, inequality, and unemployment (16).

In many parts of Africa and secondary hospitals in South Africa, access to radiologists remains limited due to workforce shortages and training across various levels of proficiency. The shortage of radiologists and the growing availability of CT scanners in low-income countries make it increasingly necessary for non-radiology junior doctors to interpret the CT scans of emergency patients (17,18).

In some instances, the radiological result may be delayed, even when a radiologist is present on site (12,17). The radiologist may be occupied with other duties, such as ultrasound or interventional radiology (17). Several studies have been conducted to investigate the discrepancy between emergency doctors' and radiologists' interpretations in middle- and high-income countries (17). However, there is a minimum of research done on this matter in low-income countries (6).

3. Research material and methods.

This was intervention-based research, utilising a one-time PowerPoint presentation training on the approach to interpreting neuro-emergency CT scans. The training was held during the general hospital doctors' morning meetings at Thelle Mogoerane Regional Hospital, Pholosong Hospital, and Far East Rand Hospital. Information sheets and consent forms were given to the junior doctors who agreed to participate in the study. The data was collected from junior medical doctors who consented to take part in the study. No restrictions were placed on those unwilling to participate, as they were allowed to attend the training for knowledge-sharing purposes.

The training spanned a total of 80 minutes. Pre-training data collection, training, and post-training data collection are all conducted on the same day. The first 20 minutes involved a pre-training survey, the next 40 minutes covered the actual training, and the final 20 minutes were for the post-training survey. For post-training assessment,

the same images (20 in number) were used. However, the order of images was altered. Both the pre-training survey (20 images) and training (20 images) were obtained from the Picture Archiving and Communication System Radiology Information System (PACS-RIS) at Thelle Mogoerane Regional Hospital (TMRH). Twenty selected images were moderated and validated by two senior radiologists.

Participants were provided with a questionnaire to select the correct responses. They were informed that some questions had multiple correct answers, while others had a single best answer. During the pre-training survey, images were shown to participants for 60 seconds per slide.. The training slides included images depicting the anatomy of the brain, as well as cases of both emergency traumatic brain injury (TBI) and non-TBI, with varying levels of complexity. “A 40-minute training session.”

The study population comprised junior doctors from the selected hospitals in the Ekurhuleni district from September to October 2024. For this research, "junior doctors" referred to medical interns, community service doctors, and medical officers who had been registered with the Health Professions Council of South Africa (HPCSA) as independent medical practitioners for less than 10 years.

4. Ethical considerations

The study received approval from the Human Research Ethics Committee of the University of the Witwatersrand, with approval number M24/02/37. Permission was also obtained from the Chief Executive Officers of Far East Rand, Thelle Mogoerane Regional, and Pholosong Hospitals.

5. Results

A comprehensive review was performed on each questionnaire. Doctors who failed to complete both the pre-and post-training questionnaires, senior medical officials with over 10 years of experience as independent practitioners, medical students, and those who did not permit participation were excluded from the research.

Initially, 81 individuals were registered as participants; however, 23 were subsequently excluded from the study. Three of the 23 excluded participants completed only the pre-training, six completed only the post-training, two held the position of Medical Officer Grade 3, four were in their fifth year of medical studies, one had experience in radiology, and seven failed to complete some or all of the required sections of the demographic information.

5.1. Percentage of Correctness

The percentage of correct versus incorrect answers was analysed on both pre-training (Table 1) and post-training data (Table 2).

Neuro-emergency	No. of assessments	No. of incorrect answers	% of incorrect answers	No. Of correct answers	% of correct answers
Abnormal meningeal enhancement	354	87	24,6%	267	75,4%
Basal meningeal enhancement	59	3	5,1%	56	94,9%
Cerebral oedema	354	237	66,9%	117	33,1%
Countre-coup haemorrhages	413	77	18,6%	336	81,4%
CVA	354	87	24,6%	267	75,4%
Diffused axonal injuries	413	238	57,6%	175	42,4%
Dural venous thrombosis	354	84	23,7%	270	76,3%
Epidural haemorrhages	59	5	8,5%	54	91,5%
Herniation syndrome	413	229	55,4%	184	44,6%
Hydrocephalus	354	52	14,7%	302	85,3%
Images (Normal or abnormal)	1180	48	4,1%	1132	95,9%
Intraparenchymal abscess	354	203	57,3%	151	42,7%
Intraparenchymal haemorrhages	59	22	37,3%	37	62,7%
Meningitis	354	82	23,2%	272	76,8%
Pneumo-ventricle	413	70	16,9%	343	83,1%
Pseudo subarachnoid haemorrhages	354	40	11,3%	314	88,7%
Simple Pneumocephalus	413	248	60,0%	165	40,0%
Skull fracture	413	254	61,5%	159	38,5%
Space-occupying lesion	354	119	33,6%	235	66,4%
Subarachnoid haemorrhages	413	150	36,3%	263	63,7%
Subdural haemorrhages	59	4	6,8%	55	93,2%
Tension pneumocephalus	413	72	17,4%	341	82,6%
White cerebella sign	354	91	25,7%	263	74,3%

Table 1: Pre-training percentages of correct vs incorrect answers.

Neuro-emergency	Number of assessments	Number of incorrect answers	Percentage of incorrect answers	Number of correct answers	Percentage of correct answers
Abnormal meningeal enhancement	354	110	31,1%	244	68,9%
Basal meningeal enhancement	59	4	6,8%	55	93,2%
Cerebral oedema	354	256	72,3%	98	27,7%
Countre-coup haemorrhages	413	91	22,0%	322	78,0%

CVA	**354**	**73**	**20,6%**	**281**	**79,4%**
Diffused axonal injuries	**413**	**160**	**38,7%**	**253**	**61,3%**
Dural venous thrombosis	**354**	**129**	**36,4%**	**225**	**63,6%**
Epidural haemorrhages	**59**	**3**	**5,1%**	**56**	**94,9%**
Herniation syndrome	**413**	**220**	**53,3%**	**193**	**46,7%**
Hydrocephalus	**354**	**33**	**9,3%**	**321**	**90,7%**
Images (Normal or abnormal)	**1180**	**57**	**4,8%**	**1123**	**95,2%**
Intraparenchymal abscess	**354**	**140**	**39,5%**	**214**	**60,5%**
Intraparenchymal haemorrhages	**59**	**14**	**23,7%**	**45**	**76,3%**
Meningitis	**354**	**65**	**18,4%**	**289**	**81,6%**
Pneumo-ventricle	**413**	**53**	**12,8%**	**360**	**87,2%**
Pseudo subarachnoid haemorrhages	**354**	**38**	**10,7%**	**316**	**89,3%**
Simple Pneumocephalus	**413**	**180**	**43,6%**	**233**	**56,4%**
Skull fracture	**413**	**212**	**51,3%**	**201**	**48,7%**
Space-occupying lesion	**354**	**81**	**22,9%**	**273**	**77,1%**
Subarachnoid haemorrhages	**413**	**52**	**12,6%**	**361**	**87,4%**
Subdural haemorrhages	**59**	**52**	**88,1%**	**7**	**11,9%**
Tension pneumocephalus	**413**	**60**	**14,5%**	**353**	**85,5%**
White cerebellar sign	**354**	**77**	**21,8%**	**277**	**78,2%**

Table 2: Post-training Percentages of correct vs incorrect answers.

The study revealed significant changes in post-training accuracy as compared to pre-training for the different neuro emergencies (Table 3). While most of the significant changes were an improvement in accuracy post-training, there were a few instances where the post-training accuracy was worse off compared to the pre-training.

Neuro-emergency	Correct answers% (before training)	Correct answers% % (After training)	P value
Abnormal meningeal enhancement	**75,4%**	**68,9%**	**0,054**
Basal meningeal enhancement	**94,9%**	**93,2%**	**0,698**
Cerebral oedema	**33,1%**	**27,7%**	**0,119**
Counter-coup haemorrhages	**81,4%**	**78,0%**	**0,225**
CVA	**75,4%**	**79,4%**	**0,204**
Diffused axonal injuries	**42,4%**	**61,3%**	**< 0.001**
Dural venous thrombosis	**76,3%**	**63,6%**	**< 0.001**
Epidural haemorrhage	**91,5%**	**94,9%**	**0,465**
Herniation syndrome	**44,6%**	**46,7%**	**0,545**
Hydrocephalus	**85,3%**	**90,7%**	**0,027**
Images (Normal or abnormal)	**95,9%**	**95,2%**	**0,819**
Intraparenchymal abscess	**42,7%**	**60,5%**	**< 0.001**
Intraparenchymal haemorrhages	**62,7%**	**76,3%**	**0,110**
Meningitis	**76,8%**	**81,6%**	**0,116**
Pneumo-ventricle	**83,1%**	**87,2%**	**0,098**
Pseudo subarachnoid haemorrhage	**88,7%**	**89,3%**	**0,799**
Simple Pneumocephalus	**40,0%**	**56,4%**	**< 0.001**
Skull fracture	**38,5%**	**48,7%**	**0,003**
Space-occupying lesion	**66,4%**	**77,1%**	**0,002**
Subarachnoid haemorrhages	**63,7%**	**87,4%**	**< 0.001**
Subdural haemorrhage	**93,2%**	**11,9%**	**< 0.001**
Tension pneumocephalus	**82,6%**	**85,5%**	**0,255**
White cerebellar sign	**74,3%**	**78,2%**	**0,223**

Table 3: Significance testing.

5.2. Statistical Significance of Pre- and Post-Training Findings.

Three methods—the paired sample t-test, the matched sample effect size, and the percentage of right responses—were used to determine if the pre- and post-training findings were statistically significant.

The findings demonstrated that the improvement from the pre-training to the post-training outcomes was statistically significant, with a p-value of 0.006. Consequently, we can ascertain that the training significantly influenced the participants' performance. The effect size reveals the practical relevance of the change, with a Cohen's d value of 0.37 implying a small effect size.

The proportion of accurate responses before and after training revealed a mean score enhancement from 69.3% to 72.9%, signifying successful training. The confidence intervals for both periods do not intersect, further substantiating the enhancement. The rise in standard deviation from 4.4 to 8.4 post-training implies heightened variability in results, indicating that some participants had substantial improvement compared to others.

5.3. Overall accuracy.

The overall accuracy between the pre-and post-training accuracy (Figure 1).

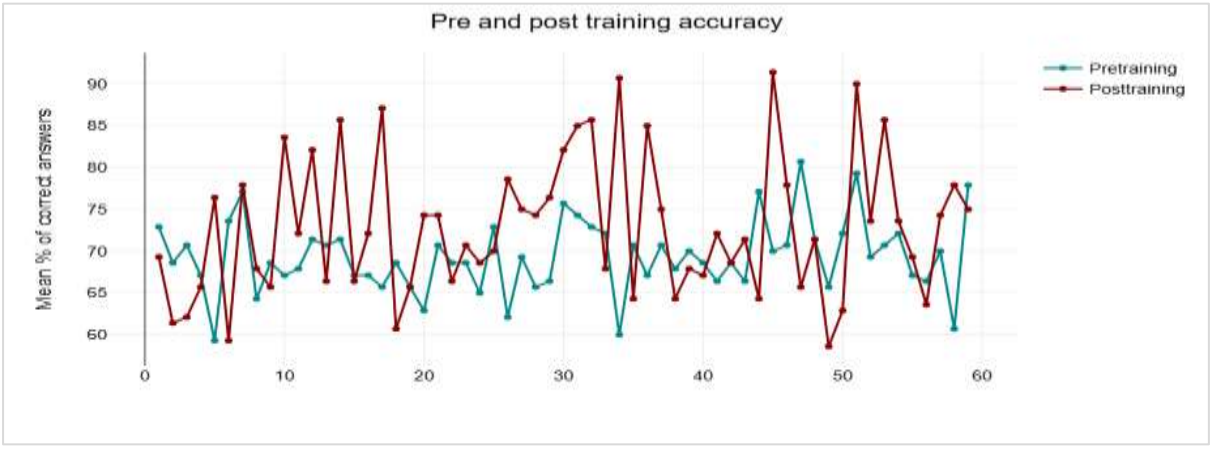

Figure 1: Pre- and post-training overall accuracy.

5.4 Accuracy Results by Demographics

Demographic criteria, including seniority level, interest in radiology, and years of medical practice, were included in the analysis of accuracy results acquired before and after training (Table 4).

Seniority			
Medical intern	**N**	**Pretraining**	**Post training**
	Mean % of correct answers	44.0	44.0
	Standard deviation	68.8	72.4
		4.0	8.0
Community service medical officer	N	3.0	3.0
	Mean % of correct answers	73.8	79.8
	Standard deviation	4.8	9.4
Medical officers	N	12.0	12.0
	Mean % of correct answers	70.2	72.6
	Standard deviation	5.3	
P-value		0.1114	0.349
Interest in Radiology			
Yes		**Pretraining**	**Post training**
	N	21,0	21,0
	Mean % of correct answers	68,2	72,3
	Standard deviation	3,8	6,7
No			
	N	38,0	38,0
	Mean % of correct answers	70,0	73,1
	Standard deviation	4,6	9,3
P-value		*0,135*	*0,731*
Years of experience as a doctor			
		Pretraining	**Post training**
<1 year	**N**		
	Mean % of correct answers	35,0	35,0
	Standard deviation	68,7	72,9
		4,2	8,4
>2years	N		
	Mean % of correct answers	24,0	24,0
	Standard deviation	70,3	72,8
		4,6	8,6
P-value		*0,162*	*0,952*

Table 4: Statistically significant differences in both the pre- and post-scores.

5.5 Accuracy by Level of Seniority

The accuracy rates were also examined for three different levels of seniority: most junior doctors (Medical Interns), Second-Level Seniority (Community Service Medical Officers), and Most Senior Participants (Medical Officers Grade 1 and 2). Following the training intervention, each group improved its diagnostic accuracy, although the extent of these increases differed depending on their level of expertise (Figure 2).

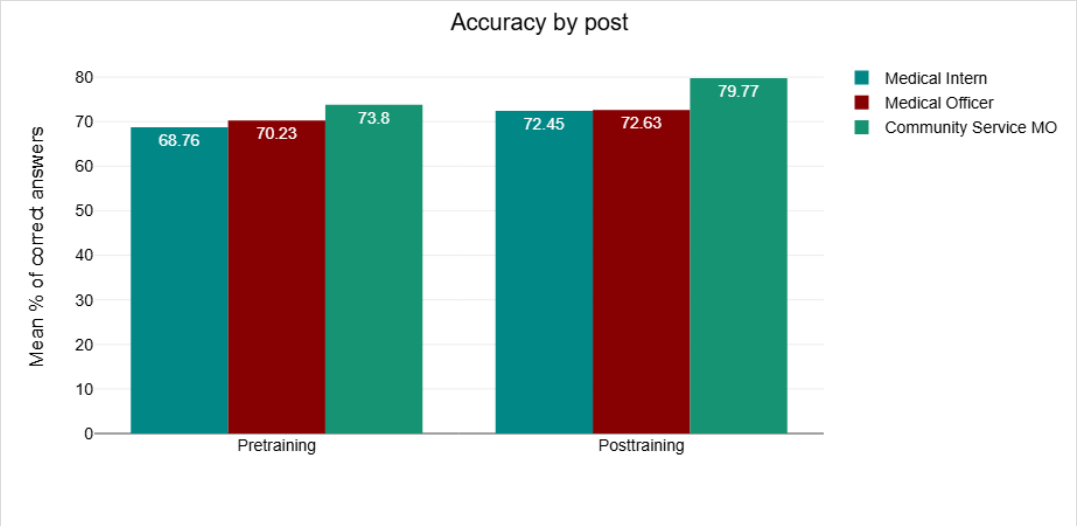

Figure 2: Accuracy by level of seniority.

The medical interns got a score of 68.76% before training. Following the training, their accuracy increased by 3.69 percentage points to 72.45.

Before training, the accuracy rate was higher at 73.8% for the Community Service Medical Officers. Their accuracy rose 6.0 percentage points, to 79.8 per cent, after the training intervention.

The most senior group in the study, which included Medical Officers Grade 1 and 2, had a pre-training accuracy of 70.23 per cent. Post-training, their accuracy improved by 2.4 percentage points, reaching 72.63%.

5.6 Accuracy by Interest in Radiology

The evaluation was further contingent upon their indicated interest in radiology (Figure 3).

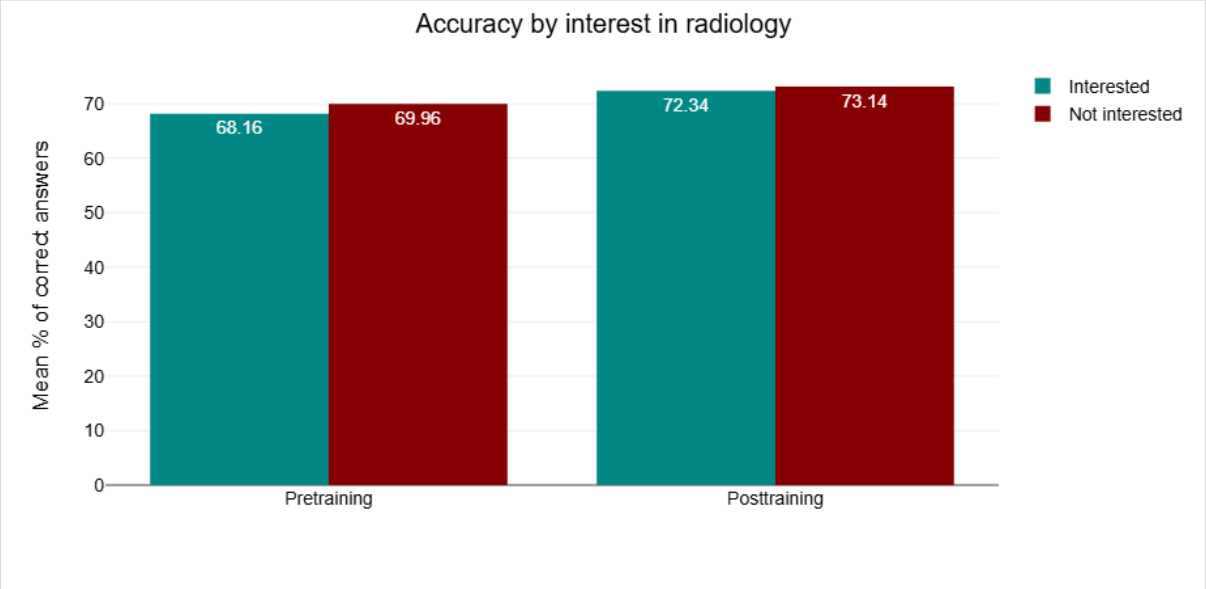

Figure 3: Accuracy by interest in radiology.

Doctors interested in radiology began with a pretraining accuracy of 68.16%. After training, their accuracy improved to 72.34%, a 4.18 percentage point increase. In contrast, doctors without a particular interest in radiology showed a smaller but still significant improvement of 3.18%.

5.7 Accuracy by Detection of Pathology

Pathology detection accuracy was divided into three categories: significant improvement, no significant improvement, and worsening results.

In some cases, the accuracy increased from 42.4% to 61.3% ($p < 0.001$) in the case of diffuse axonal injuries, 63.6% to 76.3% in detecting dural venous thrombosis ($p < 0.001$), and 42.7% to 60.5% ($p < 0.001$) in the case of intraparenchymal abscess. The rate of improvement in the detection of pneumocephalus increased from 40.0% to 56.4% ($p < 0.001$), from 38.5% to 48.7% was seen for skull fractures ($p = 0.003$), and from 66.4% to 77.1% ($p = 0.002$) for space-occupying lesions. Detection of subarachnoid haemorrhages improved from 63.7% to 87.4% ($p < 0.001$).

Several cases showed no significant change ($p > 0.05$) after the training session. These included epidural haemorrhage ($p = 0.465$), basal meningeal enhancement ($p = 0.698$) and meningitis ($p = 0.161$).

Decreased Accuracy A reduction from 93.2% to 11.9% ($p < 0.001$) was seen in cases of subdural haemorrhages. This is of significant statistical and clinical concern. It is likely that the training inadvertently introduced cognitive biases or cognitive overload, thereby adversely affecting diagnostic accuracy instead of improving it. This finding underscores the imperative for comprehensive, targeted follow-up training specifically addressing the identification of subdural haemorrhages.

6. Limitations

- The study's limitation, focusing only on junior doctors at Ekurhuleni District Hospital, restricts the generalizability of the findings. It may not represent experiences in other hospitals or healthcare settings.
- The study only evaluates short-term, immediate improvement; the durability over the long term is unknown.
- The sample size is reasonable in the context of this study.

7. Discussion

Accurate interpretation of CTB findings in the emergency department is essential for the timely and appropriate management of critical patients (1,12). Numerous studies have evaluated the error or accuracy rate of emergency doctors in the interpretation of imaging with variable outcomes (1,18). The CTB interpretation accuracy results varied across different studies, with accuracy rates ranging from 57.6% to 91.6% ((1,6,7,12,17,19). In our research, the accuracy rate in interpreting the CTB images is divided into two categories: high (above 75%) and low (below 75%). This section will also address the influence of experience on the accuracy of CTB interpretation, the effect of training on interpretation accuracy rates, and current applications.

7.1 Emergency Doctors Achieving High Accuracy (>75%) in CTB Interpretation.

Some recent studies are showing that non-radiologists can interpret CT brain scans with over 75% accuracy(1,7,17,19). This is a game-changer, especially in areas where radiologists may not always be readily available. It opens up new possibilities for improving patient care and streamlining diagnostic processes.

Parag and Hardcastle (7) revealed that neurosurgeons correctly interpreted 318 out of 347 CTBs. Out of 29 misinterpreted cases, 17 were false negatives and 12 were mismatched abnormalities. The accuracy achieved by neurosurgeons was 95.33% (7). This has resulted in the interpretation of head CT images in traumatic brain injury by neurosurgeons being reliable, particularly when radiology reports are not quickly accessible (7).

Al Asseri Z, et al (1) recorded an accuracy rate of 91.6 % by emergency medicine physicians (1). This high accuracy rate may be attributed to years of experience.

Dolatabadi et al (17) in their study, where radiology reports were used as the gold standard, EP demonstrated a higher sensitivity (86.5%) and a lower false positive rate, with an overall accuracy of 84.5%. Senior registrars had a lower sensitivity (71.4%) but higher specificity (95.8%), resulting in an accuracy of 84.1%. Both groups demonstrated statistically significant differences from the radiologist's reports (17).

In our study, the overall baseline accuracy rate for interpreting the CTB was below 75% in both pre- and post-training results, indicating significant room for improvement before any formal training was implemented. However, after undergoing a structured training program, only the community service group demonstrated a marked improvement, with their accuracy rate rising above 75%. Their noticeable progress could be attributed to the fact that many in this group have just completed their internship and are now putting in extra effort to improve their skills, aiming to prepare for independent practice.

The overall accuracy rate in our study improved from 69.3% to 72.9% after the training,

remaining below 75% for both medical interns and Medical Officers in grades 1 and 2. This suggests that, even with the positive impact of the training, there is still much room for improvement, particularly among medical interns and Medical Officers grades 1 & 2.

7.2 Non-Radiologists Achieving Low Accuracy (<75%) in CTB Interpretation.

The interpretation of CT brain scans is a critical task in clinical practice, aiding in the diagnosis and management of a wide range of neurological conditions(1). However, some studies have shown that non-radiologist doctors struggle to interpret CT brain images with accuracy, achieving rates below 75% (6,12,20). This is concerning because misinterpreting a scan can lead to delays in treatment or, worse, incorrect treatment.

Nogueira et al (12) conducted research comparing CT reports by radiologists and emergency physicians in trauma treatment in Brazil, revealing a 27% divergence rate between emergency physician and radiologist findings. Polytrauma patients had a greater likelihood of divergence and prolonged hospital stays associated with larger discrepancies, indicating that a higher number of injuries elevates the risk of missed findings. (12)

Aslaner MA, et al (20) discovered that junior doctors with no radiology experience had a median accuracy rate of 64.9%, with greater accuracy in normal CT results. Using the Angoff system, 14% of the junior doctors had scores that were lower than the passing criterion (20).

Muluberhan N (6) revealed an overall accuracy rate of 57.6%. In comparison to previous research, the aggregate discrepancy rate was exceedingly high at 42.4% (6).

In our study, we focused on junior doctors who were responsible for providing after-hours services in the emergency department for their respective departments. The primary goal was to assess how a targeted training program would impact their ability

to interpret CT brain scans. The overall accuracy in both the before and after training assessments remained below the 75% threshold.

7.3 Impact of Experience on CTB Interpretation Accuracy

Previous studies also revealed that doctors with neuroradiology experience demonstrate high accuracy in the CTB interpretation (7,19).

In the Orejuela-Zapata et al (19) study, Imaging reports analysed by junior doctors in radiology training revealed that 86.5% of findings were accurately and fully described, suggesting a strong ability to identify key abnormalities. However, 12.1% were partially described, indicating some lapses in thoroughness or attention to detail, and 1.4% of reports were incomplete, potentially leading to missed diagnoses.(19)

Our study also revealed a difference in performance between medical interns and medical officers. The pre-training scores showed that community service medical officers had an accuracy of 73.8%, followed by medical officers in grades 1 and 2 with 70.2%, and medical interns with the lowest score of 68.8%. The medical officers outperformed the interns, which may be due to their higher level of clinical exposure and experience.

7.4 Impact of Training on CTB Interpretation Accuracy Rate

Non-radiology doctors have demonstrated a statistically significant increase in computed tomography of the brain reporting accuracy with only one to two hours of training (1).

The impact of training on the interpretation of CT scans (CTB) was evident in the improvements made by both Medical Officers grade 1&2, community service medical officers and medical interns following the training.

For Medical Interns: The training had a more pronounced impact, with a 3.6% improvement in their skills, raising their score from 68.8% to 72.4%. As interns were at an earlier stage in their medical careers with less exposure and experience, they

had more room for growth. This made the training particularly beneficial, leading to a more significant relative improvement.

The Community Service Medical Officers showed a notable improvement in their CT scan interpretation skills following the training. They started with a score of 73.8%, indicating a solid foundation in CT interpretation. After the training, their score increased to 79.8%, showing a 6% improvement. This was a significant gain, suggesting that the training had a positive and impactful effect on their skills.

Medical Officers grades 1&2: The training resulted in a 2.4% improvement in their CT interpretation skills, increasing their score from 70.2% to 72.6%. While this increase was smaller relative to the interns and community service medical officers, it still indicated that the training had a positive effect. The modest improvement could be due to the medical officers starting with a stronger baseline knowledge, making their progress less pronounced as they were already closer to optimal performance.

Both groups benefited from the training, but the community service medical officer and medical interns showed a greater relative improvement, likely due to the foundational knowledge gaps they needed to fill. The study also highlights the importance of early training for junior doctors, as it can have a substantial impact on their skills development and confidence in interpreting CT scans, especially in critical situations like emergencies. Additionally, the modest improvements in senior doctors underscore the need for continuous education for all healthcare professionals, regardless of experience, to maintain diagnostic accuracy and competence in their field.

7.5 Current Applications

Neuro emergencies require rapid and accurate diagnosis to prevent severe consequences. Essential to effective management is a solid understanding of neuroanatomy and the ability to evaluate and interpret CT scans, particularly for detecting acute intracranial conditions like haemorrhages, strokes, and skull fractures.

Our study revealed a modest improvement following targeted training, from 69.3% before training to 72.9% afterwards. Although this increase suggests the benefit of

continued education, it also highlights challenges such as the misdiagnosis of abnormal results as normal, possibly due to an over-reliance on training without sufficient hands-on application.

To overcome these challenges, the study advocates for continuous, structured in-service training focused on key neuroimaging skills, including mastering neuroanatomy, understanding common pathologies, following CT imaging protocols, and utilising diagnostic algorithms. Collaboration with multidisciplinary teams and incorporating effective feedback mechanisms are also crucial for refining diagnostic skills. Regular assessments and updates in training content will ensure that clinicians remain current with the latest neuroimaging knowledge, thereby improving diagnostic accuracy and patient outcomes in neuro emergencies. This approach underscores the broader importance of ongoing professional development, which can enhance diagnostic accuracy at any stage of a clinician's career.

8. Conclusion

Neurologic emergencies are frequently assessed in the emergency department with computed tomography of the brain. Junior doctors need to develop skills and confidence in CTB imaging interpretations, as they are more likely to work in primary and secondary hospitals without radiologist cover after hours. Several studies have assessed the accuracy rates of junior medical doctors in CT scan interpretation, with considerably varied findings.

Our study emphasises that targeted training in interpreting CT brain scans can improve diagnostic accuracy across various clinician groups. The most substantial improvements were seen in community service medical officers and those with less than one year of clinical practice, though even more experienced doctors benefited from the training, just to a lesser degree. This highlights that continuous medical education is valuable for all doctors, regardless of their experience level, particularly in high-pressure areas like emergency CT interpretation. The findings suggest that focused training can lead to meaningful improvements, supporting the need for lifelong learning in the medical field.

9. Recommendations

To improve early and accurate detection of neurological emergencies through imaging, it is recommended that structured radiology rotations be incorporated into the clinical schedules of junior doctors, including student interns (6th year medical students), medical interns and community service doctors. These rotations will provide hands-on exposure to neuroimaging modalities such as CT and MRI, fostering essential interpretive skills and clinical judgement.

Additionally, the implementation of ongoing in-service training for all clinicians involved in patient care is crucial. Regular workshops, case-based discussions, and multidisciplinary meetings led by radiologists and neurologists should be instituted to reinforce knowledge of imaging indications, interpretation of common neuroimaging findings, and appropriate referral protocols.

10. Research Integrity and Acknowledgements

10.1 Authors contributions

The research was conducted by RMG, GM and BHM, who jointly created and designed the study. RMG was tasked with the literature review and article production. Cases used in the study were collected by RMG and moderated by RLT and PT. GM and BHM were responsible for the revision and overview of the article.

10.2 Acknowledgement

Supervisors Dr G Mndebele and Dr BH Mojapelo are acknowledged for their exceptional guidance, patience, and support throughout this research.

Case moderators Dr P. Tshalibe and Dr RL Tshivhase: Their expertise and commitment to ethical standards were invaluable in guiding this study.

10.3 Interests

The authors affirm that they have no personal relationships or financial gains that could have inappropriately influenced their decision to write this article.

10.4 Funding information

This study was executed autonomously and was entirely self-financed. No financial assistance was obtained from commercial enterprises, state institutions, or non-governmental organisations.

10.5 Data availability

To facilitate additional research or evaluation, the raw data were recorded in an Excel file and are available for access upon request.

10.6 Disclaimers

The perspectives and assertions articulated in this paper are exclusively those of the writers and are founded on their autonomous professional inquiry. These viewpoints do not inherently represent the official policy, attitude, or position of any associated institution, agency, or publication. The writers assume all accountability for the accuracy, results, conclusions, and material included in the work. Any findings or suggestions presented are solely those of the authors and do not signify support or concurrence by any external groups or agencies.

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12. Appendices

Appendix A: Ethics Approval

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Dr RM Goloto

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M240237

NAME: (Principal Investigators)	Dr RM Goloto DEGREE: M Med (Diag Rad)
DEPARTMENT:	School of Clinical Medicine Department of Radiation Sciences Division of Diagnostic Radiology Faculty of Health Sciences
TITLE:	*Ekurhuleni junior doctors' accuracy rate in neuro emergency CTB interpretation*
DATE CONSIDERED:	1 March 2024
DECISION:	Approved unconditionally
CONDITIONS:	This approval applies only to the study sites listed in Annex 1 attached. Further sites may be added on presentation of evidence of management approval to the HREC (Med)
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office <Nicoleen.Potgieter@wits.ac.za>
SUPERVISORS:	Dra G Ndebele and HB Mojapelo
APPROVED BY:	Professor P Ruff, Chairperson, HREC (Medical)
DATE OF APPROVAL: 2 July 2024	EXPIRY DATE: 1 July 2029

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and ONE COPY returned to the Research Office secretariat on the 3rd floor, Philip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. I agree to submit a yearly progress report in the format available at https://wits.ac.za/research/researcher-support/research-ethics/ethics-committees/. This report is due annually, for the duration of the Clearance Certificate, beginning on the first anniversary of Date of Approval above. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator Date

Annex 1

Protocol No. M240237 Dr RM Goloto

Study title: *Ekurhuleni junior doctors' accuracy rate in neuro emergency CTB interpretation*

Study sites approved under this Clearance Certificate

Study site	Date of HREC (Med) Approval
1. Pholosong Regional Hospital	2024/08/19
2. Thelle Mogoerane Hospital	2024/07/02

Professor P Ruff
Chairperson: HREC (Medical)
University of the Witwatersrand, Johannesburg

Date: 2024/08/19

Appendix B: Permission to conduct research at Far East Rand Hospital

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

FAR EAST RAND HOSPITAL
OFFICE OF THE: ACTING CHIEF EXECUTIVE OFFICER

Far East Rand Hospital
Private Bag x 50
SPRINGS
1560

Enquiries: Dr M. S. Maphobela
Telephone: (011)812-8644
Fax: (011)813-1411
Cell: 078 511 6914
E-mail: Moloko.Maphobela@gauteng.gov.za

PERMISSION TO CONDUCT RESEARCH

TITLE OF PROJECT: Ekurhuleni junior doctors' accuracy rate in neuro emergency CTB interpretation

UNIVERSITY: UNIVERSITY OF THE WITWATERSRAND

Principal Investigator: DR. R.M. GOLOLO

Reference: GP-202311

Institution: Far East Rand Hospital

The CEO/Clinical Manager recommends that the said research be conducted at Far East Rand Hospital. The CEO/Clinical Manager of Far East Rand Hospital is accordingly informed and the study is subject to:-

- Permission having granted by the CEO/ Clinical Manager.
- The hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital.
- The research will not impose additional workload on our staff.
- The CEO/Clinical Manager will be informed of any serious adverse events as soon as they occur.
- Permission is granted for the duration of the Ethics Committee approval as well as Gauteng Department of Health Research Committee approval.
- The researcher will provide hospital management with feedback every six months and at the end of the study.

.....
Approved/Not Approved
Hospital Acting CEO

Date: 31/7/2024

Appendix C: Permission to conduct research at Pholosong Hospital

'24/7/26

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

PHOLOSONG HOSPITAL
Enquiries: Dr N Jwara
Clinical Manager
Tel: 011 812 5055
Email- Nonjabulo.Jwara@gauteng.gov.za

TO : **DR RM GOLOLO**

FROM : **DR N JWARA - CLINICAL MANAGER**

SUBJECT : **RESEARCH PROTOCOL APPROVAL**

DATE : **26 JULY 2024**

RE: *Research Protocol Approval* – "Ekurhuleni District Junior Doctors' Accuracy Rate in Neuro-Emergency CTB Interpretation."

Researcher: *Dr. RM Gololo*

This is to formally inform you that your research titled, "Ekurhuleni District Junior Doctors' Accuracy Rate in Neuro-Emergency CTB Interpretation" at Pholosong Hospital, has been approved with the condition that the institution will not provide assistance with retrieving patient files for data collection.

All data collected remains the property of Pholosong Regional Hospital.

Regards,

Dr. N Jwara
Clinical Manager
Pholosong Regional Hospital
26 July 2024

Appendix D: Permission to conduct research at Thelle Mogoerane Regional Hospital

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Enquiries: T. Mabizela Clinical Coordinator
Directorate: Staff Development
Telephone number: (011) 590 0109
Email: Thandiwe. Mabizela @gauteng.gov.za

Date 08 November 2023

Dr Gololo

Thelle Mogoerane Regional Hospital Management Team is pleased to grant you provisional permission to **utilize the TMRH patients computed tomography (CT) brain images from the CT images database for research purpose.** data will be conducted through obtaining information through **"Prospective data collection"** in your protocol for which you will obtain the ethics clearance certificate from University of Pretoria for Full permission to be granted.

The following condition must be adhered to otherwise permission will be withdrawn:

- Only the research and/or research methods outlined in the protocol presented to the Research Committee should be conducted and/or followed otherwise the research will be cancelled.
- Once the research is finalized the results and recommendation of the research should be submitted to Clinical Education and Training Unit

Please note that you can only get full clearance once you provide the hospital with the Ethics Clearance Certificate

Dr C. Ndobe
Acting Chief Executive Officer
Thelle Mogoerane Regional Hospital
Date: ..6..11..2023.....

To be the best provider of quality health care services to the people of Gauteng"

Appendix E: Information Sheet

Title of the study

Ekurhuleni District Junior Doctors' Accuracy Rate in Neuro-Emergency CTB

Interpretation.

Good day!

Introduction

I am Dr Ramatsemela Gololo. I am registered for an MMed degree in Diagnostic Radiology at the University of the Witwatersrand. One of the requirements of this qualification is to complete a research study. The title of my study is shown above.

Aim of Study

This research aims to assess the accuracy of emergency Computed Tomography of the Brain (CTB) interpretation by determining the accuracy rate of junior doctors working in Emergency Departments (EDS) at selected Ekurhuleni District Hospitals. I would like to invite you to participate in my research study. Participation is entirely voluntary; there is no consequence to refusing to participate. Those willing to participate will be asked to complete a Consent Form.

Procedures

In this study, the researcher will conduct a quantitative cross-sectional descriptive study.

Data will be collected in two stages:

1) Stage 1: Pre-training data collection.

Before the training, the questionnaire will be distributed to the participants for completion. Completion will be anonymous. Participants will assemble at a pre-agreed time in a room at your hospital (I am conducting this study at 5 hospital sites). I will show the group several CTB images on PowerPoint, which participants will be asked

to interpret using the questionnaire. The questionnaire consists of a set of single best answers (SBA) for multiple CTB images of various commonly encountered neuro emergencies. This is expected to take about 20 minutes.

2) Stage 2: Explanatory talk

On the completion of Stage 1, I will deliver a talk on how best to interpret CTB images. This will take place in the same venue and will last around 40 minutes.

3) Post-course data collection.

After the training, I will provide the same participants with another set of SBA questions for post-training analysis. Again, this will be an anonymous exercise, lasting about 20 minutes and in the same venue.

After the tests, I will compare the aggregate scores, before and after my talk, to assess whether and, if so, to what extent, there has been an improvement in the interpretive skills of the junior doctors.

Any participant who requests it can receive a results summary, free of charge.

Benefits

The study will assist in

- Determining the accuracy rate in detecting neuro-emergency-relevant CTB findings by junior emergency department doctors.
- Comparing the accuracy rates of community service doctors, junior medical officers, and first- and second-year medical interns.
- Determining the most frequently missed/ identifiable pertinent findings in CTB interpretation in neuro-emergency cases.
- Assessing the impact of a one-time PowerPoint course on junior doctors' ability to detect relevant CTB neuro-emergency findings. This will assist management in deciding whether upskilling is required and, if so, what the best method of achieving this might be.
-

Risk

No identifiable risks were involved in the study. Images used for training and data collection will be de-identified. Information and identity of the participants will be kept strictly confidential.

Compensation

There is no external funding for this study; therefore, there will be no compensation to the research participants. There will, however, be no cost to the participants either.

Contact information

If any further information is required at any time, please contact:

Dr RM Gololo (Principal Investigator) on tel. No. 081 341 4799, or by e-mail at drramatsemela@gmail.com

Or

Dr G Mndebele (Supervisor) on tel. No. 060 343 3552, or by e-mail on Gopolang.Ndebele@icloud.com

Or

Dr B H Mojapelo (Supervisor) on Tel 083 896 7849 or by email besley.mojapelo@gmail.com

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concerns over the way the study is being conducted, please contact the Chairperson of this Committee, Professor Paul Ruff, who may be contacted via any one member of the secretariat. The telephone numbers for the Committee secretariat are 011 717 2700/1234/2656/1252, and the e-mail addresses are

Zanele.Ndlovu@wits.ac.za, Rhulani.Mukansi@wits.ac.za, Mapula.Ramaila@wits.ac.za and Iain.Burns@wits.ac.za.

Thank you for reading this Study Information Sheet.

July 2024

Appendix F: Participant consent sheet

WITS UNIVERSITY

PARTICIPANT CONSENT SHEET

Project Title: *Ekurhuleni District Junior Doctors' Accuracy Rate in Neuro-Emergency CTB Interpretation*.

1. I have been given a Participant Information Sheet, which explains the nature and processes involved in this study, which is attached hereto.
2. I was given time to read it or had it read to me, in the language I best understand.
3. I was given time to ask any questions I wanted to, and found any answers given to me to be reasonable and satisfactory.
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be.
5. I understand that there will be no immediate benefit to me should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.

6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study, I am free to speak to any of these contacts.

Contact details:

Dr Ramatsemela Gololo, Principal Investigator, telephone no. 0813414799, or by e-mail address drramatsemela@gmail.com,

Dr Gopolang Mndebele, Supervisor, on telephone no. 060 343 3552, or by e-mail at Gopolang.Ndebele@icloud.com
Or
Dr B H Mojapelo (Supervisor) on telephone no. 083 896 7849 or by email, besley.mojapelo@gmail.com

Professor P Ruff, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, may be contacted via any one member of the secretariat. The telephone numbers for the Committee secretariat are 011 717 2700/1234/2656/1252, and the e-mail addresses are Zanele.Ndlovu@wits.ac.za, Rhulani.Mukansi@wits.ac.za, Mapula.Ramaila@wits.ac.za and Iain.Burns@wits.ac.za.

Name of Participant: _____

Date: _____

Place: _____

Signature or mark _____

Witnessed by:

Name of Witness: _____

Signature: _____

Date: _____

Appendix G: Pre-training answer sheet

Neuro-emergency Cases Tick Sheet

Demographics

Age	<30yrs	30-35 years	35-40 years	>40years
Gender	Male	Female		

Experiences and radiology interests.

		Experience			
			Tick		**Tick**
Medical Intern		First-year		Second year	
Medical Officer		Grade 1		Grade 2	
Other		**Specify….**			
Would you consider radiology as your future speciality of choice?				**Yes**	**No**
Any experience working in the Radiology Department? If yes, specify the number of years.				**Yes**	**No**
Year completed a medical degree.					
Years of experience as a doctor					

Answer sheet A

	Answers 1-5			
Questions 1-5 **Identify Pertinent Findings.**	**Tick one**		**Tick the correct diagnosis.** **Multiple answers may be correct.**	
Image 1	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 2	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 3	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 4	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 5	Normal			
			Skull fracture	

	Abnormal		Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	

Answer sheet B

	Answers 6-10			
Questions 6-10 **Identify Pertinent Findings.**	**Tick one**		**Tick correct diagnosis** **Multiple answers may be correct.**	
Image 6	Normal			
	Abnormal		Subarachnoid haemorrhages	
			Intraparenchymal haemorrhages	
			Epidural haemorrhage	
			Subdural haemorrhage	
			Basal meningeal enhancement	
			Herniation syndrome	
Image 7	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 8	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 9	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	

			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 10	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	

Answer sheet C

	Answers 11-15			
Questions 11-15 **Identify Pertinent Findings.**	**Tick one**		**Tick the correct diagnosis** **Multiple answers may be correct.**	
Image 11	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 12	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 13	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	

			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 14	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 15	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	

Answer sheet D

	Answers 16-20			
Questions 16-20 **Identify Pertinent Findings.**	**Tick one**		**Tick the correct diagnosis** **Multiple answers may be correct.**	
Image 16	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	

Image 17	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 18	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 19	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 20	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	

APPENDIX H: Post-training answer sheet

Neuro-emergency Cases Tick Sheet

Demographics

Age	<30yrs	30-35 years	35-40 years	>40years
Gender	Male	Female		

Experiences and radiology interests.

	Experience				
		Tick		**Tick**	
Medical Intern	First-year		Second year		
Medical Officer	Grade 1		Grade 2		
Other		**Specify….**			
Would you consider radiology as your future speciality of choice?				**Yes**	**No**
Any experience working in the Radiology Department? If yes specify the number of years.				**Yes**	**No**
Year completed a medical degree.					
Years of experience as a doctor					

Answer sheet A

	Answers 1-5		
Questions 1-5 **Identify Pertinent Findings.**	**Tick one**	**Tick the correct diagnosis** **Multiple answers may be correct.**	

Image 1	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 2	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 3	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 4	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 5	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	

Answer sheet B

	Answers 6-10			
Questions 6-10 **Identify Pertinent Findings.**	**Tick one**		**Tick the correct diagnosis** **Multiple answers may be correct.**	
Image 6	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 7	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 8	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 9	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	

			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 10	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	

Answer sheet C

	Answers 11-15			
Questions 11-15 **Identify Pertinent Findings.**	**Tick one**		**Tick the correct diagnosis** **Multiple answers may be correct.**	
Image 11	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image12	Normal			

	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 13	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 14	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	
Image 15	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	

Answer sheet D

	Answers 16-20			
Questions 16-20 **Identify Pertinent Findings.**	**Tick one**		**Tick the correct diagnosis** **Multiple answers may be correct**	
Image 16	Normal			
	Abnormal		Subarachnoid haemorrhages	
			Intraparenchymal haemorrhages	
			Epidural haemorrhage	

			Subdural haemorrhage	
			Basal meningeal enhancement	
			Herniation syndrome	
Image 17	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 18	Normal			
	Abnormal		Meningitis	
			Space-occupying lesion	
			CVA	
			White cerebellar sign.	
			Cerebral oedema	
			Hydrocephalus.	
Image 19	Normal			
	Abnormal		Skull fracture	
			Simple Pneumocephalus	
			Tension pneumocephalus	
			Pneumo-ventricle	
			Diffused axonal injuries	
			Countre-coup haemorrhages	
Image 20	Normal			
	Abnormal		Intraparenchymal abscess	
			Dural venous thrombosis.	
			Abnormal meningeal enhancement.	
			Herniation syndrome	
			Pseudo subarachnoid haemorrhages	
			Subarachnoid haemorrhages	

Appendix I: Results

Appendix I-1 Demographics

Age in years		
	N	%
<30 years	50	84,7%
30-45 years	9	15,3%
Total	59	100,0%

Gender		
	N	%
Male	18	30,5%
Female	41	69,5%
Total	59	100,0%

Post		
	N	%
Medical Intern	44	74,6%
Medical Officer	12	20,3%
Community Service MO	3	5,1%
Total	59	100,0%

Grade/year		
	N	%
1st year MI	31	52,5%
2nd year MI	13	22,0%
Grade 1 MO	10	16,9%
Grade 2 MO	2	3,4%
CMO	3	5,1%
Total	59	100,0%

Interested in radiology		
	N	%
Interested	21	35,6%
Not interested	38	64,4%
Total	59	100,0%

Experience in radiology		
	N	%
Experienced	1	1,7%
Not experienced	58	98,3%
Total	59	100,0%

Years of experience as a doctor		
	N	%
≤1 year	35	59,3%
≥2 years	24	40,7%
Total	59	100,0%

Appendix I-2 Accuracy - images

Pre-Training

Pre_Image1_Normal or Abnormal

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Pre_Image1_Skull fracture

	N	%
Incorrect	16	27,1
Correct	43	72,9
Total	59	100,0

Pre_Image1_Simple Pneumocephalus

	N	%
Incorrect	32	54,2

Correct	27	45,8
Total	59	100,0

Pre_Image1_Tension pneumocephalus

	N	%
Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Pre_Image1_Pneumo-ventricle

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image1_Diffused axonal injuries

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image1_Countre-coup haemorrhages

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image2_Normal or Abnormal

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Pre_Image2_Meningitis

	N	%
Incorrect	48	81,4
Correct	11	18,6
Total	59	100,0

Pre_Image2_Space-occupying lesion

		N	%
	Incorrect	5	8,5
	Correct	54	91,5
	Total	59	100,0

Pre_Image2_CVA

		N	%
	Incorrect	3	5,2
	Correct	55	94,8
	Total	58	100,0

Pre_Image2_White cerebellar sign

		N	%
	Incorrect	3	5,1
	Correct	56	94,9
	Total	59	100,0

Pre_Image2_Cerebral oedema

		N	%
	Incorrect	42	71,2

Correct	17	28,8
Total	59	100,0

Pre_Image2_Hydrocephalus

	N	%
Incorrect	35	59,3
Correct	24	40,7
Total	59	100,0

Pre_Image3_Normal or abnormal

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Pre_Image3_Skull fracture

	N	%
Incorrect	48	82,8
Correct	10	17,2
Total	58	100,0

Pre_Image3_Simple Pneumocephalus

	N	%
Incorrect	37	63,8
Correct	21	36,2
Total	58	100,0

Pre_Image3_Tension pneumocephalus

	N	%
Incorrect	12	20,7
Correct	46	79,3
Total	58	100,0

Pre_Image3_Pneumo-ventricle

	N	%
Incorrect	3	5,2
Correct	55	94,8
Total	58	100,0

Pre_Image3_Diffused axonal injuries

		N	%
	Incorrect	2	3,4
	Correct	56	96,6
	Total	58	100,0

Pre_Image3_Countre-coup haemorrhages

		N	%
	Incorrect	4	6,9
	Correct	54	93,1
	Total	58	100,0

Pre_Image4_Normal or abnormal

		N	%
	Incorrect	1	1,7
	Correct	58	98,3
	Total	59	100,0

Pre_Image4_Intraparenchymal abscess

		N	%
	Incorrect	38	64,4

Correct	21	35,6
Total	59	100,0

Pre_Image4_Dural venous thrombosis

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Pre_Image4_Abnormal meningeal enhancement

	N	%
Incorrect	12	20,3
Correct	47	79,7
Total	59	100,0

Pre_Image4_Herniation syndrome

	N	%
Incorrect	42	71,2
Correct	17	28,8
Total	59	100,0

Pre_Image4_Pseudo subarachnoid hemorrhage

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Pre_Image4_Ssubarachnoid hemorrhage

	N	%
Incorrect	7	11,9
Correct	52	88,1
Total	59	100,0

Pre_Image5_Normal or Abnormal

	N	%
Correct	59	100,0

Pre_Image5_Skull fracture

	N	%
Incorrect	45	76,3

Correct	14	23,7
Total	59	100,0

Pre_Image5_Simple Pneumocephalus

	N	%
Incorrect	44	74,6
Correct	15	25,4
Total	59	100,0

Pre_Image5_Tension pneumocephalus

	N	%
Incorrect	9	15,3
Correct	50	84,7
Total	59	100,0

Pre_Image5_Pneumo-ventricle

	N	%
Incorrect	5	8,8
Correct	52	91,2
Total	57	100,0

Pre_Image5_Diffused axonal injuries

	N	%
Incorrect	48	82,8
Correct	10	17,2
Total	58	100,0

Pre_Image5_Countre-coup haemorrhages

	N	%
Incorrect	35	60,3
Correct	23	39,7
Total	58	100,0

Pre_Image6_Normal or abnormal

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image6_Subarachnoid hemorrhages

		N	%
	Incorrect	56	94,9
	Correct	3	5,1
	Total	59	100,0

Pre_Image6_Intraparenchymal haemorrhages

		N	%
	Incorrect	22	37,3
	Correct	37	62,7
	Total	59	100,0

Pre_Image6_Epidural hemorrhage

		N	%
	Incorrect	5	8,5
	Correct	54	91,5
	Total	59	100,0

Pre_Image6_Subdural hemorrhage

		N	%
	Incorrect	4	6,8

Correct	55	93,2
Total	59	100,0

Pre_Image6_Basal meningeal enhancement

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Pre_Image6_Herniation syndrome

	N	%
Incorrect	35	59,3
Correct	24	40,7
Total	59	100,0

Pre_Image7_Normal or abnormal

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Pre_Image7_Skull fracture

	N	%
Incorrect	41	69,5
Correct	18	30,5
Total	59	100,0

Pre_Image7_Simple Pneumocephalus

	N	%
Incorrect	45	76,3
Correct	14	23,7
Total	59	100,0

Pre_Image7_Tension pneumocephalus

	N	%
Incorrect	15	25,4
Correct	44	74,6
Total	59	100,0

Pre_Image7_Pneumo-ventricle

		N	%
	Incorrect	7	11,9
	Correct	52	88,1
	Total	59	100,0

Pre_Image7_Diffused axonal injuries

		N	%
	Incorrect	55	93,2
	Correct	4	6,8
	Total	59	100,0

Pre_Image7_Countre-coup haemorrhages

		N	%
	Incorrect	4	6,8
	Correct	55	93,2
	Total	59	100,0

Pre_Image8_Normal or abnormal

		N	%
	Incorrect	2	3,4

	Correct	57	96,6
	Total	59	100,0

Pre_Image8_Meningitis

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Pre_Image8_Space-occupying lesion

	N	%
Incorrect	16	27,1
Correct	43	72,9
Total	59	100,0

Pre_Image8_CVA

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Pre_Image8_White cerebellar sign

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image8_Cerebral oedema

	N	%
Incorrect	53	89,8
Correct	6	10,2
Total	59	100,0

Pre_Image8_Hydrocephalus

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Pre_Image9_Normal or abnormal

		N	%
	Incorrect	10	17,2
	Correct	48	82,8
	Total	58	100,0

Pre_Image9_Skull fracture

		N	%
	Incorrect	4	6,9
	Correct	54	93,1
	Total	58	100,0

Pre_Image9_Simple Pneumocephalus

		N	%
	Incorrect	10	17,2
	Correct	48	82,8
	Total	58	100,0

Pre_Image9_Tension pneumocephalus

		N	%
	Incorrect	14	24,1

Correct	44	75,9
Total	58	100,0

Pre_Image9_Pneumo-ventricle

	N	%
Incorrect	1	1,7
Correct	57	98,3
Total	58	100,0

Pre_Image9_Diffused axonal injuries

	N	%
Incorrect	46	79,3
Correct	12	20,7
Total	58	100,0

Pre_Image9_Countre-coup haemorrhages

	N	%
Incorrect	12	20,3
Correct	47	79,7
Total	59	100,0

Pre_Image10_Normal or abnormal

	N	%
Correct	59	100,0

Pre_Image10_Intraparenchymal abscess

	N	%
Incorrect	11	18,6
Correct	48	81,4
Total	59	100,0

Pre_Image10_Dural venous thrombosis

	N	%
Incorrect	9	15,3
Correct	50	84,7
Total	59	100,0

Pre_Image10_Abnormal meningeal enhancement

	N	%
Incorrect	12	20,3

	Correct	47	79,7
	Total	59	100,0

Pre_Image10_Herniation syndrome

		N	%
	Incorrect	4	6,8
	Correct	55	93,2
	Total	59	100,0

Pre_Image10_Pseudo subarachnoid hemorrhage

		N	%
	Incorrect	12	20,3
	Correct	47	79,7
	Total	59	100,0

Pre_Image10_Subarachnoid hemorrhage

		N	%
	Incorrect	42	71,2
	Correct	17	28,8
	Total	59	100,0

Pre_Image11_Normal or abnormal

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image11_Intraparenchymal abscess

	N	%
Incorrect	43	72,9
Correct	16	27,1
Total	59	100,0

Pre_Image11_Dural venous thrombosis

	N	%
Incorrect	49	83,1
Correct	10	16,9
Total	59	100,0

Pre_Image11_Abnormal meningeal enhancement

		N	%
	Incorrect	47	79,7
	Correct	12	20,3
	Total	59	100,0

Pre_Image11_Herniation syndrome

		N	%
	Incorrect	6	10,2
	Correct	53	89,8
	Total	59	100,0

Pre_Image11_Pseudo subarachnoid hemorrhage

		N	%
	Incorrect	5	8,5
	Correct	54	91,5
	Total	59	100,0

Pre_Image11_Subarachnoid hemorrhage

		N	%
	Incorrect	11	18,6

Correct	48	81,4
Total	59	100,0

Pre_Image12_Normal or abnormal

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Pre_Image12_Meningitis

	N	%
Incorrect	6	10,2
Correct	53	89,8
Total	59	100,0

Pre_Image12_Space-occupying lesion

	N	%
Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Pre_Image12_CVA

	N	%
Incorrect	54	91,5
Correct	5	8,5
Total	59	100,0

Pre_Image12_White cerebellar sign

	N	%
Incorrect	17	28,8
Correct	42	71,2
Total	59	100,0

Pre_Image12_Cerebral oedema

	N	%
Incorrect	36	61,0
Correct	23	39,0
Total	59	100,0

Pre_Image12_Hydrocephalus

		N	%
	Incorrect	4	6,8
	Correct	55	93,2
	Total	59	100,0

Pre_Image13_Normal or abnormal

		N	%
	Incorrect	1	1,7
	Correct	58	98,3
	Total	59	100,0

Pre_Image13_Intraparenchymal abscess

		N	%
	Incorrect	34	57,6
	Correct	25	42,4
	Total	59	100,0

Pre_Image13_Dural venous thrombosis

		N	%
	Incorrect	7	11,9

Correct	52	88,1
Total	59	100,0

Pre_Image13_Abnormal meningeal enhancement

	N	%
Incorrect	9	15,3
Correct	50	84,7
Total	59	100,0

Pre_Image13_Herniation syndrome

	N	%
Incorrect	53	89,8
Correct	6	10,2
Total	59	100,0

Pre_Image13_Pseudo subarachnoid hemorrhage

	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

Pre_Image13_Subarachnoid hemorrhage

	N	%
Incorrect	10	16,9
Correct	49	83,1
Total	59	100,0

Pre_Image14_Normal or abnormal

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Pre_Image14_Meningitis

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Pre_Image14_Space-occupying lesion

		N	%
	Incorrect	47	79,7
	Correct	12	20,3
	Total	59	100,0

Pre_Image14_CVA

		N	%
	Incorrect	3	5,1
	Correct	56	94,9
	Total	59	100,0

Pre_Image14_White cerebellar sign

		N	%
	Incorrect	12	20,3
	Correct	47	79,7
	Total	59	100,0

Pre_Image14_Cerebral oedema

		N	%
	Incorrect	22	37,3

	Correct	37	62,7
	Total	59	100,0

Pre_Image14_Hydrocephalus

		N	%
	Incorrect	4	8,5
	Correct	54	91,5
	Total	59	100,0

Pre_Image15_Normal or abnormal

		N	%
	Correct	59	100,0

Pre_Image15_Intraparenchymal abscess

		N	%
	Incorrect	50	84,7
	Correct	9	15,3
	Total	59	100,0

Pre_Image15_Dural venous thrombosis

		N	%
	Incorrect	4	6,8
	Correct	55	93,2
	Total	59	100,0

Pre_Image15_Abnormal meningeal enhancement

		N	%
	Incorrect	5	8,5
	Correct	54	91,5
	Total	59	100,0

Pre_Image15_Herniation syndrome

		N	%
	Incorrect	32	54,2
	Correct	27	45,8
	Total	59	100,0

Pre_Image15_Pseudo subarachnoid hemorrhage

		N	%
	Incorrect	4	6,8

Correct	55	93,2
Total	59	100,0

Pre_Image15_Subarachnoid hemorrhage

	N	%
Incorrect	16	27,1
Correct	43	72,9
Total	59	100,0

Pre_Image16_Normal or abnormal

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Pre_Image16_Meningitis

	N	%
Incorrect	9	15,3
Correct	50	84,7
Total	59	100,0

Pre_Image16_Space-occupying lesion

	N	%
Incorrect	44	74,6
Correct	15	25,4
Total	59	100,0

Pre_Image16_CVA

	N	%
Incorrect	15	25,4
Correct	44	74,6
Total	59	100,0

Pre_Image16_White cerebellar sign

	N	%
Incorrect	10	16,9
Correct	49	83,1
Total	59	100,0

Pre_Image16_Cerebral oedema

		N	%
	Incorrect	46	78,0
	Correct	13	22,0
	Total	59	100,0

Pre_Image16_Hydrocephalus

		N	%
	Incorrect	1	1,7
	Correct	58	98,3
	Total	59	100,0

Pre_Image17_Normal or abnormal

		N	%
	Incorrect	4	8,5
	Correct	54	91,5
	Total	59	100,0

Pre_Image17_Skull fracture

		N	%
	Incorrect	46	79,3

Correct	12	20,7
Total	58	100,0

Pre_Image17_Simple pneumocephalus

	N	%
Incorrect	41	70,7
Correct	17	29,3
Total	58	100,0

Pre_Image17_Tension pneumocephalus

	N	%
Incorrect	4	6,9
Correct	54	93,1
Total	58	100,0

Pre_Image17_Pneumo-ventricle

	N	%
Incorrect	3	5,2
Correct	55	94,8
Total	58	100,0

Pre_Image17_Diffused axonal injuries

	N	%
Incorrect	40	69,0
Correct	18	31,0
Total	58	100,0

Pre_Image17_Countre-coup haemorrhages

	N	%
Incorrect	9	15,5
Correct	49	84,5
Total	58	100,0

Pre_Image18_Normal or abnormal

	N	%
Correct	59	100,0

Pre_Image18_Intraparenchymal abscess

	N	%
Incorrect	27	45,8

Correct	32	54,2
Total	59	100,0

Pre_Image18_Dural venous thrombosis

	N	%
Incorrect	10	16,9
Correct	49	83,1
Total	59	100,0

Pre_Image18_Abnormal meningeal enhancement

	N	%
Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Pre_Image18_Herniation syndrome

	N	%
Incorrect	57	96,6
Correct	2	3,4
Total	59	100,0

Pre_Image18_Pseudosubarachnoid hemorrhage

	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

Pre_Image18_Subarachnoid hemorrhage

	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

Pre_Image19_Normal or abnormal

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Pre_Image19_Meningitis

		N	%
	Incorrect	11	19,0
	Correct	47	81,0
	Total	58	100,0

Pre_Image19_Space-occupying lesion

		N	%
	Incorrect	5	8,6
	Correct	53	91,4
	Total	58	100,0

Pre_Image19_CVA

		N	%
	Incorrect	8	13,8
	Correct	50	86,2
	Total	58	100,0

Pre_Image19_White cerebellar sign

		N	%
	Incorrect	48	82,8

Correct	10	17,2
Total	58	100,0

Pre_Image19_Cerebral oedema

	N	%
Incorrect	38	65,5
Correct	20	34,5
Total	58	100,0

Pre_Image19_Hydrocephalus

	N	%
Incorrect	4	6,9
Correct	54	93,1
Total	58	100,0

Pre_Image20_Normal or abnormal

	N	%
Correct	59	100,0

Pre_Image20_Skull fracture

		N	%
	Incorrect	54	91,5
	Correct	5	8,5
	Total	59	100,0

Pre_Image20_Simple Pneumocephalus

		N	%
	Incorrect	39	66,1
	Correct	20	33,9
	Total	59	100,0

Pre_Image20_Tension pneumocephalus

		N	%
	Incorrect	16	27,1
	Correct	43	72,9
	Total	59	100,0

Pre_Image20_Pneumo-ventricle

		N	%
	Incorrect	50	84,7

Correct	9	15,3
Total	59	100,0

Pre_Image20_Diffused axonal injuries

	N	%
Incorrect	46	78,0
Correct	13	22,0
Total	59	100,0

Pre_Image20_Countre-coup haemorrhages

	N	%
Incorrect	12	20,3
Correct	47	79,7
Total	59	100,0

Post_Image1_Normal or Abnormal

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Post-Training

Post_Image1_Intraparechymal abscess

	N	%
Incorrect	18	30,5
Correct	41	69,5
Total	59	100,0

Post_Image1_Dural venous thrombosis

	N	%
Incorrect	52	88,1
Correct	7	11,9
Total	59	100,0

Post_Image1_Abnormal menigeal enhancement

	N	%
Incorrect	46	78,0
Correct	13	22,0
Total	59	100,0

Post_Image1_Herniation syndrome

	N	%
Incorrect	49	83,1
Correct	10	16,9
Total	59	100,0

Post_Image1_Pseudo subarachnoid haemorrhages

	N	%
Incorrect	9	15,3
Correct	50	84,7
Total	59	100,0

Post_Image1_Subarachnoid haemorrhages

	N	%
Incorrect	6	10,2
Correct	53	89,8
Total	59	100,0

Post_Image2_Normal or Abnormal

	N	%

Incorrect	3	5,2
Correct	55	94,8
Total	58	100,0

Post_Image2_Meningitis

	N	%
Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Post_Image2_Space-occupying lesion

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Post_Image2_CVA

	N	%
Incorrect	34	57,6
Correct	25	42,4

Total	59	100,0

Post_Image2_White cerebellar sign

	N	%
Incorrect	15	25,4
Correct	44	74,6
Total	59	100,0

Post_Image2_Cerebral oedema

	N	%
Incorrect	45	76,3
Correct	14	23,7
Total	59	100,0

Post_Image2_Hydrocephalus

	N	%
Incorrect	6	10,2
Correct	53	89,8
Total	59	100,0

Post_Image3_Normal or abnormal

	N	%
Correct	55	100,0

Post_Image3_Intraparenchymal abscess

	N	%
Incorrect	27	45,8
Correct	32	54,2
Total	59	100,0

Post_Image3_Dural venous thrombosis

	N	%
Incorrect	53	89,8
Correct	6	10,2
Total	59	100,0

Post_Image3_Abnormal meningeal enhancement

	N	%
Incorrect	1	1,7
Correct	58	98,3

	Total	59	100,0

Post_Image3_Herniation syndrome

	N	%
Incorrect	43	72,9
Correct	16	27,1
Total	59	100,0

Post_Image3_Pseudo subarachnoid haemorrhages

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Post_Image3_Subarachnoid haemorrhages

	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

Post_Image4_Normal or abnormal

	N	%
Incorrect	6	10,2
Correct	53	89,8
Total	59	100,0

Post_Image4_Meningtis

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Post_Image4_Space-occupying lesion

	N	%
Incorrect	34	57,6
Correct	25	42,4
Total	59	100,0

Post_Image4_CVA

	N	%

Incorrect	6	10,2
Correct	53	89,8
Total	59	100,0

Post_Image4_White cerebellar sign

	N	%
Incorrect	10	16,9
Correct	49	83,1
Total	59	100,0

Post_Image4_Cerebral oedema

	N	%
Incorrect	46	78,0
Correct	13	22,0
Total	59	100,0

Post_Image4_Hydrocephalus

	N	%
Incorrect	3	5,1
Correct	56	94,9

Total	59	100,0

Post_Image5_Normal or Abnormal

	N	%
Correct	59	100,0

Post_Image5_Intraparenchymal abscess

	N	%
Incorrect	37	62,7
Correct	22	37,3
Total	59	100,0

Post_Image5_Dural thrombosis

	N	%
Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Post_Image5_Abnormal meningeal enhancement

	N	%

Incorrect	51	86,4
Correct	8	13,6
Total	59	100,0

Post_Image5_Herniation syndrome

	N	%
Incorrect	26	44,1
Correct	33	55,9
Total	59	100,0

Post_Image5_Pseudo subarachnoid haemorrhages

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Post_Image5_Subarachnoid haemorrhages

	N	%
Incorrect	11	18,6
Correct	48	81,4

Total	59	100,0

Post_Image6_Normal or abnormal

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Post_Image6_Meningitis

	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

Post_Image6_Space-occupying lesion

	N	%
Incorrect	29	49,2
Correct	30	50,8
Total	59	100,0

Post_Image6_CVA

	N	%
Incorrect	16	27,1
Correct	43	72,9
Total	59	100,0

Post_Image6_White cerebellar sign

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Post_Image6_Cerebral oedema

	N	%
Incorrect	49	83,1
Correct	10	16,9
Total	59	100,0

Post_Image6_Hydrocephalus

	N	%

Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Post_Image7_Normal or Abnormal

	N	%
Incorrect	1	1,7
Correct	57	98,3
Total	58	100,0

Post_Image7_Skull fracture

	N	%
Incorrect	52	89,7
Correct	6	10,3
Total	58	100,0

Post_Image7_Simple Pneumocephalus

	N	%
Incorrect	44	75,9
Correct	14	24,1

Total	58	100,0

Post_Image7_Tension pneumocephalus

	N	%
Incorrect	6	10,3
Correct	52	89,7
Total	58	100,0

Post_Image7_Pneumo-ventricle

	N	%
Incorrect	1	1,7
Correct	57	98,3
Total	58	100,0

Post_Image7_Diffused axonal injuries

	N	%
Incorrect	28	48,3
Correct	30	51,7
Total	58	100,0

Post_Image7_Countre-coup haemorrhages

	N	%
Incorrect	21	36,2
Correct	37	63,8
Total	58	100,0

Post_Image8_Normal or abnormal

	N	%
Incorrect	2	3,4
Correct	56	96,6
Total	58	100,0

Post_Image8_Intraparenchymal abscess

	N	%
Incorrect	21	35,6
Correct	38	64,4
Total	59	100,0

Post_Image8_Dural venous thrombosis

	N	%

Incorrect	12	20,3
Correct	47	79,7
Total	59	100,0

Post_Image8_Abnormal meningeal enhancement

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Post_Image8_Herniation syndrome

	N	%
Incorrect	47	79,7
Correct	12	20,3
Total	59	100,0

Post_Image8_Pseudo subarachnoid haemorrhages

	N	%
Incorrect	3	5,1
Correct	56	94,9

Total	59	100,0

Post_Image8_Subarachnoid haemorrhages

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Post_Image9_Normal or abnormal

	N	%
Incorrect	4	7,0
Correct	53	93,0
Total	57	100,0

Post_Image9_Meningitis

	N	%
Incorrect	5	8,6
Correct	53	91,4
Total	58	100,0

Post_Image9_Space-occupying lesion

	N	%
Incorrect	1	1,7
Correct	57	98,3
Total	58	100,0

Post_Image9_CVA

	N	%
Incorrect	7	12,1
Correct	51	87,9
Total	58	100,0

Post_Image9_White cerebelllar sign

	N	%
Incorrect	42	72,4
Correct	16	27,6
Total	58	100,0

Post_Image9_Cerebral oedema

	N	%

Incorrect	31	53,4
Correct	27	46,6
Total	58	100,0

Post_Image9_Hydrocephalus

	N	%
Correct	58	100,0

Post_Image10_Normal or abnormal

	N	%
Correct	58	100,0

Post_Image10_Skull fracture

	N	%
Incorrect	43	74,1
Correct	15	25,9
Total	58	100,0

Post_Image10_Simple Pneumocephalus

	N	%

Correct	58	100,0

Post_Image10_Tension pneumocephalus

	N	%
Incorrect	30	51,7
Correct	28	48,3
Total	58	100,0

Post_Image10_Pneumo-ventricle

	N	%
Incorrect	46	79,3
Correct	12	20,7
Total	58	100,0

Post_Image10_Diffused axonal injuries

	N	%
Incorrect	9	15,5
Correct	49	84,5
Total	58	100,0

Post_Image10_Countre-coup haemorrhages

	N	%
Incorrect	7	12,1
Correct	51	87,9
Total	58	100,0

Post_Image11_Normal or abnormal

	N	%
Incorrect	1	1,8
Correct	56	98,2
Total	57	100,0

Post_Image11_Skull fracture

	N	%
Incorrect	13	22,4
Correct	45	77,6
Total	58	100,0

Post_Image11_Simple Pneumocephalus

	N	%

Incorrect	35	60,3
Correct	23	39,7
Total	58	100,0

Post_Image11_Tension pneumocephalus

	N	%
Incorrect	3	5,2
Correct	55	94,8
Total	58	100,0

Post_Image11_Pnemo-ventricle

	N	%
Correct	58	100,0

Post_Image11_Diffused axonal injuries

	N	%
Incorrect	3	5,2
Correct	55	94,8
Total	58	100,0

Post_Image11_Countre-coup haemorrhages

	N	%
Incorrect	3	5,2
Correct	55	94,8
Total	58	100,0

Post_Image12_Normal or abnormal

	N	%
Incorrect	3	5,4
Correct	53	94,6
Total	56	100,0

Post_Image12_Meningitis

	N	%
Incorrect	45	78,9
Correct	12	21,1
Total	57	100,0

Post_Image12_Space-occupying lesion

	N	%

Incorrect	2	3,5
Correct	55	96,5
Total	57	100,0

Post_Image12_CVA

	N	%
Incorrect	2	3,5
Correct	55	96,5
Total	57	100,0

Post_Image12_White cerebellar sign

	N	%
Incorrect	4	7,0
Correct	53	93,0
Total	57	100,0

Post_Image12_Cerebral oedema

	N	%
Incorrect	37	64,9
Correct	20	35,1

Total	57	100,0

Post_Image12_Hydrocephalus

	N	%
Incorrect	18	31,6
Correct	39	68,4
Total	57	100,0

Post_Image13_Normal or abnormal

	N	%
Incorrect	15	25,9
Correct	43	74,1
Total	58	100,0

Post_Image13_Skull fracture

	N	%
Incorrect	39	67,2
Correct	19	32,8
Total	58	100,0

Post_Image13_Simple Pneumocephalus

	N	%
Incorrect	27	46,6
Correct	31	53,4
Total	58	100,0

Post_Image13_Tension Pneumocephalus

	N	%
Incorrect	8	13,8
Correct	50	86,2
Total	58	100,0

Post_Image13_Pneumo-ventricle

	N	%
Correct	58	100,0

Post_Image13_Diffused axonal injuries

	N	%
Incorrect	3	5,2
Correct	55	94,8

Total	58	100,0

Post_Image13_Countre-coup haemorrhages

	N	%
Incorrect	4	6,9
Correct	54	93,1
Total	58	100,0

Post_Image14_Normal or abnormal

	N	%
Incorrect	2	3,4
Correct	56	96,6
Total	58	100,0

Post_Image14_Intraparenchymal abscess

	N	%
Incorrect	35	60,3
Correct	23	39,7
Total	58	100,0

Post_Image14_Dural venous thrombosis

	N	%
Incorrect	2	3,4
Correct	56	96,6
Total	58	100,0

Post_Image14_Abnormal meningeal enhancement

	N	%
Incorrect	4	6,9
Correct	54	93,1
Total	58	100,0

Post_Image14_Herniation syndrome

	N	%
Incorrect	27	46,6
Correct	31	53,4
Total	58	100,0

Post_Image14_Pseudo subarachnoid haemorrhages

	N	%

Incorrect	6	10,3
Correct	52	89,7
Total	58	100,0

Post_Image14_Subarachnoid haemorrhages

	N	%
Incorrect	11	19,0
Correct	47	81,0
Total	58	100,0

Post_Image15_Normal or abnormal

	N	%
Incorrect	1	1,8
Correct	54	98,2
Total	55	100,0

Post_Image15_Skull fracture

	N	%
Incorrect	38	65,5
Correct	20	34,5

Total	58	100,0

Post_Image15_Simple Pneumocephalus

	N	%
Incorrect	39	67,2
Correct	19	32,8
Total	58	100,0

Post_Image15_Tension Pneumocephalus

	N	%
Incorrect	4	6,9
Correct	54	93,1
Total	58	100,0

Post_Image15_Pneumo-ventricle

	N	%
Incorrect	5	8,6
Correct	53	91,4
Total	58	100,0

Post_Image15_Diffused axonal injuries

	N	%
Incorrect	38	65,5
Correct	20	34,5
Total	58	100,0

Post_Image15_Countre-coup haemorrhages

	N	%
Incorrect	30	51,7
Correct	28	48,3
Total	58	100,0

Post_Image16_Normal or abnormal

	N	%
Correct	59	100,0

Post_Image16_Subarachnoid haemorrhages

	N	%
Incorrect	4	6,8
Correct	55	93,2

Total	59	100,0

Post_Image16_Intraparenchymal haemorrhages

	N	%
Incorrect	14	23,7
Correct	45	76,3
Total	59	100,0

Post_Image16_Epidural haemorrhage

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Post_Image16_Subdural haemorrhage

	N	%
Incorrect	52	88,1
Correct	7	11,9
Total	59	100,0

Post_Image16_Basal meningeal enhancement

	N	%
Incorrect	4	6,8
Correct	55	93,2
Total	59	100,0

Post_Image16_Herniation syndrome

	N	%
Incorrect	28	47,5
Correct	31	52,5
Total	59	100,0

Post_Image17_Normal or abnormal

	N	%
Incorrect	1	1,7
Correct	57	98,3
Total	58	100,0

Post_Image17_Skull fracture

	N	%

Incorrect	25	43,1
Correct	33	56,9
Total	58	100,0

Post_Image17_Simple Pneumocephalus

	N	%
Incorrect	28	48,3
Correct	30	51,7
Total	58	100,0

Post_Image17_Tension pneumocephalus

	N	%
Incorrect	7	12,1
Correct	51	87,9
Total	58	100,0

Post_Image17_Pneumo-ventricle

	N	%
Incorrect	1	1,7
Correct	57	98,3

Total	58	100,0

Post_Image17_Diffused axonal injuries

	N	%
Incorrect	51	87,9
Correct	7	12,1
Total	58	100,0

Post_Image17_Countre-coup haemorrhages

	N	%
Incorrect	13	22,4
Correct	45	77,6
Total	58	100,0

Post_Image18_Normal or abnormal

	N	%
Correct	59	100,0

Post_Image18_Meningitis

	N	%

Incorrect	1	1,7
Correct	58	98,3
Total	59	100,0

Post_Image18_Space-occupying lesion

	N	%
Incorrect	12	20,3
Correct	47	79,7
Total	59	100,0

Post_Image18_CVA

	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

Post_Image18_White cerebellar sign

	N	%
Incorrect	2	3,4
Correct	57	96,6

Total	59	100,0

Post_Image18_Cerebral oedema

	N	%
Incorrect	48	81,4
Correct	11	18,6
Total	59	100,0

Post_Image18_Hydrocephalus

	N	%
Incorrect	3	5,1
Correct	56	94,9
Total	59	100,0

Post_Image19_Normal or abnormal

	N	%
Incorrect	10	16,9
Correct	49	83,1
Total	59	100,0

Post_Image19_Skull fracture

	N	%
Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Post_Image19_Simple Pneumocephalus

	N	%
Incorrect	7	11,9
Correct	52	88,1
Total	59	100,0

Post_Image19_Tension pneumocephalus

	N	%
Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Post_Image19_Pneumo-ventricle

	N	%

Correct	59	100,0

Post_Image19_Diffused axonal injuries

	N	%
Incorrect	28	47,5
Correct	31	52,5
Total	59	100,0

Post_Image19_Countre-coup haemorrhages

	N	%
Incorrect	13	22,0
Correct	46	78,0
Total	59	100,0

Post_Image20_Normal or abnormal

	N	%
Correct	59	100,0

Post_Image20_Intraparenchymal abscess

	N	%

Incorrect	2	3,4
Correct	57	96,6
Total	59	100,0

Post_Image20_Dural venous thrombosis

	N	%
Incorrect	9	15,3
Correct	50	84,7
Total	59	100,0

Post_Image20_Abnormal meningeal enhancement

	N	%
Incorrect	5	8,5
Correct	54	91,5
Total	59	100,0

Post_Image20_Herniation syndrome

	N	%
Correct	59	100,0

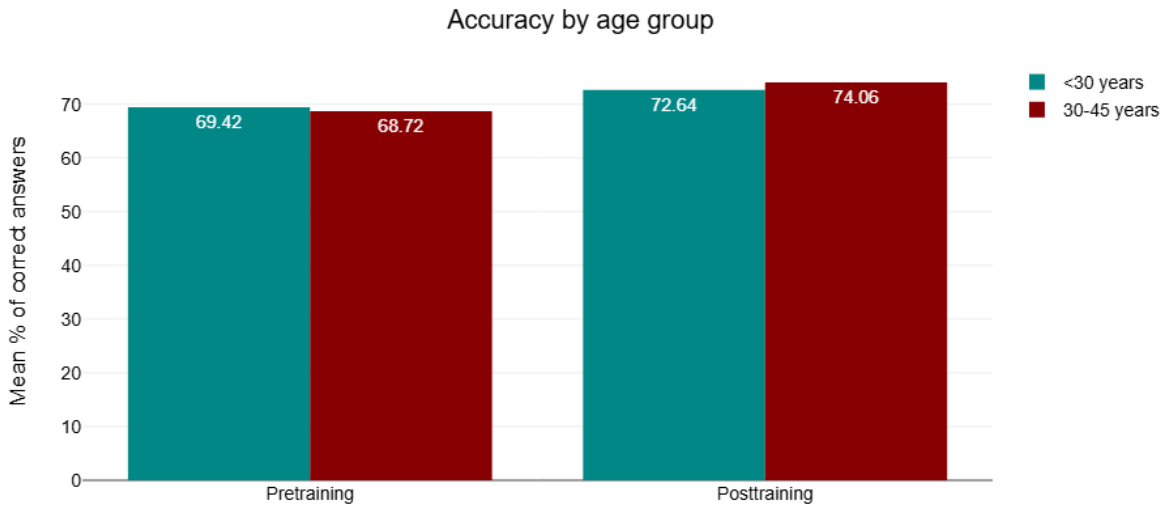
Post_Image20_Pseudo subarachnoid haemorrhages

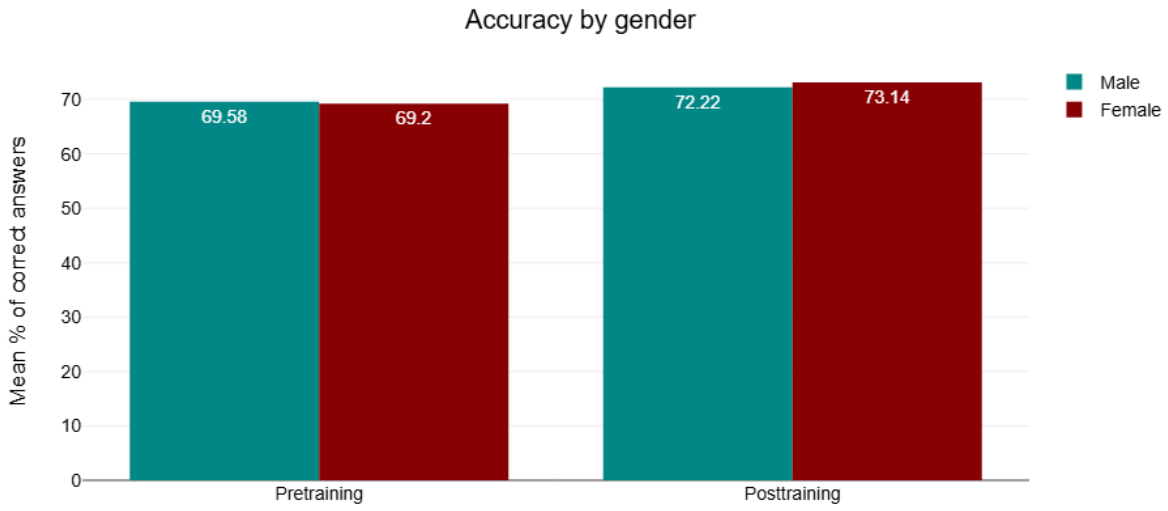
	N	%
Incorrect	11	18,6
Correct	48	81,4
Total	59	100,0

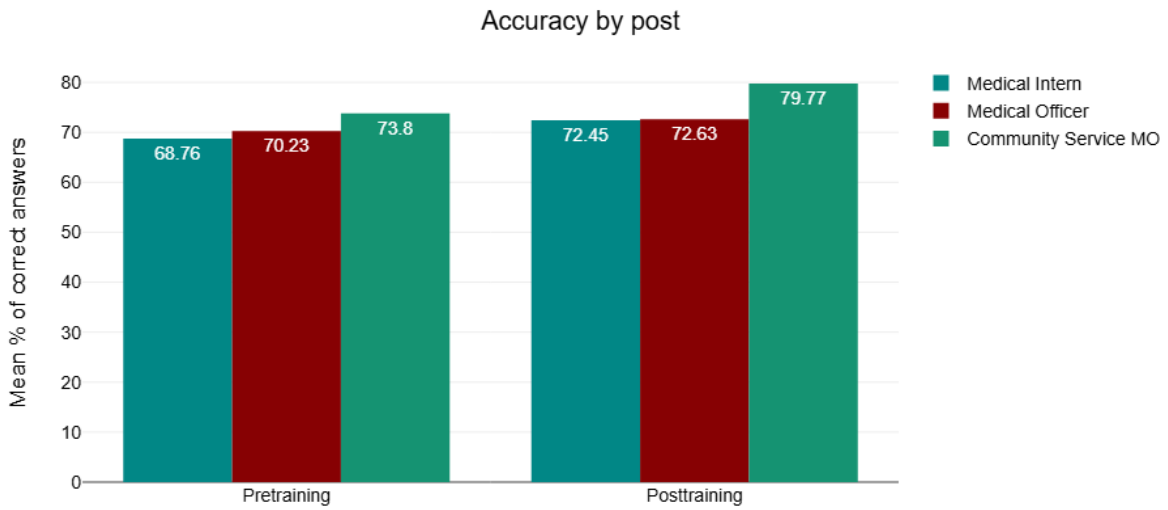
Post_Image20_Subarachnoid haemorrhages

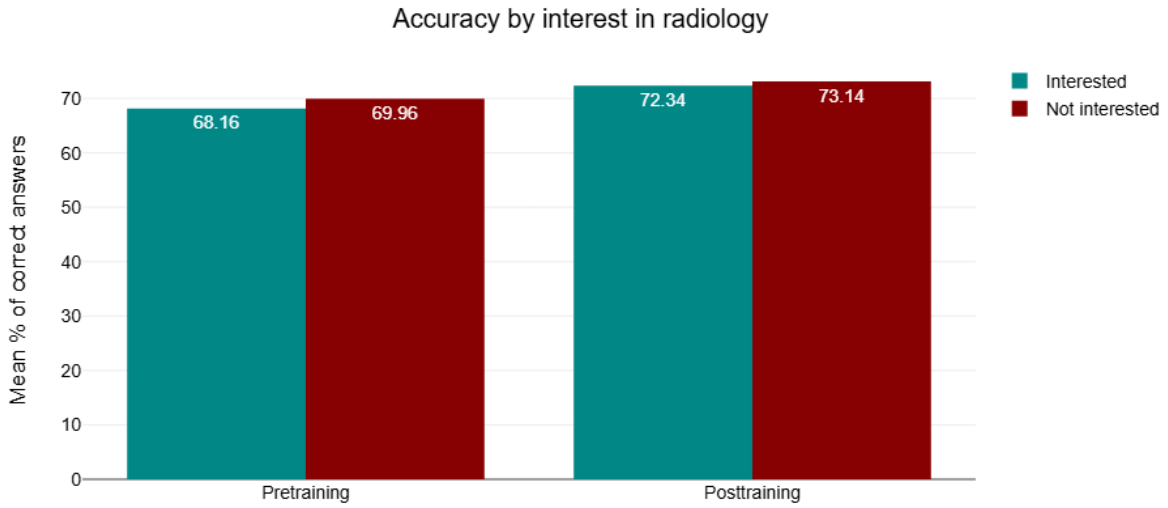
	N	%
Incorrect	8	13,6
Correct	51	86,4
Total	59	100,0

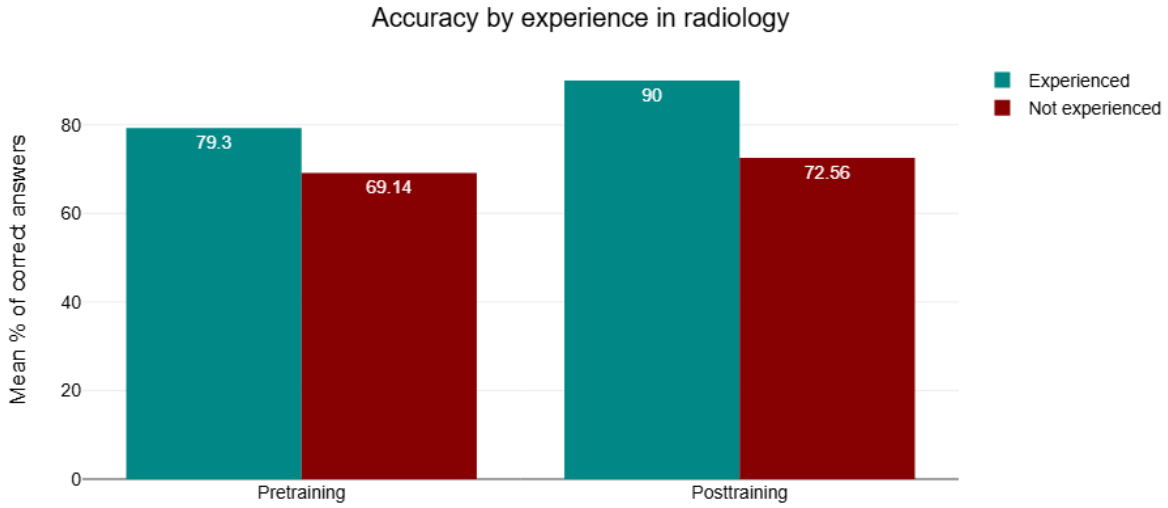
Appendix I-3- Results Graphs




Accuracy by gender
Mean % of correct answers
70
60
50
40
30
20
10
0
69.58
69.2
72.22
73.14
Pretraining
Posttraining
Male
Female


Accuracy by post
Mean % of correct answers
80
70
60
50
40
30
20
10
0
68.76
70.23
73.8
72.45
72.63
79.77
Pretraining
Posttraining
Medical Intern
Medical Officer
Community Service MO





APPENDIX J: Original protocol

APPENDIX K: Turnit in results