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CLINICIANS' INTERPRETATION OF VENTILATION/PERFUSION (V/Q) LUNG SCAN REPORTS

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A Research Report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine (Nuclear Medicine)

Johannesburg, 2021

DECLARATION:

I, Ayesha Ismail, declare that this Research Report is my own, unaided work.

It is being submitted for the Degree of Master of Medicine (Nuclear Medicine) at the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination at any other university.



_____

(Signature of candidate)

_____01/02/2022_____

(Date)

DEDICATION:

To my parents, Abdul Ahad and Fatima Ismail, for their encouragement and support over the years.

ABSTRACT

The survey of clinicians' interpretation of Ventilation/Perfusion (V/Q) scan reports will determine which further decisions are taken for the management of patients with suspected pulmonary embolism (PE). This study assessed the referring clinicians' interpretation of terminology used in V/Q scan reports and how this affected clinical management. **Methods:** A questionnaire was sent out to 300 clinicians with varying experience levels and working in various different clinical departments. Questions related to terminology used, further management of patients, clinicians' preferences and areas where imaging reports can be improved. **Results:** 162 responses were received. Most clinicians (87-94%) understood the terminology recommended by guidelines as intended. A negative V/Q scan despite a high clinical pre-test probability led 33% of clinicians to consider an alternative diagnosis and 59% of clinicians to refer the patient for Computed Tomography Pulmonary Angiography (CTPA). The remaining 8% of respondents would trust their clinical judgement and treat as PE despite a negative V/Q scan. For inconclusive findings on V/Q scan, 72% of respondents would investigate further with CTPA, if there were no contraindications. Only 12% of clinicians would consider therapeutic anticoagulation and repeat V/Q scan in 7-14 days in this situation. There were 16% of clinicians who would trust their clinical judgement and treat as confirmed pulmonary embolism in the case of an inconclusive study. There were 77% of respondents who understood that a negative V/Q scan rules out PE. **Conclusion:** The majority of respondents understood the intended meaning of the probability of PE described in V/Q reports in our clinical setting. Most clinicians would consider referral for CTPA or an alternative diagnosis in the event of a negative study but a high clinical suspicion for PE. The majority of respondents would refer the patient for CTPA if the V/Q scan was reported as inconclusive. The majority of clinicians understood that a negative V/Q study rules out a diagnosis of PE. Areas where V/Q scans may be improved are important to evaluate as this will facilitate better communication with referring clinicians and ultimately improve patient care.

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Nomenclature/ List of Abbreviations

PE	Pulmonary Embolism
DVT	Deep Vein Thrombosis
COVID-19	Corona Virus Disease - 2019
PERT	Pulmonary Embolism Response Team
GBD	Global Burden of Disease
VTE	Venous Thromboembolism
CTPA	Computed Tomography Pulmonary Angiography
V/Q	Ventilation / Perfusion
CT	Computed Tomography
NM	Nuclear Medicine
SPECT	Single Photon Emission Computed Tomography
EANM	European Association of Nuclear Medicine
SNMMI	Society for Nuclear Medicine and Molecular Imaging
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
CHBAH	Chris Hani Baragwanath Academic Hospital
HJH	Helen Joseph Hospital
PIOPED	Prospective Investigation of Pulmonary Embolism Diagnosis
PISAPED	Prospective Investigative Study of Acute Pulmonary Embolism Diagnosis
RCR	Royal College of Radiologists
RANZCR	Royal Australian and New Zealand College of Radiologists
O & G	Obstetrics and Gynaecology
PACS	Picture Archiving and Communication System

1 Chapter 1: Introduction and Literature Review

1.1 Background

Pulmonary embolism (PE) is a serious medical disorder in which perfusion to lung tissue is disrupted when intravascular material becomes wedged in the pulmonary arteries. It is usually caused by a deep vein thrombosis (DVT) migrating to the lungs. In addition to thrombi, PE may also be caused by fat, air, amniotic fluid and tumour fragments embolizing to the lungs. These emboli may also originate in the deep veins of the upper extremities but this is much less common (1). When perfusion to a lung segment is restricted, there is resultant hypoxia and PE may be life-threatening. Prompt diagnosis and treatment of PE is critical, as it is associated with high rates of morbidity and mortality (1–4).

PE is the most common preventable cause of death amongst hospital inpatients and is responsible for 10% of all hospital deaths (1,4). Undiagnosed PE can be fatal (1–5). Untreated PE can result in morbidity from pulmonary hypertension, recurrent PE and right ventricular failure (1–3). Conversely, an inaccurate diagnosis of PE and inappropriate continuation of anticoagulation places a patient at risk of adverse effects such as hypersensitivity reactions, bleeding and thrombocytopenia (1–4). Such a patient will also be made to undergo repeated blood tests to assess adequacy of anticoagulation.

The Corona Virus Disease - 2019 (COVID-19) pandemic has introduced new challenges to the diagnosis of PE. Symptoms and clinical signs of PE and COVID-19 infection often overlap and diagnosis of PE can be challenging (6). In the United States, some institutions use a dedicated Pulmonary Embolism Response Team (PERT) with physicians from various disciplines to handle this serious complication. They function to accelerate the diagnosis and treatment of PE (6). An unambiguous conclusion on a V/Q scan report is essential for correct interpretation by clinicians.

The Global Burden of Disease (GBD) study is a comprehensive epidemiological study which describes morbidity and mortality from major diseases and injuries. It is continually updated and examines data from 1990 to the present. It is endorsed by the World Health Organization. The GBD study estimates the global incidence rate of

venous thromboembolism (VTE), which manifests clinically as PE and DVT, is between 115 – 269 per 100 000 people in the general population (7). The mortality rate due to VTE is estimated at 9.4 – 32.3 per 1000 deaths (7). There is a lack of data regarding the incidence and management of VTE in low- and middle-income countries such as South Africa (5). According to the South African Society of Thrombosis and Haemostasis, the prevalence of PE amongst hospital inpatients is between 10 – 40% amongst medical, surgical and gynaecological patients (4). These figures increase up to 80% in orthopaedic, trauma and critical care patients (4).

The diagnosis of PE is made by clinical assessment and lung imaging including Computed Tomography Pulmonary Angiography (CTPA) or Ventilation/Perfusion (V/Q) lung scans. Based on clinical findings, the clinician will decide on a pre-test likelihood of PE prior to requesting imaging to confirm the presence of PE. Specific validated scoring systems, such as the Wells' and revised Geneva Scores, are used to decide on the likelihood of PE (2,3). These scoring systems divide patients into a 'PE likely/unlikely' group or a 'high/intermediate/low risk of PE' group (2,3). The choice of lung imaging will depend on the clinician's preference and other factors including the presence of renal dysfunction, pregnancy and contrast allergy (2,3,8). The radiation dose received from each imaging modality will also determine which is preferred depending on the age and sex of the patient (2,3,8).

CTPA is performed by the radiology department using injection of an iodine-containing contrast material at a fast rate. CT X-ray images from various angles around the body are processed to create cross sectional slices of the body. Images of the contrast material moving through the lung vasculature are acquired. A normal CTPA scan will show the contrast filling the blood vessels and causing them to appear bright white. If there is a blockage to blood flow due to an embolus, the area will appear as a filling defect. The scan is completed before the contrast reaches the left side of the heart (2,3).

CTPA is for diagnosing PE in a hemodynamically unstable patient as it is completed within a few minutes (2,3). This short duration is also useful in patients who are unable to lie still or supine for prolonged periods of time due to discomfort. CTPA has the advantage of being able to demonstrate additional pathologies that may present

in a similar manner to PE. These include pneumothorax, pneumonia, interstitial lung disease, aortic dissection, tumours, bone pathology and pleural disease (2,3).

CTPA is contraindicated in some patients and in these situations a V/Q scan will be the preferred investigation. In patients with renal dysfunction, contrast media may cause an acute kidney injury, worsen renal dysfunction and result in chronic renal failure (2). Iodine should not be used in patients prone to allergy or those with severe iodine deficiency due to hypersensitivity reactions and the induction of thyroid dysfunction respectively. CTPA delivers ten to 20 times greater radiation exposure to the female breast than a V/Q scan (2,8,9). This amount depends on the imaging parameters used for acquiring the CTPA scan. The increased glandular breast tissue of a pregnant woman is additionally radiosensitive and will receive a higher radiation dose (2,8,9). Foetal absorbed radiation doses for CTPA and V/Q scans have been found to be similar and are not actually high enough to be considered clinically significant (2,8). Thus, the low radiation dose of a V/Q scan is preferred for protection of the female breast, especially in young females and during pregnancy. The increased cardiac output and blood volume that occurs with pregnancy may also affect the filling of contrast in the lung vessels (3). This may cause CTPA to be technically insufficient for diagnosis of PE (3). Subsegmental PE are filling defects in the smaller pulmonary vessels. Theses may be overlooked when interpreting CTPA thus reducing the sensitivity for detection of PE (8,9).

V/Q scans are performed in the Nuclear Medicine (NM) Department and use trace amounts of radioisotopes to assess the ventilation and perfusion of the lungs. An image of the distribution of radioactive emissions from the body is acquired on a gamma camera scanner which uses a complex system of many components that allow the detection of radiation (10). This process is known as scintigraphy. The ventilation part of the scan is usually performed first in a process whereby radioactive particles or gases are inhaled into the lungs. Images of the lungs are acquired and ventilation scintigraphy will show the distribution of inhaled gases or radioaerosols in the lungs. The perfusion part of the scan is then performed (usually within a few minutes after the ventilation scan) and radioactive particles are injected intravenously. These tiny particles travel to the right side of the heart and subsequently to the lungs. The particles get trapped in the smaller precapillary arterioles of the lung. The trapped particles emit radiation photons that allow the

acquisition images of the lungs. The perfusion scan shows the distribution of blood flow through the lungs. A V/Q scan will not damage a patient's lungs if the correct number of particles is used. This is because only 0.1% of the 300 million precapillary arterioles are actually blocked during the study (11).

The major advantage of V/Q scans over CTPA is that they have very few contraindications. The contraindications include the weight restriction of the gamma camera scanner bed (250 kg) and the duration of the scan requiring the patient to lie supine for approximately 20-30 minutes (2,3,8,9). The main disadvantage of V/Q scans compared to CTPA is the need for a normal recent chest radiograph to adequately assess for PE (2,3). An abnormal radiograph with lung parenchymal changes decreases the sensitivity, specificity and accuracy of the V/Q scan, as the perfusion defect may be caused by parenchymal disease instead of obstruction of an end artery (2,3).

V/Q scan images are acquired either as planar images or Single Photon Emission Computed Tomography (SPECT) images. For planar imaging, a picture of the distribution of radioactivity is taken from one angle resulting in a two-dimensional image (10). For SPECT imaging, images are taken from many angles around the patient (10). The latter allows three-dimensional cross sectional tomographic images of the body to be generated. Depth and images of underlying layers can be appreciated. CT can be added to the V/Q SPECT acquisition technique. This will require a specialized integrated gamma camera which has CT capabilities. This CT has a low radiation dose and may enable visualization of other chest pathologies such as emphysema, pneumonia and mass lesions compressing a lung vessel (2). V/Q SPECT-CT has a similar sensitivity to V/Q SPECT but slightly increased specificity for PE (2).

The use of V/Q SPECT technique has become more popular in the past decade. It has allowed for the scan to be reported in a binary method as PE positive or PE negative (2). Planar V/Q imaging has been shown to have a sensitivity of 67-85% and specificity of 78-93% (3,12). The sensitivity and specificity of CTPA is similar to planar V/Q imaging. Sensitivity and specificity of CTPA are between 78-83% and 84-96% respectively (8,9,12,13). V/Q SPECT has improved the sensitivity and specificity of V/Q scans to 96-99% and 91-98% respectively (2,9), even in patients with

abnormal chest radiographs and changes in lung parenchyma. The three-dimensional images have resulted in fewer inconclusive scans (2,3). This imaging modality is used frequently and has gained widespread recognition throughout Europe and Australia. The European Association of Nuclear Medicine (EANM) guidelines for V/Q scintigraphy promote the use of SPECT over planar imaging if it is available (2,3,8). In the United States, however, planar V/Q imaging is preferred (8). The general consensus in the United States is that planar V/Q imaging is adequate and accurate enough to diagnose clinically significant PE (8). The additional emboli detected by V/Q SPECT are felt to be small peripheral lesions that do not require treatment in low-risk patients and may lead to overdiagnosis of PE and unnecessary anticoagulation (8,9).

In South Africa, the South African Society of Nuclear Medicine endorses both the EANM and the American Society for Nuclear Medicine and Molecular Imaging (SNMMI) guidelines. Prior to the COVID-19 pandemic reaching us in March 2020, planar imaging routinely performed in our NM department. VQ SPECT was not routinely performed due to software limitations, time constraints preventing prolonged scanning time and a lack of familiarity with the technique of acquisition.

COVID-19 has forced us to modify our scanning technique due to the risk of transmission of the virus during the ventilation part of the scan (6,14,15). Staff and other patients in the department may be at risk. In line with several guidelines (9–11), our NM department has decided to omit the ventilation part of the scan. This is because the environment is not well-ventilated and suitable personal protective equipment is not always available due to resource constraints. In NM departments where ventilation images are still being performed, guidelines advise that personnel should optimally wear N-95 or higher-level respirators, eye protection, gloves and gown (14,15). We currently use a protocol of perfusion-only planar and SPECT images with an additional low dose CT to improve the diagnostic accuracy of the study. In specific patients to aid in image interpretation, the ventilation part of the study is necessary and a full V/Q SPECT study is performed. This requires full personal protective equipment to be available.

Prior to the COVID-19 pandemic, there have been instances when the V/Q scan protocol has had to be modified and the ventilation part of the scan omitted. Criteria

were developed for the interpretation of perfusion-only scans. The most common reason for performing a perfusion-only scan in our setting is when ventilation sets are not available due to supply chain disruption. In some patients with significant airway disease, adequate inhalation of radioactivity is not possible and ventilation images are not feasible or uninterpretable (3). A recent chest radiograph (<24 hours) is used as a comparison for perfusion scan findings. In the first trimester of pregnancy, ventilation images are omitted to reduce the radiation dose that the patient and foetus are exposed to (3). If segmental perfusion defects are seen and there are no corresponding areas of parenchymal lung disease on the radiograph, then a diagnosis of PE is made. If the perfusion is normal, then PE is excluded. Other perfusion findings may require comparison to ventilation images and these can be done the next day to allow for the radioactivity from the perfusion scan to wash out from the lungs (3). The modified protocols require the use of alternative diagnostic criteria which will be discussed in the subsequent literature review.

V/Q scans make use of the unique pulmonary artery segmental anatomy (2,3). The lung segments function as individual units with their own bronchial and vascular supply (2,3,11). Each bronchopulmonary segment has its own end-artery. The presence of an occlusive thrombus causes perfusion to the lung segment to be absent and the result on perfusion images (in linear colour scale) is a dark area in a wedge shape corresponding to a lung segment. This is termed a segmental perfusion defect. The lung tissue however is still viable and ventilation of that segment is preserved (2,3). The ventilation images will show a contrasting white area in that segment. This is termed a V/Q mismatch and it is the fundamental principle for diagnosing a PE (2,3,11). Normal blood flow on perfusion images excludes a PE (2,3). If ventilation and perfusion are both affected, this is termed a V/Q match. Dark areas (in linear colour scale) on ventilation and perfusion images will match. This usually occurs with disorders of the airways or lung parenchyma such as emphysema or pneumonia (2,3). These conditions may also show ventilation is more affected than perfusion and this is termed reverse V/Q mismatch. A diagnosis of PE is unlikely in this situation (2,3,8).

Certain features of a perfusion abnormality seen on a V/Q scan will make the NM physician more likely to consider the possibility of PE. These include the size, number, location, shape, type and relation to ventilation pattern (11). A moderate or

large perfusion defect and multiple defects will be associated with a higher probability of PE. Defects which are larger than corresponding chest radiograph densities, will increase the probability of PE. Pleural-based wedge-shaped defects are more likely to represent PE than defects that do not correspond to the shape of a bronchopulmonary segment (3). This is due to the shape and orientation of the segments. The apices of the conical bronchopulmonary segments point toward the hilum of the lung and the bases lie on the pleural surface (3). Perfusion defects occurring in the lower lobes of the lung are more likely to represent PE than those in other areas (11). The lower lobes of the lung are better perfused and ventilated due to gravity. The gradient is more noticeable in perfusion than ventilation (11). Areas with high flow rates are more likely to occlude (11). Defects that are matched on perfusion and ventilation or do not have a segmental anatomy are likely to represent disease in the lung parenchyma or anatomical structures (3).

There are also various ancillary signs seen on V/Q scans which assist with interpretation (8). Some of these include:

- ‘Stripe’ sign – a stripe of normally perfused lung tissue which occurs between the perfusion defect and adjacent pleural surface. This sign makes a diagnosis of PE unlikely.
- Fissure sign – a linear defect corresponding to an anatomical fissure of the lung. This sign makes a diagnosis of PE unlikely.
- Pleural effusion – a large effusion occupying a third or more of the hemi-thorax is not likely to represent PE.
- Triple matched defects – defects on perfusion, ventilation and chest radiograph images. If they occur in the upper or mid-lung fields, they are associated with PE in 11 and 12% of cases respectively (3,8). They are thus classified as low probability for PE. A triple match in the lower lung fields has 33% (3,8) incidence of PE and is considered an intermediate risk for PE.

Ultimately the interpreting NM physician will apply the Gestalt principle described in psychology. In its simplified form it proposes that an organized whole is perceived as more than the sum of its parts (8). The pre-test probability based on clinical history and findings, the scan findings, the guidelines and the interpreter’s own experience will all be used to come to a conclusion on a V/Q scan.

V/Q scans are performed almost daily in the NM Departments at the main academic hospital in Johannesburg, namely the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) and Chris Hani Baragwanath Academic Hospital (CHBAH). According to the departmental electronic database of reports, in 2019, 429 and 1125 V/Q scans were performed at CMJAH and CHBAH respectively. Patients requiring a V/Q scan from Helen Joseph Hospital (HJH), the third largest academic hospital in Johannesburg, are referred to CHBAH. The three hospitals make up the main academic training platforms affiliated to the University of the Witwatersrand.

In our NM Department, interaction with the referring clinician occurs predominantly when a booking for a scan is requested. For a V/Q scan, the discussion focuses on the pre-test probability of PE and the urgency of the booking. This interaction is essential to aid the NM physician with interpreting the V/Q scan as important clinical information is often omitted on the scan request form. Interaction with the referring clinician after the scan has been performed is limited. If the scan is found to be positive or non-diagnostic for PE, the referring clinician is informed telephonically. The printed report is subsequently collected by the clinician. If the scan is negative, it is assumed that the result will be noted when the printed report is collected. The experience in our department has been that clinicians rarely contact the NM physician to clarify the meaning of a V/Q scan report, even in the event of unusual findings. Thus, the department has very little feedback of how the referring clinicians interpret our V/Q scan reports. This lack of interaction also makes it essential for the written reports to communicate the scan findings clearly.

The main aim of this study was to assess the referring clinicians' interpretation of the terminology used in V/Q scan reports. In addition, it assessed if this interpretation is affected by experience level and how interpretation impacts clinical management decisions. The study also highlighted areas where V/Q scan reports may be improved to facilitate better communication of findings by the NM Physician to the referring clinician.

1.2 Literature Review

The NM imaging report is the primary method of communication between the NM physician and the referring clinician. Clinicians mainly judge the specialty of NM and

our capabilities through these documents instead of through personal interaction (16). Various clinicians, with different experience and knowledge levels, receive these reports and use them to guide further clinical management (17–19). It is therefore critical for the report to be accurate, explicit and easily understood by even the most junior doctor involved in patient care.

There are various interpretation systems that are used to determine if PE is present or absent on a scan. Initially, an interpretative scheme using probability interpretations for PE were described by the Biello classification in 1979 (8). A retrospective correlation of V/Q scans with catheter pulmonary angiograms was used. Two or more large V/Q mismatches were classified as a high probability of PE (>85% likelihood of PE). A large defect was considered to be more than 75% of a bronchopulmonary segment. Two or more small mismatches were classified as a low probability of PE (<10% likelihood of PE). A single moderate sized mismatch, with a defect in 25-75% of a segment, was classified as an intermediate probability of PE. These probability interpretations continued through the two subsequent Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) studies (8).

The initial PIOPED I study began in 1983 and aimed to evaluate the sensitivity and specificity of V/Q scanning compared to pulmonary angiography (8,9). Pulmonary angiography was considered to be the gold standard for PE diagnosis at the time (8). This study changed a few things from the Biello classification. A high probability of PE required three or more large mismatched defects. A low probability of PE now corresponded to 20% likelihood of PE (instead of 10%) and a single segmental mismatch was reclassified to represent a low instead of intermediate probability. This 20% likelihood of PE was considered unacceptable to clinicians to decide on whether or not to start anticoagulation (8). It was also found that 36% of patients with a single segmental mismatch went on to be diagnosed with PE on angiography (8). The PIOPED investigators then had to revise the PIOPED report published in 1993 and went back to the initial classification of a single segmental mismatch as described by Biello (8). A new category of very low probability was introduced to represent <10% likelihood of PE. This included finding perfusion abnormalities that were non-segmental, smaller than a corresponding chest radiograph abnormality, matched to ventilation defects, very small but numerous and the presence of a ‘stripe’ sign (20).

The PIOPED II study in 2006 investigated the diagnostic accuracy of CTPA in diagnosing PE (8,9). It went back to using two or more large perfusion defects to represent a high probability of PE as described by Biello (20). The very low probability criteria were similar to the PIOPED I criteria with the addition of the presence of a large pleural effusion and specification of the number of small and matched defects (20). Instead of an intermediate category, a nondiagnostic category was added. This included all findings not specified in the high or low probability categories (20). A scan classified as normal had no perfusion defects.

Following the PIOPED II study, the committed reporting style of CTPA was popular with clinicians and the use of V/Q scans with probabilistic reporting fell out of favour (9). In response to this, the Modified PIOPED II V/Q reporting criteria were introduced. This had a similar reporting style to CTPA reports (9). According to the Modified PIOPED II criteria, a high probability scan equates to >85% likelihood of PE (8). A very low probability of PE on scan translates to <10% likelihood of PE (8). In data from the PIOPED II study, patients with a low probability clinical assessment and a very low probability V/Q scan, the positive predictive value of VQ scan was 3.1% [8 of 259 patients] (21). For this study, a high probability scan had a positive predictive value more than 90% and a normal V/Q scan had a negative predictive value of close to 100% (12).

In instances where ventilation images cannot be acquired, the Perfusion-only Modified PIOPED II criteria are used. Perfusion images are compared to a recent (<24 hours) chest radiograph. The very low probability category is referred to as PE absent and matched V/Q defects no longer apply as there no ventilation images to compare to. Criteria for the other categories remains the same.

The Prospective Investigative Study of Acute Pulmonary Embolism Diagnosis (PISAPED) reporting system was first published in 1995 (9). It changed from probabilistic reporting and based its method of PE diagnosis on perfusion scan and chest radiograph findings. It is useful in the absence of ventilation images. This method categorized scans as PE absent, PE present or non-diagnostic for PE. The presence of one or more wedge shaped perfusion defects is in keeping with PE being present. PE is absent if perfusion is normal, or the perfusion defect is not wedge-shaped or is caused by an anatomical structure such as the heart or

diaphragm. Appendix F compares the various PIOPED and PISAPED criteria in table format.

V/Q SPECT technique uses the criteria of a mismatch in at least one segment or two subsegments of the lung to diagnose PE as present. No PE is concluded if perfusion is completely normal, matched defects or reversed mismatched defects are found or the defect does not follow a segmental pattern. A scan is nondiagnostic for PE if there are widespread V/Q abnormalities which are not typical for specific diseases. The Modified PIOPED II criteria are used in our NM department under normal circumstances, when a full study with ventilation and perfusion components can be obtained. The categories under this system include high probability, nondiagnostic, very low probability and normal scan. During the COVID-19 pandemic, with the absence of the ventilation portion of the study, the Perfusion-only Modified PIOPED II criteria have been used. The categories under this system include PE present, nondiagnostic and PE absent. Thus, in the past one and a half years the terminology used in our V/Q scan conclusions has changed considerably.

The choice of words in a V/Q scan report is important for communicating information to the referring clinician. The language or terminology used can influence the clinician's understanding of a report (8,22–25). The likelihood of PE is reported as a linguistic probability (high, indeterminate, low or very low probability) and not numerical percentages or likelihood ratios in our reports. Variability in clinicians' interpretation of V/Q scan reports is inevitable (22). One of two keynote articles on V/Q lung scan interpretation was written by Gray *et al* (25) in 1993. They sent out a questionnaire to 211 NM consultant physicians with a series of expressions of probability used in lung scan reporting. Respondents were asked to estimate the probability of PE using these expressions on a visual linear probability scale. Results showed a wide variation in the interpretation of the probability language by NM physicians themselves. Gray et al (25) concluded that "the use of verbal probability language complicates the communication of PE" and they proposed the use of numerical expression of the likelihood of PE to reduce the confusion amongst clinicians.

Clinicians have never fully understood what these probability interpretations mean (8,9). Many clinicians may not be familiar with the diagnostic accuracy values of V/Q

scans. NM physicians have also never fully standardized the meaning of each probability (8,22). A normal V/Q scan excludes clinically significant PE irrespective of the pre-test diagnosis (8,9,22). However, there is still misunderstanding amongst clinicians about the specificity of a normal V/Q scan. In the second keynote article on lung scan interpretation by Gray *et al* (22), clinicians interpretation of V/Q lung scans was assessed. Only 34% of 217 consultant physicians understood that a normal lung scan makes a diagnosis of PE highly unlikely. A normal report was interpreted to still mean an uncertain diagnosis in 31% of respondents. A high probability scan indicates acute PE, except in patients with a preceding low pre-test probability of PE (22). This exception may include patients with unresolved perfusion defects from a previous PE. In the study by Gray et al (22) , most physicians seemed to understand what a high probability scan meant and 82% responded that a diagnosis of PE was likely. The remaining 18% of clinicians considered a diagnosis of PE to be uncertain. Amongst the participants in this study, a low probability of PE was still associated with a possibility of PE up to 40% and these clinicians would either initiate anticoagulation therapy or investigate the patient further. Kember et al (26) found that 35% of indeterminate V/Q reports were misinterpreted by clinicians as meaning negative for PE and these clinicians would erroneously not investigate further.

The inclusion of a short explanation correlating the use of certain phrases and the likelihood of PE may help to clarify the meaning of reports (27). Panicek and Hricak (27) described a standardized lexicon that they use in radiology reports at Memorial Sloan Kettering Cancer Centre. The terms used to describe the certainty [*consistent with, suspicious for, possibly, less likely and unlikely*] are given corresponding numerical estimates of the radiologist's certainty of a condition [>90%, ~75%, ~50%, ~25% and <10% respectively] (27). The authors suggest that the use of this lexicon facilitates clearer communication among radiologists, referring physicians and patients.

V/Q scan reporting in the United States and Europe has moved away from probabilistic reporting since 2009 (9). It now focuses on a more committed interpretation of V/Q scans as PE positive or PE negative. This has resulted in a much smaller number of scans being concluded as indeterminate (2,9). In a study by Glaser et al (13), a simple trinary scheme of V/Q scan reporting was used to replace the traditional probability method. V/Q scans of patients in a busy Emergency

Department were interpreted as no evidence of PE, PE present and non-diagnostic study. Clinicians were informed of how the new terminology corresponded to the old terminology. Glaser et al (13) found that the trinary interpretation had outcomes similar to standard probability reporting and could be safely implemented to allow for clearer communication with referring clinicians. Clinicians' satisfaction with the new system was not formally investigated in the study but anecdotal reports were positive.

The indeterminate V/Q scan report poses a diagnostic dilemma for the NM physician and the referring clinician. Up to 30% of indeterminate scans have proven pulmonary emboli on subsequent gold standard imaging with angiography (26). The risk of unnecessary anticoagulation must be weighed against the risk of untreated PE. A dedicated PERT is ideal in these situations to decide if further investigation is necessary. Alternative imaging such as CTPA should be used if there are no contraindications to it (26). If contraindications to the use of CTPA are present, there are no clear guidelines or diagnostic algorithms to follow. A reasonable approach is to let clinical index of suspicion for PE guide further management. The clinician can use doppler ultrasound (to assess for associated DVT), chest radiograph findings, clinical examination, blood D-Dimer levels and the pre-test likelihood of PE to come to a decision regarding anticoagulation (8,26). V/Q SPECT may allow for better visualization of perfusion defects and aid with interpretation of images (3).

In certain clinical situations, inappropriate anticoagulation or thrombolysis may carry a greater risk or be undesirable. This includes pregnancy, bleeding disorders and renal dysfunction (28). It is then essential to confirm the diagnosis of PE and an indeterminate V/Q scan result will require further investigation. Further imaging also includes a repeat V/Q scan (28). When CTPA or clinical assessment is not suitable for investigating PE, the approach in our department has been to suggest therapeutic doses of anticoagulation for seven to 14 days. This is followed by a repeat perfusion-only scan, to allow for assessment of resolution of defects. Resolution of defects on the repeat scan will indicate that fibrinolysis has occurred and that there is a high likelihood that PE is present. However, non-resolution of perfusion defects does not equate to PE being absent, as various scenarios including chronic PE may give this finding. Clinicians must be educated on the significance of the indeterminate V/Q result and how to approach these patients (26).

Guidelines on medical reporting should be used to assist imaging physicians to produce clear reports that are easy to understand. Farmer et al (17), did a detailed review of radiology reporting guidelines from six different professional bodies worldwide. Many radiology reporting guidelines describe the concept of 'actionable' reporting (17,19). This is the process during which the radiology image is transformed into a report that leads to actions which assist patient care and influence outcome (17). If the report is not properly understood, the clinician may order further unnecessary tests or treat the patient unnecessarily. The report should be clear and easy to understand so that appropriate management may be initiated.

The experience and knowledge level of the clinician who will read the medical report should be kept in mind. The Royal College of Radiologists (RCR) published updated guidelines in 2018 for reporting of imaging investigations (19). One of the recommendations is that the report should be appropriate for the referrer. The wording of the report should differ when written to a general practitioner as compared to a specialist in a particular field (18,19). The familiarity of an obstetrician with PE probability criteria is likely to be different to a pulmonologist. Recommendations regarding management may also be appreciated differently depending on the referrer's background and experience (24). An unambiguous conclusion with a sensible recommendation will be considered acceptable to most clinicians.

Most radiology reporting guidelines do suggest the use of structured reports or standardized templates with a comprehensive description of findings (17). This is important as clinicians may need to extract information from reports later on. Larson et al (29), developed a standardized structured reporting program using automatically populated reports and a checklist at the end to ensure consistency of reports throughout their radiology department. This can assist in avoiding the omission of important information which may occur with individualized style reports. Some busy clinicians may prefer to have a conclusion and recommendations section clearly highlighted on the report for quick referral at a later stage (24). All the guidelines reviewed by Farmer et al (17) recommended giving treatment or management suggestions in the report. This is especially useful for junior intern doctors or medical officers as they are likely to be the first clinician reading the report and alerting a senior to initiate further treatment. In the South African health context, junior doctors in outlying areas work without much senior supervision and may require advice (5).

Medical imaging reporting guidelines are not without shortcomings. Farmer et al (17) found that radiology reporting guidelines generally focus on technical detail and structure of reports, without much attention to how the message of the scan findings must be communicated. The terms ‘readability’ and ‘clarity’ were often used in the guidelines yet the actual definition of these terms is not made clear and may be subjective (17). Farmer et al (17) also found that the radiology guidelines rarely consider preferences for reporting expressed by clinicians and this leads to confusion. There was only one guideline, from the Royal Australian and New Zealand College of Radiology (RANZCR), that had an evidence-based guideline for written radiology reports. It was based on a literature review, multidisciplinary panel (including non-radiologists), an online survey of clinical radiologists and public consultation (30). Input from the referring clinician as the end user is essential for giving guidance to imaging physicians regarding what the clinician wants to see in an imaging report.

Variation in how a statement is worded or the actual words used, can impact on further decision making (22,24,27,31). Gray et al (22) noted that the most frequent comment from clinicians was that usage of the word “suspicious” in a medical report is vague and imprecise. There is divergence amongst clinicians in the interpretation of imaging reports using verbal expressions such as ‘likely’ and ‘probable’ (31). Some clinicians may understand these phrases to mean a high probability of PE and others may take the meaning as the diagnosis is uncertain. There is also a significant difference between the conclusion of the clinician and the NM physician when reading the same report (31). Whilst standard terminology and phrases may be clear to the NM physician, the referring clinician may not request V/Q scans routinely and thus may be unfamiliar with certain words and their implications. It is important for the NM physician to have a standardized method of reporting so that the clinician accurately understands what is the intended meaning of the terms used (17,19,31).

The language used in a medical report should be sensitive towards cultural idiosyncrasies. A study was done in France by Bastuji – Garin *et al* (31) to evaluate if different clinicians interpret the same words and sentences in the same way. They argue that each culture has its own different way of thinking, usage of phrases and interpretation of words. Some cultures may appreciate medical reports that simply describe the findings and allow the clinician to come to his own conclusion. Other

more paternalistic cultures may prefer some guidance on further management included in the report.

Medical images are interpreted by a physician and are susceptible to human error (32). Whilst it is important for the nuclear physician to be clear and decisive in the report conclusion, limitations of imaging and radiographic interpretation must not be overlooked (32). If the clinical findings and pre-test probability do not correlate with the scan findings, the referring clinician and the nuclear physician should consider that the scan diagnosis may be incorrect. Bayes' Theorem is a concept that states that probability cannot be defined from a single test without taking into account prior probability (3). The RCR guidelines (19) emphasize that the report conclusion should take into account the clinical context. Treatment guided by clinical index of suspicion and a repeat study at a later stage may be a practical approach to such situations. Ultimately, the clinician will have assessed the patient clinically, taken an extensive history and assessed all the patient's investigation results. They will be in the best position to make management decisions, taking all factors into account.

The possibility that the patient may read their report must be kept in mind. In South Africa, the Promotion of Access to Information Act of 2000 gives every person the right to access their records held by public or private bodies, for legitimate purposes and provided it will not cause serious harm to the affected person (33). This includes health records. In our setting, outpatients collect their reports and take them to the requesting doctor for review. Sometimes reports are misplaced or not available at subsequent consultations and a new medical practitioner will have to rely on the patient's version of events when taking a medical history. Farmer et al (17) found that the RCR and RANZCR guidelines were the only two to recognize that patients may read their own report. No guidelines suggested the use of a lay summary for the patient to read (17). The language used to describe incidental findings may not be understood by patients and may cause increased patient anxiety (34). This may cause the patient to present with new symptoms and the unsuspecting physician may order further unnecessary investigations (34). The use of different terminology for the same condition may influence management preferences and psychological outcomes in patients (23,24). Carefully chosen words may encourage a patient to choose less aggressive management of low-risk findings and reduce their anxiety. Radiology reporting strategies need to consider the patient as a potential end user and

accommodate for this. If clinicians find medical reports ambiguous at times, then it is likely that patients are also misunderstanding their reports.

Lukaszewicz et al (24) describe the medical report as a translation of imaging findings into words. The medical report is a reflection of the imaging department and thus it should be read carefully and edited prior to finalizing it. Incorrect patient details, grammar, vocabulary, unnecessary descriptions and an inaccurate diagnosis can all reflect poorly on the NM department (16,18,24). These errors should be amended as required, prior to release of the report. The report should be concise, make sense and communicate critical findings to the clinician. When appropriate, critical findings such as a positive V/Q scan or indeterminate findings should be communicated telephonically to the clinician (24). Details of the conversation should also be documented in the report as it may be important for medico-legal purposes at a later stage (24).

The assessment of how clinicians interpret V/Q lung scan reports is important as this is the main method of communicating results with referring clinicians. The clinicians' interpretation ultimately influences further treatment and management decisions. Taking into account the preference of clinicians regarding the language used in reports is imperative to facilitate better communication between the NM physician and referring clinician. Formal investigation of the clinicians' thoughts on V/Q scan reports is necessary before the NM department can improve the format and style of our reports in a meaningful way.

1.3 Problem Statement

In the NM Department, most of our interaction with referring clinicians occurs when the V/Q scan is requested. Very little interaction with clinicians occurs after the scan has been performed. During our literature search, limited published data on the interpretation of medical reports by clinicians in the South African context was found. NM physicians have minimal formal training as to what constitutes a good report (16,18). There is therefore very little indication of how the clinician interprets terminology in our lung scan reports and if this affects clinical management decisions.

Clinicians from various backgrounds and experience levels receive our reports and it has not been assessed how this influences scan interpretation. Many doctors are unlikely to be familiar with the PIOPED reporting criteria used in V/Q scan interpretation. It must be determined if our reporting style is clinically relevant and what are the preferences of clinicians when reading our reports. This will aid us in modifying our imaging reports to make them easy to understand by clinicians from a wide scope of practice and to improve the clinical utility of our V/Q lung scan reports. Assessment of these factors will also provide a starting point from which an education program can be developed to achieve two things:

1. Ensure that referring clinicians understand the implications of the language used in our V/Q scans
2. Train NM registrars to develop good reports which are useful to clinicians

1.4 Study Objectives

Primary objective:

a) To assess the referring clinicians' interpretation of terminology and jargon used in V/Q scan reports.
b) To assess if experience level affects interpretation of V/Q scan reports. Experience level will be categorized as intern, medical officer, registrar and consultant.
c) To assess how the clinicians' interpretation of the presence or absence of VTE impacts further clinical management decisions.

Secondary objectives:

a) To describe how V/Q scan reports may be improved to facilitate clearer communication of findings to the clinician and more efficient clinical decision making.
b) To describe the factors that encourage or discourage clinicians from requesting V/Q scans

The subsequent sections of this research report will encompass the research methodology, data analysis, a comprehensive discussion of results and conclusion.

2 Chapter 2: Materials and Methods

2.1 Study Design Methodology

A questionnaire-based study amongst clinicians who refer patients to the NM department was carried out. This was an observational, cross-sectional study. The questionnaire was distributed over six months made up of two, separate, three-month periods (September 2020 to November 2020 and March 2021 to May 2021). The gap between collection periods was to accommodate for interruptions in the academic program, due to the end of year holidays and registrar board exams.

The questionnaire consisted of 24 questions. A study information sheet was attached to the questionnaire. The study information sheet and questionnaire are attached in Appendix G. All questions, except the last question, had options to select. The questions focused on the following aspects:

Question 1 – 4: Demographic details including experience level and place of work.
Question 5 – 6: Factors encouraging or discouraging the booking of V/Q scans.
Question 7 – 23: Questions related to V/Q reports including terminology used, utility of the report and impact on management decisions.
Question 24: Open-ended question asking for comments, suggestions and questions regarding V/Q scans.

2.2 Sample

The sample consisted of clinicians from the Internal Medicine, Surgery and Obstetrics/Gynaecology (O&G) departments at the three academic hospitals (CMJAH, CHBAH and HJH) affiliated to the University of the Witwatersrand. The clinicians included interns, medical officers, registrars and consultants. After discussion with the three main departmental secretaries, the estimated number of clinicians in each group during a standard rotation was as follows:

Table 2-1 Estimated number of clinicians per category

Clinician	Number
Interns	10
Medical Officers	5
Registrars	10
Consultants	10

Thus the estimated study population was approximately 100 clinicians per hospital or 300 clinicians for the three hospitals.

Sample size calculation

Cochran's formula for sample size calculation for categorical data and associated tables were used (35). Using this method, the variables were:

1. Population size = **300** clinicians
2. Confidence interval of **95%**
3. Margin of error = **5%**
4. Variance level in the population = **50%** (not all clinicians will have referred patients for V/Q scans)

The estimated sample size was calculated as 168 clinicians. This is comparable to a similar study by Gray et al (22) who received 194 responses. If 300 questionnaires were to be given out, a response rate of around 56% was required to achieve the sample size of 168 responses. Data from a review of 9 studies comparing online and paper-based questionnaires showed the overall response rate to be 33% and 56% respectively (36). Thus, a response rate between these values was expected.

Table 2-2 Variable values to estimate sample size based on desired accuracy from Taherdoost H. Determining Sample Size: How to Calculate Survey Sample Size. Int J Econ Manag. 2017;2:237–9. (35)

	Variance of the population P=50%		
	Confidence level=95% *Margin of error*		
Population Size	5	3	1
50	44	48	50
75	63	70	74
100	79	91	99
150	108	132	148
200	132	168	196
250	151	203	244
300	168	234	291
400	196	291	384
500	217	340	475
600	234	384	565
700	248	423	652
800	260	457	738
1000	278	516	906
1500	306	624	1297
2000	322	696	1655
3000	341	787	2286
5000	357	879	3288
10000	370	964	4899

2.3 Inclusion criteria

Any medical doctor working in the internal medicine, surgery or O&G departments, who refers patients for V/Q scans and is involved in patient management was included in the study.

2.4 Exclusion criteria

Medical students and short-term visiting doctors based at other hospitals were excluded from the sample.

2.5 Data collection

Prior to commencing the study, the questionnaire was validated in a pilot study of five staff members from the NM department and five randomly selected clinicians. The questionnaire was adjusted according to feedback. This ensured that the questions were easy to understand and the pre-selected responses had adequate options.

Paper-based and online questionnaires (designed with Microsoft Forms survey collection tool) were given out to 300 clinicians. After informing each relevant head of department in writing about the study, the investigator was given an opportunity to introduce the study in person or by electronic methods (email or departmental Whatsapp group) and distributed the anonymous questionnaires in person or via an electronic channel. Electronic questionnaires were requested by some departments due to COVID-19 pandemic precautions moving academic meetings online. This was done after departmental academic meetings which most clinicians attended. Clinicians were given some time to complete the printed questionnaires and these were collected at the end of the day from the departmental secretary. A few questionnaires were left with departmental secretaries to accommodate doctors who were on leave or on call and unable to attend the academic meetings. The electronic methods allowed clinicians to fill in the questionnaire at a time which was convenient.

2.6 Data Analysis

Responses to the 24 questions were analysed. Data analysis was performed using Microsoft Excel and Word. The data was de-identified and collated into worksheets using Microsoft Excel. The data was then imported into STATA (Version 15

STATACORP) for further analysis. This data was categorized and quantified according to the response provided.

A mixture of descriptive statistics, graphs and non-parametric inferential statistics was used. Categorical variables were presented as frequencies and percentages. The association between categorical variables and level of experience or management decisions was assessed using Pearson's Chi square test. Statistically significant associations were set at a p-value of <0.05.

2.7 Ethics and Confidentiality

This was a voluntary questionnaire-based study involving clinicians working at the three academic hospitals affiliated to the University of the Witwatersrand. Current patient management and lung scan reporting was not impacted. Permission from the University of the Witwatersrand Human Research Ethics Committee (medical) and the hospital Chief Executive Officers at CMJAH, CHBAH and HJH was obtained prior to commencement of the study (Clearance certificate number M200320) in September 2020. Please see Appendix A, B and C.

A memorandum issued by the university on 1 October 2020 stated that any research projects where people are conducting surveys, interviews or questionnaires on university staff and students would also require permission from the Head of the School of Clinical Medicine and the University Deputy Registrar. Appropriate permission was sought as soon as this was received. Please see Appendix D and E.

The relevant heads of department in Internal Medicine, Surgery and O&G were informed about the study in writing. As per the Ethics Committee, a separate consent form was not required for this questionnaire as it was voluntary and anonymous. Completion of the questionnaire signalled consent to participate in the study.

Confidentiality

The study was anonymous and study participants were not required to put personal identifying data on the questionnaire. Data from this study will only be used for the purposes of this Master of Medicine research report and scientific publications.

3 Chapter 3: Results

3.1 Response rate

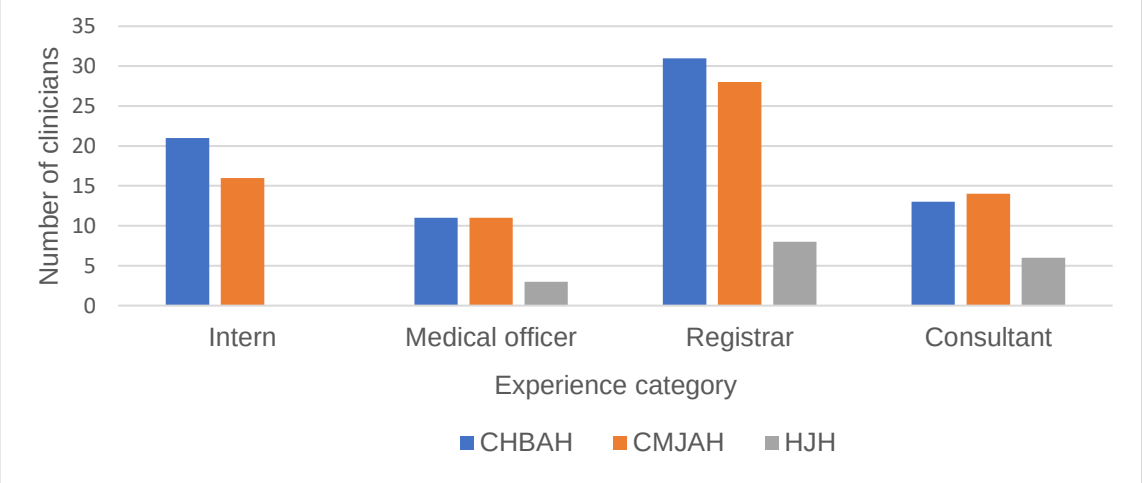
There were 300 questionnaires given out in total and 162 completed responses were received. There were six responses with missing data and these were excluded. This represents a 54% response rate.

The questionnaire consisted of 24 questions. The questionnaire was arranged in a sequence that allowed for logical flow of questions and systematically covered various areas. These pertained to the respondents' demographic data, factors influencing the decision to book a V/Q scan, contents of the V/Q report and clinical management decisions. The questions have been grouped into themes (indicated by subheadings in bold font) to allow for easier representation of results and a comprehensive discussion of the study.

3.2 Demographic analysis

Questions one to four asked questions relating to respondents' experience and place of work. Figure 3-1 shows the experience category of respondents for each of the hospitals. The majority of respondents were registrars, who made up 68(42%) of the responses overall. Interns and consultants had a similar proportion of responses with overall 37(23%) and 33(20%) respectively. The smallest number of responses was received from the category of medical officer. This included 25(15%) of the overall responses.

Figure 3-1 Experience category of respondents at each hospital



There were 134(83%) respondents who had two or more years of working in clinical medicine. Almost a quarter of respondents were senior clinicians with more than ten years of experience. The largest number of responses were received from registrars with two to five years of experience (Figure 3-2).

Figure 3-2 Number of years of experience post-graduation from medical school

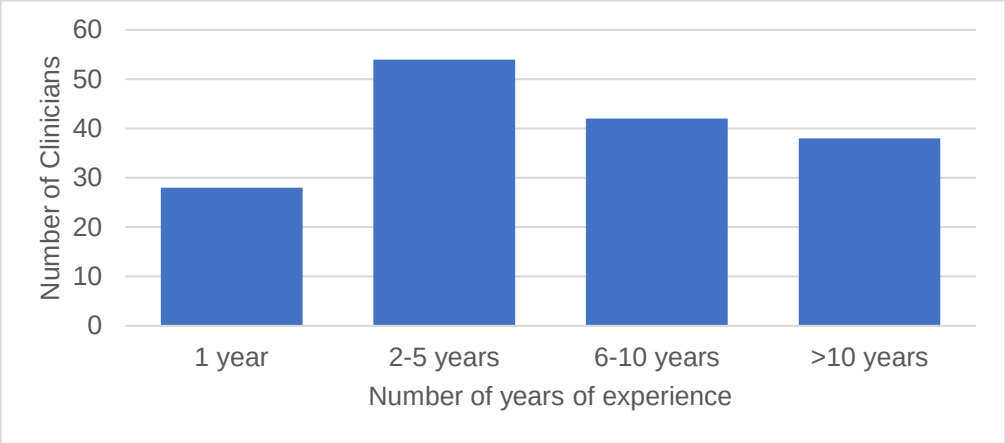


Figure 3-3 shows that the majority of answers were received from clinicians at CHBAH followed by CMJAH.

Figure 3-3 Current Hospital where respondent was based

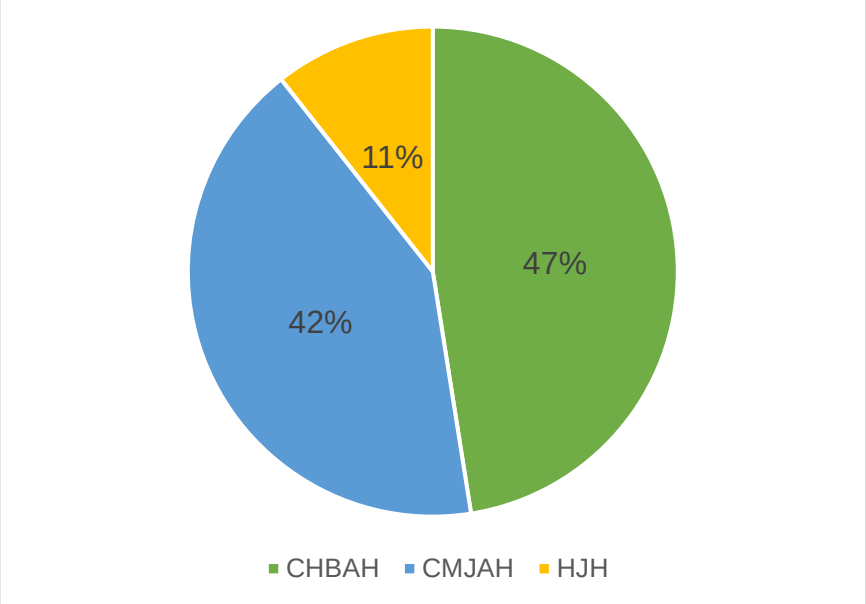
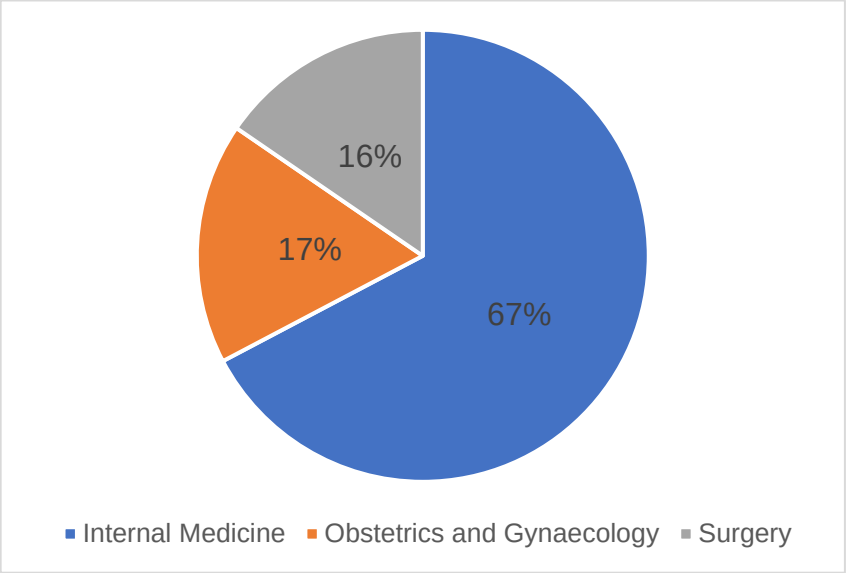


Figure 3-4 illustrates the proportion of responses according to specialty. The majority of responses (67%) were from the internal medicine department. A similar number of responses (16-17%) were received from the O& G and surgery departments.

Figure 3-4 Specialty affiliation of respondent



3.3 Factors to consider when booking a V/Q scan

Questions five and six asked the clinicians to select factors which are considered when booking a V/Q scan to investigate PE. More than one option could be selected. Figures 3-5 and 3-6 illustrate these factors and the number of respondents who chose each option. Renal dysfunction was the most common factor encouraging the selection of a V/Q scan to investigate PE. An abnormal chest radiograph was the most common factor discouraging the selection of a V/Q scan to investigate PE.

Figure 3-5 Factors encouraging clinicians to book a V/Q scan

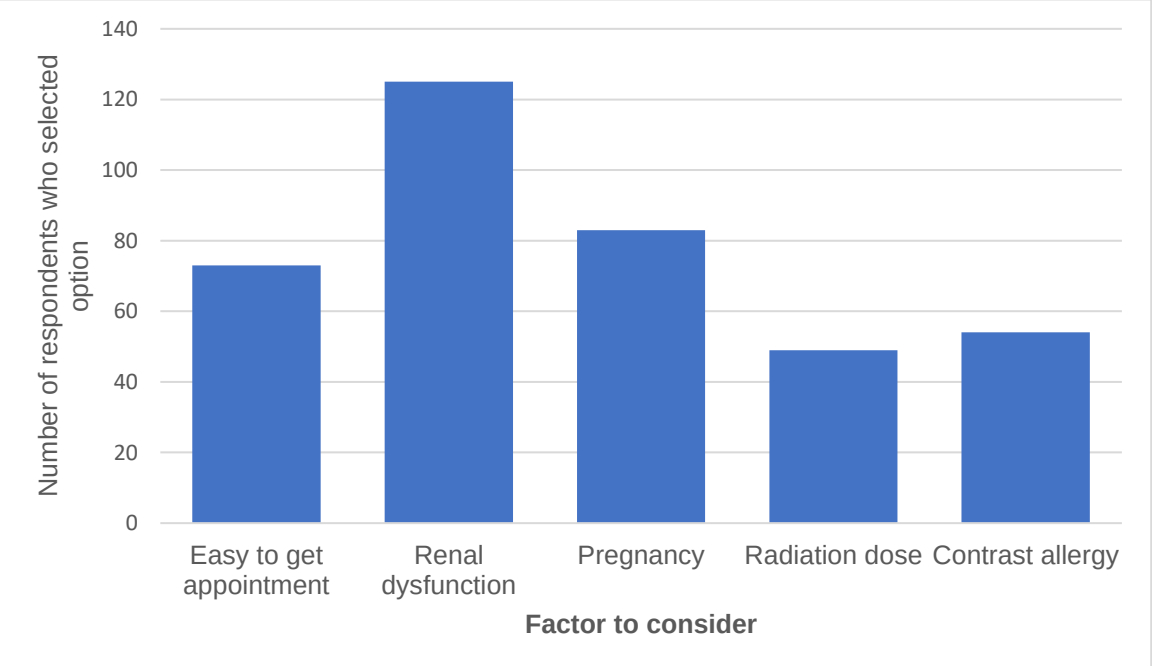
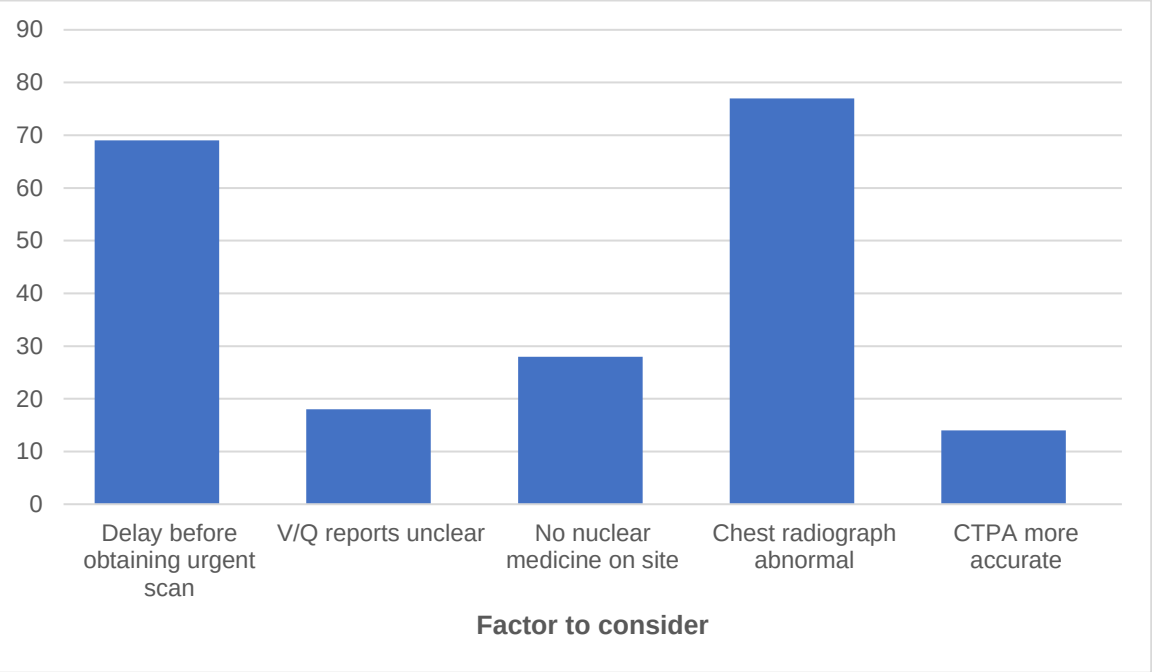


Figure 3-6 Factors discouraging clinicians to book a V/Q scan



3.4 Clinical utility of V/Q scan report

Questions seven and 23 asked if V/Q scans were easy to understand and useful for making clinical decisions. In figure 3-7, the proportions of each experience category and their opinion on the clinical utility of V/Q scans is demonstrated. There were 20(61%) and 13(39%) consultants who found V/Q reports useful most of the time and sometimes respectively. No consultants found V/Q reports to be rarely useful. There were 40(60%) and 24(36%) registrars who found V/Q reports useful most of the time and sometimes respectively. A minority 3(4%) of registrars rarely found V/Q scans to be useful. Responses from medical officers and interns reflected proportions which were similar to each other. These groups had a slightly higher proportion of those who found the reports useful most of the time, compared to the consultant and registrar groups.

Figure 3-7 Opinions on clinical utility of V/Q scan reports per experience category

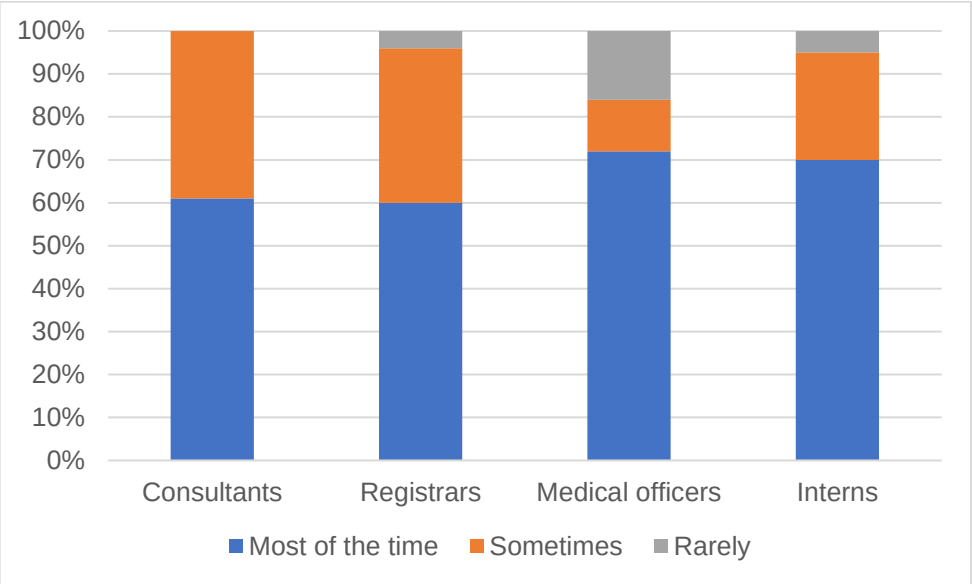
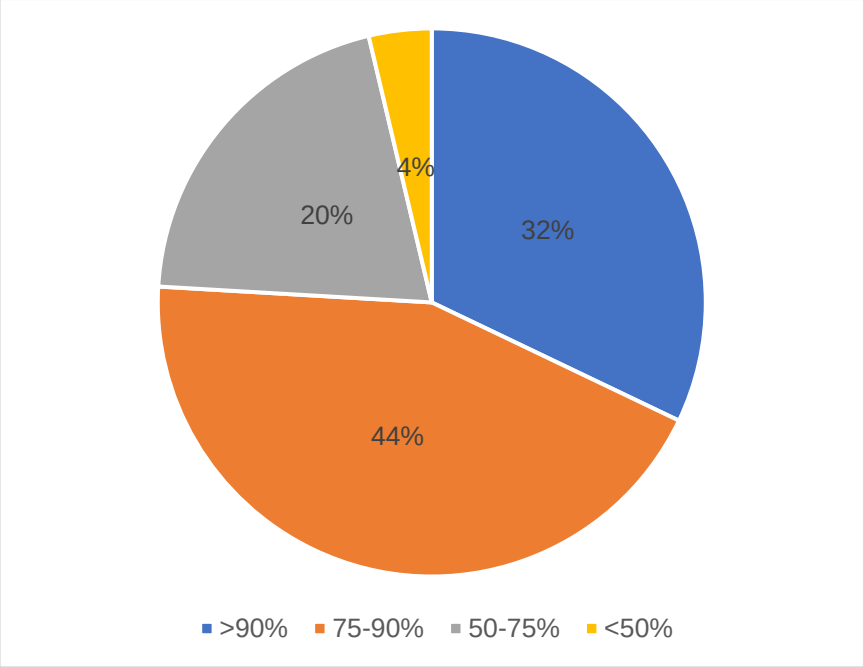


Figure 3-8 shows that 71(44%) clinicians found V/Q reports helpful for making clinical management decisions 75-90% of the time. There were 52(32%) and 32(20%) clinicians who felt this way about V/Q reports > 90% of the time and 50-75% of the time respectively. A small number of respondents 7(4%) found V/Q scan reports to be clinically useful <50% of the time.

Figure 3-8 Frequency of finding clinical utility in V/Q scan report



3.5 Preferred terminology

Questions eight, nine and ten assessed what was the most understandable language to communicate the presence or absence of PE on V/Q scan. Question 14 assessed if numerical or qualitative description of probability of PE was preferred.

The preferred terminology for 81(50%) respondents when there was no PE present was ‘no convincing evidence of PE’. This was followed by 61(38%) clinicians preferring the phrase ‘scan is negative for PE’. This is illustrated in Table 3-1. A minority of respondents preferred the terms ‘normal’ and ‘PE is absent’. When PE is present, the preferred terminology for 86(53%) clinicians was ‘findings consistent with PE’ followed by ‘scan is positive for PE’ for 59(36%) clinicians. The phrases ‘PE present’ and ‘abnormal V/Q scan’ were preferred by a minority. This was consistent in consultant, registrar, medical officer and intern sub-categories.

For a non-diagnostic V/Q report, 111(68%) respondents preferred the term ‘inconclusive’ compared to 43(27%) respondents who preferred ‘indeterminate’. There were 8(5%) clinicians who preferred the term ‘non-diagnostic’. These clinicians all worked in internal medicine. Question ten (best language to describe a non-diagnostic scan) had a statistically significant p-value of 0.028 (indicated with an asterisk).

Approximately two thirds of clinicians would prefer the use of numerical instead of qualitatively described PE probability.

Table 3-1 Preferred terminology by experience category

Variable	Total	Consultant	Registrar	Medical officer	Intern	p-value
Best language to describe no presence of PE						**0.307**
No convincing evidence of PE	81(50)	19(58)	31(46)	10(40)	21(57)	
Normal V/Q scan	13(8)	0	5(8)	2(8)	6(16)	
PE Absent	7(4)	1(3)	4(6)	1(4)	1(3)	
Scan is negative for PE	61(38)	13(39)	27(40)	12(48)	9(24)	
Best language to describe presence of PE						**0.556**
Abnormal V/Q scan	2(1)	1 (3)	0	0	1(3)	
Findings consistent with PE	86(53)	19(58)	34(51)	11(44)	22(59)	
PE Present	15(9)	3(9)	5(7)	2(8)	5(14)	
Scan is positive for PE	59(36)	10(30)	28(42)	12(48)	9(24)	
Best language to describe non-diagnostic scan						****0.028***
V/Q scan inconclusive	111(68)	21(64)	50(75)	19(76)	21(57)	
V/Q scan indeterminate	43(27)	7(21)	15(22)	6(24)	15(40)	
V/Q scan is non-diagnostic for PE	8(5)	5(15)	2(3)	0	1(3)	
Preference for numbers not probability words						**0.129**
Agree	105(65)	19(58)	51(76)	16(64)	19(51)	
Disagree	14(9)	5(15)	2(3)	3(12)	4(11)	
Neutral	43(26)	9(27)	14(21)	6(24)	14(38)	

() Percentages of each category are indicated in parentheses

3.6 Effect of clinicians' interpretation of the presence or absence of venous thromboembolism on further clinical management

Questions 11, 18, 19 and 20 asked the respondents what their next step would be when certain findings and conclusions were reported. Question 22 investigated whether the presence of a DVT raised suspicion of an associated PE. From Table 3-2, it is evident that 72% of clinicians would book a CTPA in the event of an inconclusive V/Q scan. Treatment with therapeutic anticoagulation and repeating the scan was considered an option by 12% of clinicians. When the report mentioned 'features of parenchymal lung disease', 152(93%) of the responses favoured investigating further. If the cardiac outline was reported as enlarged, 88(54%) of the respondents would refer for cardiac evaluation and 72(44%) would do a chest radiograph to confirm the finding. When the clinical index of suspicion for PE was high but the V/Q report was negative, 95 (59%) clinicians would book a CTPA. A third of respondents would consider an alternative diagnosis. A small number of clinicians (8%) would still treat as PE despite the negative report. The p-value for responses to this question was 0.008.

If a doppler ultrasound report confirmed limb DVT, just over half of respondents 89(55%) would not book a V/Q scan as there were no symptoms of PE. There were 39(24%) respondents who would book a V/Q scan to have a baseline for patient management. There were 34 (21%) clinicians who would book a V/Q scan as they believed a concomitant PE should extend the duration of anticoagulation. This group of clinicians included junior doctors predominantly and one consultant. The p-value for answers to this question was 0.001.

Table 3-2 Patient management in response to particular findings

Finding	Total	Consultant	Registrar	Medical officer	Intern	p-value
Inconclusive V/Q scan						**0.180**
Book a CTPA	116(72)	27(82)	42(63)	16(64)	31(84)	
Therapeutic anticoagulation and repeat V/Q scan in 7-14 days	19(12)	2(6)	10(15)	5(20)	2(5)	
Use my clinical judgement and treat as PE	27(16)	4(12)	15(22)	4(16)	4(11)	
Features of parenchymal lung disease						**0.123**
Treat the patient as a pneumonia	8(5)	0	6(9)	2(8)	0	
Investigate further	151(93)	33(100)	60(90)	23(92)	35(95)	
Ignore the comment	3(2)	0	1(1)	0	2(5)	
Cardiac outline enlarged						**0.748**
Confirm cardiomegaly on CXR	72(44)	13(39)	30(45)	14(56)	15(41)	
Refer for cardiac review	88(54)	19(58)	36(54)	11(44)	22(59)	
Ignore the comment	2(2)	1(3)	1(1)	0	0	
High clinical suspicion for PE but scan is negative for PE						****0.008***
Book a CTPA	95(59)	27(82)	32(48)	13(52)	23(62)	
Consider another diagnosis	54(33)	4(12)	32(48)	9(36)	9(24)	
Trust my clinical judgement and treat as PE	13(8)	2(6)	3(4)	3(12)	5(14)	
Doppler ultrasound confirmed limb DVT						****0.001***
Book V/Q scan to extend anticoagulation	34(21)	1(3)	16(24)	4(16)	13(35)	
Book V/Q scan as baseline	39(24)	4(12)	22(33)	7(28)	6(16)	
Not book V/Q	89(55)	28(85)	29(43)	14(56)	18(49)	

() Percentages of each category are indicated in parentheses

3.7 Clinicians' interpretation of terminology used in V/Q scan reports

Questions 12, 13 and 15 assessed the referring clinicians' knowledge of terminology used in the Modified PIOPED II criteria guidelines and their interpretation of particular phrases used in V/Q scan reports. Figure 3-9 shows when a scan was reported as 'high probability of PE', the majority response (94%) was there is >85% chance of PE or definitely PE present. Overall 124 (76%) clinicians considered the likelihood of PE to be >85% when the report mentioned 'high probability of PE'. This included 21(64%) consultants, 26(70%) interns, 21(84%) medical officers and 56(84%) registrars.

Figure 3-9 Interpretation of V/Q scan reported as high probability for PE

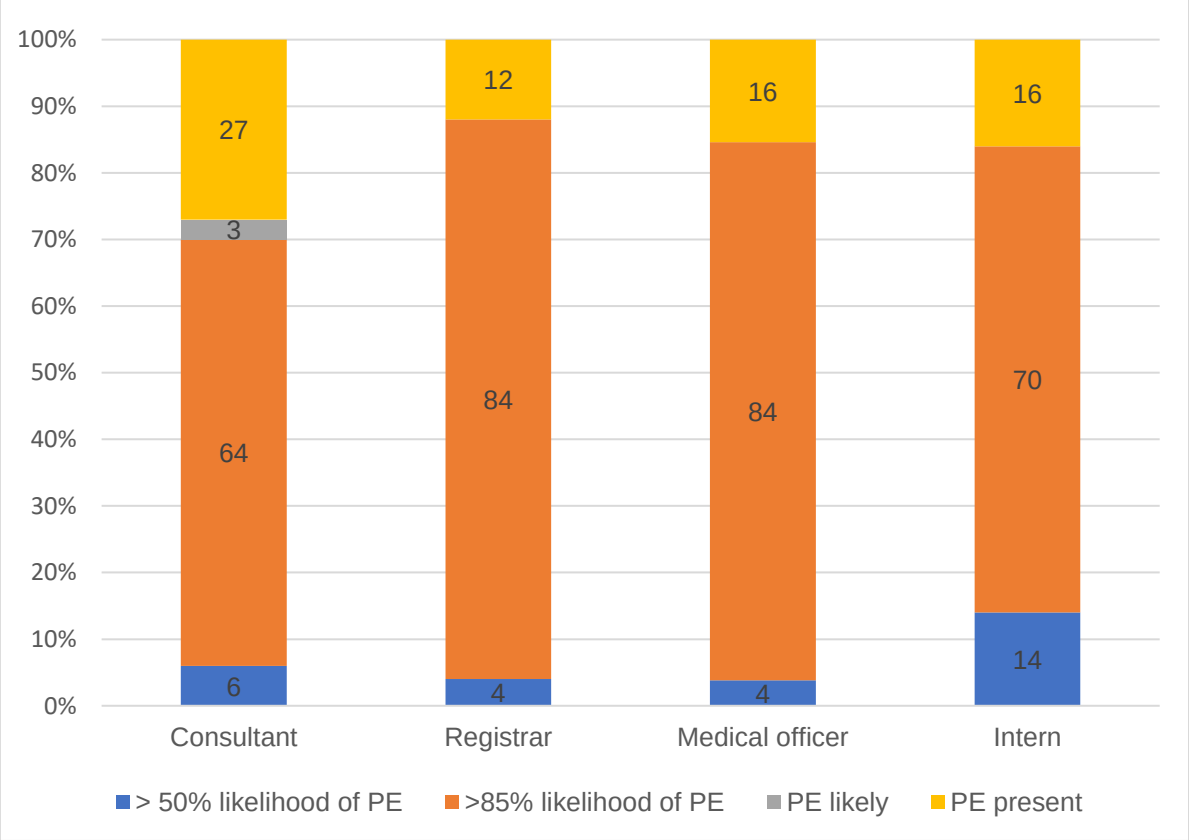
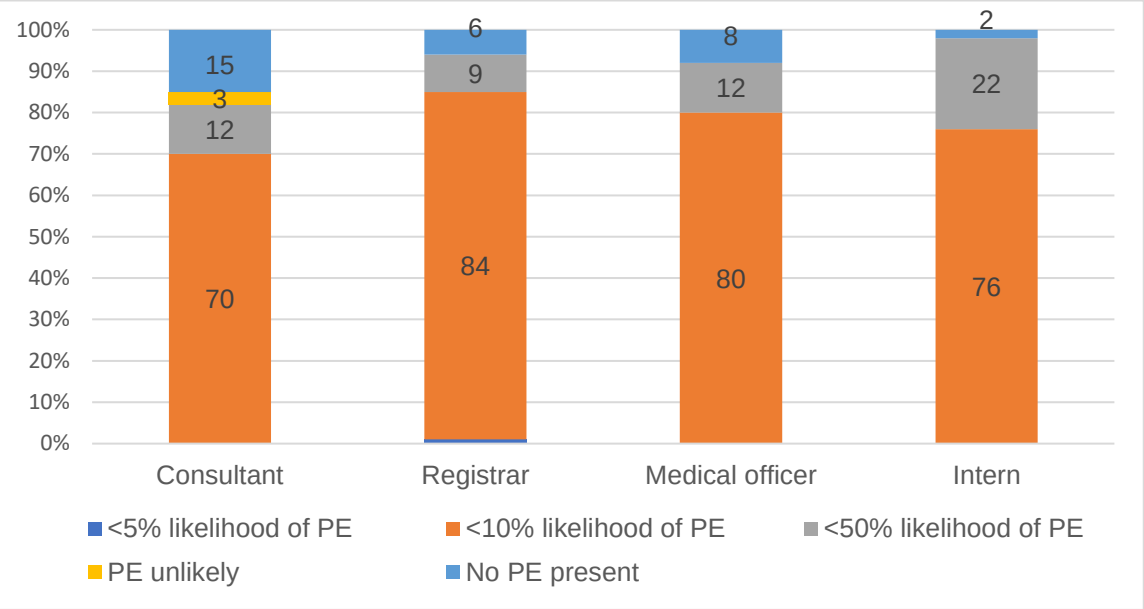


Figure 3-10 shows when a scan was reported as 'low probability of PE', most (87%) referring clinicians interpreted this as <10% chance of PE or definitely no PE present. Overall 127 (78%) clinicians considered the likelihood of PE to be <10% when the report mentioned 'low probability of PE'. This included 23(70%) consultants, 28(76%) interns, 20(80%) medical officers and 56(84%) registrars.

Figure 3-10 Interpretation of V/Q scan reported as low probability for PE



3.7.1 Effect of experience level on interpretation of V/Q scan reports

Figure 3-11 shows that 80% or more clinicians with an experience range of two to five and six to ten years correctly interpreted the meaning of high probability of PE according to the Modified PIOPED II guidelines. For clinicians with one or more than ten years of experience, less than 80% of clinicians had the interpretation correct. Figure 3-12 illustrates that for clinicians with an experience range of six to ten years, 88% had the interpretation of low probability of PE correct according to the guideline. For the rest of the experience categories, 72-79% of clinicians correctly interpreted the meaning of low probability of PE according to the Modified PIOPED II guidelines.

Figure 3-11 Interpretation of V/Q scan reported as high probability for PE by experience in years

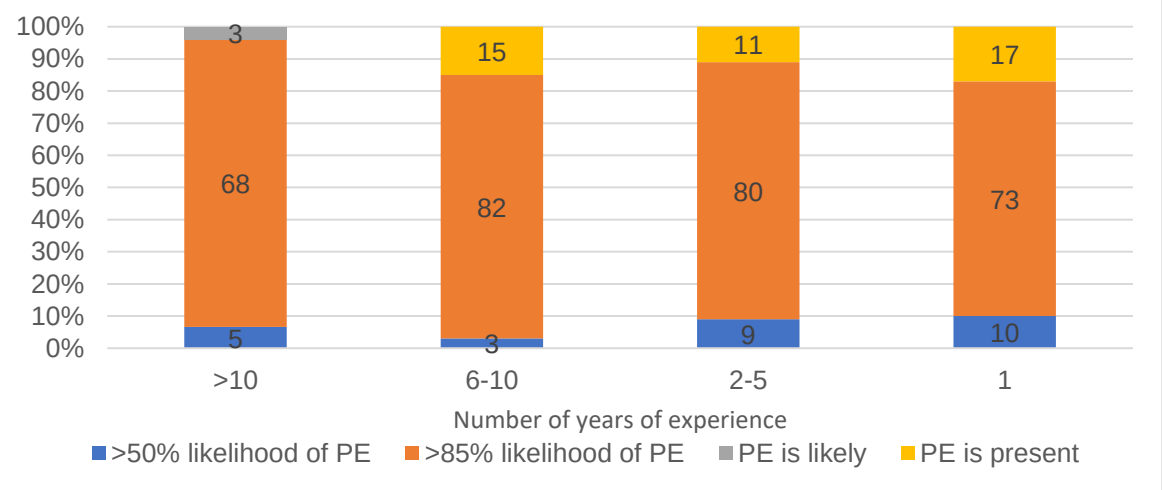


Figure 3-12 Interpretation of V/Q scan reported as low probability for PE by experience in years

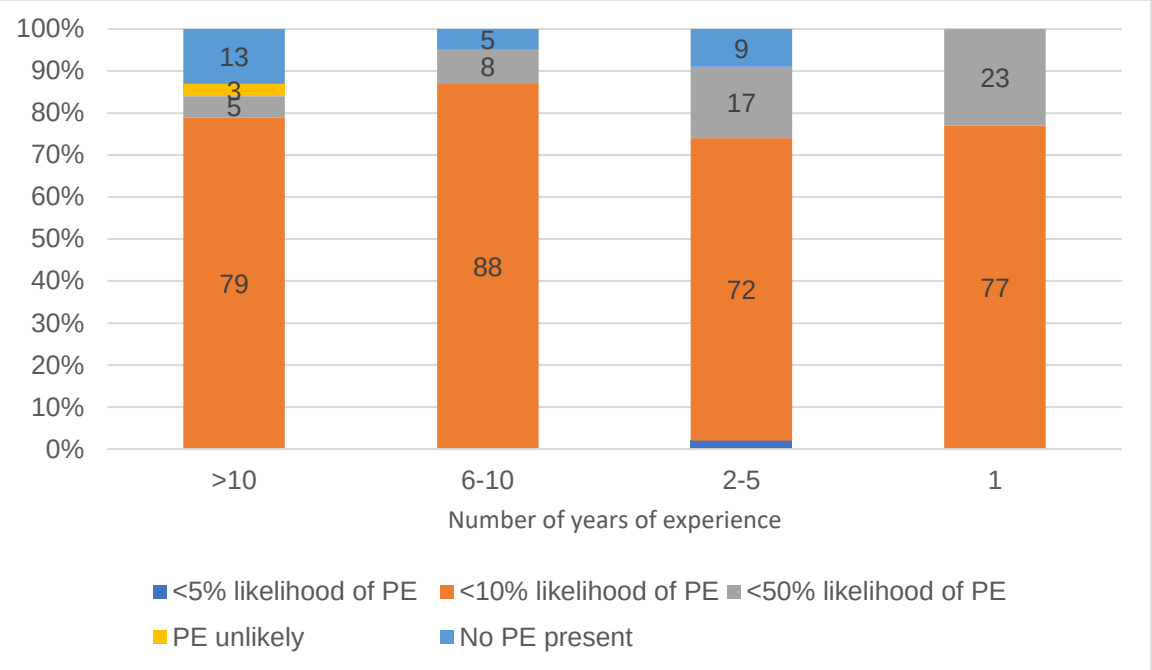
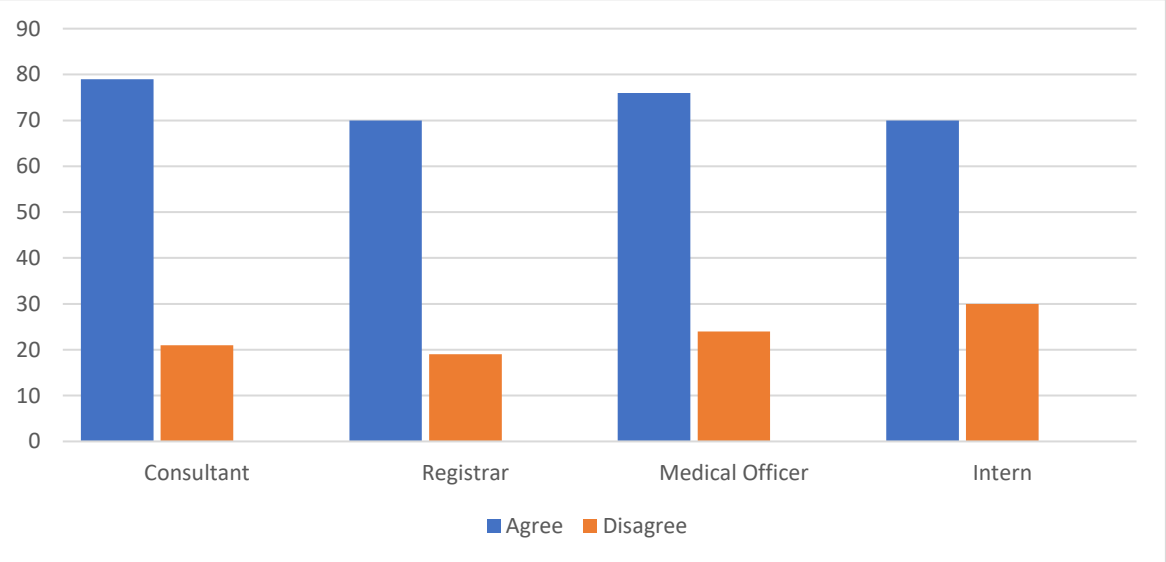


Figure 3-13 shows that the majority of respondents agreed with the statement that a clinically significant PE is ruled out with a normal V/Q scan. The numbers for each category were similar with 26(79%) consultants, 26(70%) interns, 19(76%) medical officers and 54(81%) registrars. Total number of clinicians in agreement was 125(77%). Total number of clinicians not in agreement was 37(23%).

Figure 3-13 Normal V/Q scan rules out PE



3.8 Areas where V/Q scan reports may be improved

3.8.1 Other information found in the V/Q report

Questions 16 and 17 related to information found in the V/Q report other than the conclusion regarding the presence or absence of PE. This includes the 'findings' section of the report which describes all the results on the scan in detail and lists the NM registrar and physician who interpreted the scan. In Table 3-3 it is evident that 91(56%) clinicians do always read the 'findings' section of the report. 62(38%) of clinicians sometimes read this section. There were 9(6%) clinicians who never read the 'findings' section. This included only one consultant and the remainder of these clinicians belonged to other experience categories. The p-value for answers to this question was 0.003.

Table 3-3 Reading the 'findings' section of the report

Variable	Total	Consultant	Registrar	Medical officer	Intern	p-value
Reading the 'findings' section						
Always	91(56)	27(82)	19(51)	7(28)	38(57)	
Sometimes	62(38)	5(15)	14(38)	16(64)	27(40)	
Never	9(6)	1(3)	4(11)	2(8)	2(3)	**0.003**

() Percentages of each category are indicated in parentheses

Figure 3-14 shows that 46% of clinicians rarely and 14% never respectively contact the NM physician if a report is unclear. Some commonly cited reasons for this were:

1. Junior interns would rely on their registrar to clarify the report
2. A direct contact number is not listed on the report and it is time consuming to try to contact the relevant person in the NM department.

Figure 3-14 Contacting the NM physician if the report is unclear

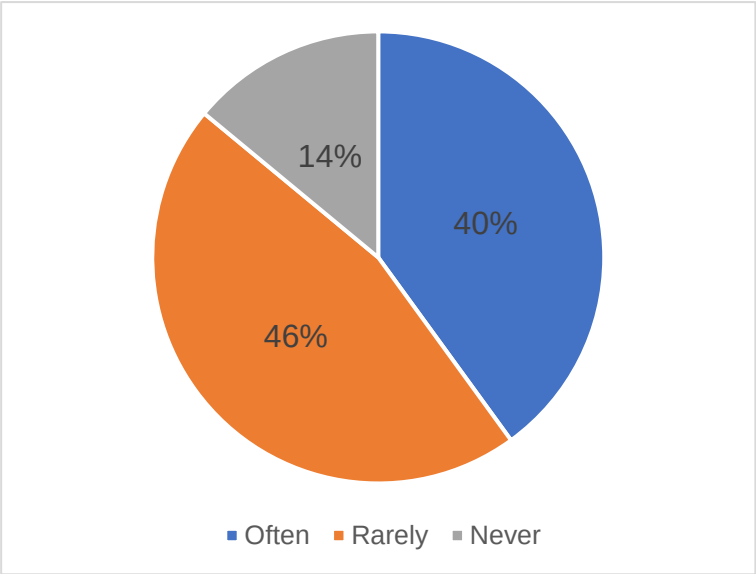
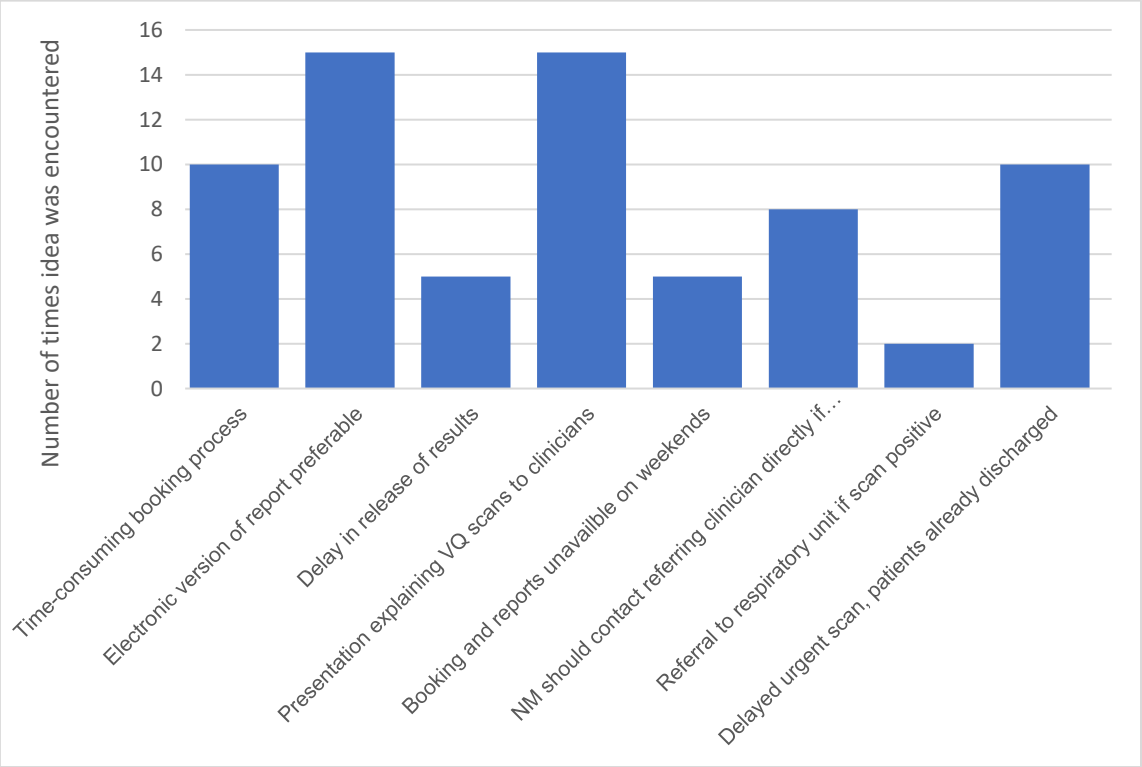


Figure 3-15 represents the qualitative responses to question 24. Any additional comments, questions and suggestions regarding V/Q scans were requested. There were 75 additional comments and some recurring ideas are illustrated beneath.

Figure 3-15 Additional comments, questions and suggestions about V/Q scans



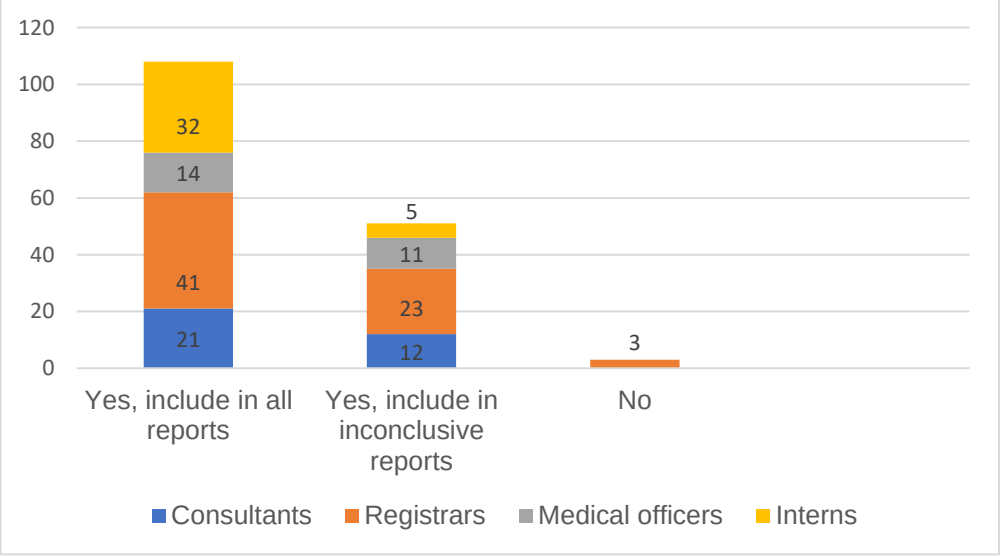
3.8.2 Suggestion of further management by the NM physician

Question 21 investigated whether the clinician wants advice on further management depending on the V/Q scan findings. Figure 3-16 illustrates that most clinicians (98%) do want to receive some advice on suggested further management related to the V/Q scan findings. There were 108(67%) respondents who thought this advice would be useful for all reports, 51(31%) who thought it was necessary for inconclusive scans only and 3 (2%) clinicians who did not want further management advice on the report. The last group all belonged to the registrar category (Figure 3-17). Figure 3-17 also shows that clinicians from all categories did appreciate further management advice and the highest proportion was the registrars.

Figure 3-16 Further management advice



Figure 3-17 Opinion on further management advice by experience category



4 Chapter 4: Discussion

4.1 Response rate

The response rate to the questionnaire was 54%. Data from a review of 9 studies comparing online and paper-based questionnaires showed the overall response rate to be 33% and 56% respectively (36). This study was a mix of both paper-based and online responses. Thus, a response rate of 54% was within the expected range and considered acceptable.

4.2 Demographic analysis

The majority of responses were received from registrars. Feedback from the registrars was considered most important as they predominantly request V/Q scans and treat patients accordingly. Interns were included in the study as they are usually the clinicians who complete the request form and are often the first audience to read V/Q reports. It is necessary for them to understand the meaning of a V/Q report to inform their seniors appropriately. A significant proportion (25%) of respondents were senior clinicians with experience of 10 years or more. Inclusion of various specialties ensured that the study was not biased in favour of those who are familiar with VTE guidelines. The largest number of responses were received from CHBAH which parallels the largest overall number of clinicians employed by the hospital.

4.3 Factors to consider when booking V/Q scans

A secondary objective of this study was to describe factors that encourage or discourage clinicians from requesting a V/Q scan when investigating PE. The most commonly cited reasons for choosing a V/Q scan were renal dysfunction, pregnancy and ease of getting an urgent appointment.

Renal dysfunction is an important factor when selecting a V/Q scan as the use of intravenous contrast for CTPA may cause a contrast induced acute kidney injury (2). In patients with pre-existing renal dysfunction, there may be further deterioration of function and this may lead to a need for dialysis (2). Most clinicians seemed to be aware of this risk.

Pregnancy was another important reason to prefer a V/Q scan and most clinicians were very concerned about minimizing the risk of radiation to foetal development.

However, literature has shown that foetal absorbed radiation doses for CTPA and V/Q scans are similar, and not actually high enough to be considered clinically significant (2,8). Very few respondents who selected this option also selected the option of radiation dose. It is unclear if our respondents associated the risk of radiation to the foetus only or also considered exposure of glandular maternal breast tissue. This may be an area about which clinicians need to be educated since CTPA delivers ten to 20 times greater radiation exposure to the female breast than a V/Q scan (2,8,9). In addition to normal female breast tissue exposure, the increased glandular breast tissue of a pregnant woman is additionally radiosensitive and will receive a higher radiation dose (2,8,9).

Iodine contrast allergy was also a less popular reason to book a V/Q scan. This is understandable as this rare condition can be suppressed with premedication (2).

The most commonly cited reason for not selecting a V/Q scan when investigating PE was an abnormal chest radiograph. Planar V/Q imaging has been shown to have a sensitivity of 67-85% and specificity of 78-93% (3,12). Abnormalities on chest radiograph will reduce the sensitivity and specificity of planar V/Q scans below these values and clinicians involved in our study appear to be well informed of this. The EANM promotes the use of three-dimensional V/Q SPECT technique when imaging the lungs to increase the sensitivity, specificity and accuracy of the test (2,3). It has improved the sensitivity and specificity of V/Q scans to 96-99% and 91-98% respectively, even in patients with abnormal chest radiographs and changes in the lung parenchyma (2,3). The sensitivity and specificity of CTPA is similar to planar V/Q imaging. Sensitivity and specificity of CTPA are between 78-83% and 90-96% respectively (8,9,13). The three-dimensional images of V/Q SPECT have resulted in fewer inconclusive scans. This technique has been found to be particularly useful in suspected PE with a background history of chronic obstructive pulmonary disease, heart failure and pneumonia (2,3). These are conditions in which the chest radiograph is likely to be abnormal. COVID-19 infection will present a similar situation as described earlier. The addition of three-dimensional imaging has assisted us with interpreting scans despite an abnormal chest radiograph. Our study results show that many clinicians may still not be fully aware of this and need to be updated on the previous requirement of a normal chest radiograph.

The next most common reason for not choosing a V/Q scan, stated by just under half of the respondents, is the delay in obtaining an urgent scan. This is worrying as PE is an emergency situation which requires prompt diagnosis and should be prioritized. Our NM department considers V/Q scans to be an urgent investigation and requests are discussed personally with NM physicians. The department strives to perform urgent V/Q scans on the same day or at least within one to two days after the request is made. These results are therefore somewhat unexpected. A few clinicians did report that patients were discharged home by the time they were called for a V/Q scan. This is of concern as even though the scan may not be necessary to initiate treatment in a high probability scenario, it is still necessary to confirm the diagnosis and determine if therapeutic anticoagulation should be continued or stopped.

Very few respondents found V/Q reports to be unclear. Approximately 20% of respondents had experienced difficulty with booking a V/Q scan as there is no NM department on site (as is the case with HJH) or NM and radioactivity was difficult to access after-hours. This is still one of the major advantages of CTPA over V/Q scans that is recognized in the literature (3,8,9).

The higher accuracy of CTPA compared to V/Q scan was not listed as a reason for selecting either modality but it was mentioned by 10% of respondents. This perception of clinicians is incorrect. The sensitivity and specificity of both modalities is similar. Planar V/Q imaging has been shown to have a sensitivity of 67-76% and specificity of 78-85% (3). Sensitivity and specificity of CTPA is similar with values between 78-83% and 84-96% respectively (8,9,12,13). V/Q SPECT has near 100% accuracy and minimal contraindications and is recommended as the investigation of choice for investigating PE (2,3). CTPA is not more accurate than V/Q scan for diagnosing PE but may provide information on other chest pathology such as a pneumothorax, aortic dissection and tumours which may explain the patient's clinical presentation (2). It may thus be more suitable when PE is part of a list of differential diagnoses to explain a patient's symptoms.

4.4 Clinical utility of the V/Q scan report

This study found that the majority of clinicians found V/Q scan reports easy to understand and clinically useful. Very few respondents selected the option 'rarely'. The vast majority (96%) found V/Q reports useful for making clinical decisions > 50%

of the time. These findings are in line with the literature (17,19,24) which found general satisfaction amongst physicians when asked about radiology reporting.

The utility of the V/Q scan report is particularly important when treating patients with COVID-19 infection. The risk of PE increases with hospitalization due to factors including immobilization, sepsis and insertion of venous catheters into large central veins. In addition, COVID-19 infection itself leads to a prothrombotic state and predisposition to VTE (6,14,15). All moderate and severe cases of infection admitted to hospital, should be started on prophylactic anticoagulation to prevent PE. Clinicians should have a low threshold for investigating PE in patients whose clinical picture does not fit with expected findings or those who deteriorate after initial improvement. Appropriate therapeutic anticoagulation can then be initiated earlier.

Prior to the COVID-19 pandemic, D-dimer blood tests were useful to detect products of clot breakdown and an increased risk of VTE. It has now emerged that COVID-19 infection can independently cause elevated D-dimer levels (6). Elevated D-dimer levels have been shown to correlate with disease severity and are a reliable prognostic marker for in-hospital mortality (6). D-dimer levels are therefore routinely done on admission in patients with COVID-19 infection. There has been insufficient evidence to support using an elevated D-dimer level to diagnose VTE in patients with COVID-19 infection. For this reason, the American National PERT Consortium does not recommend the use of elevated D-dimer levels to diagnose PE and instead advises the use of standard diagnostic testing (CTPA and V/Q scan) (6).

4.5 Preferred Terminology

The modified acquisition of lung scans due to the COVID-19 pandemic has also resulted in our department modifying our reporting style over the past one and a half years. We have changed to use of the Perfusion-only Modified PIOPED II system predominantly. This includes categories of PE present, PE absent and nondiagnostic for PE, instead of using probabilities of PE. The conclusions in our reports have changed accordingly.

This study showed that only four to nine % of respondents preferred the conclusion of ‘PE is absent’ or ‘PE is present’. Yet this is the terminology used in the guidelines for the Perfusion-only Modified PIOPED II system. All responses to this study were

collected after the COVID-19 pandemic began and our reporting style had changed. Farmer et al (17) found that radiology guidelines rarely consider preferences for reporting expressed by clinicians and this leads to confusion. The terms ‘absent’ and ‘present’ are straightforward to understand and it is more likely that clinicians prefer the other terms due to linguistic preference rather than clarity of meaning. Clinicians may also prefer probabilities as this is the reporting system that they have become accustomed to. Whilst it is important to consider the clinicians’ preference as they are the end users, it is also important to follow guidelines and standardize the use of terminology to avoid confusion.

Approximately half of respondents favoured the terminology ‘no convincing evidence of PE’ when there was no PE present. They also preferred the statement ‘findings consistent with PE’ when PE was present. This is contrary to Hartung et al (18) who suggest minimal use of terms of perception and avoiding redundancy. They are of the opinion that words such as ‘is visualized’ or ‘there is evidence of’ may be omitted without a change in meaning of the report. They argue that a subheading reading ‘findings’ is adequate to imply something was visualized or evidence of it was found and redundant words do not need to be included. A third of respondents preferred the direct descriptions of ‘scan is negative for PE’ or ‘scan is positive for PE’.

For a non-diagnostic V/Q report, two thirds of respondents preferred the term ‘inconclusive’. Only five % of clinicians preferred the term ‘non-diagnostic’ which is the language used in the Modified PIOPED II and PISAPED guidelines. These clinicians all worked in internal medicine and were predominantly consultants. The p-value when analysing this question was statistically significant (p-value 0.028). This indicates that preference for the term ‘non-diagnostic’ was not simply a random language preference but rather due to familiarity with the guidelines and terminology. No other specialties chose this unusual option. Unlike the words ‘absent’ and ‘present’, the term ‘nondiagnostic’ is not common language. There is also a wide range of scan findings that will result in a nondiagnostic scan and the guidelines cannot elaborate on each one. In nondiagnostic cases, the use of an easily understood alternative term (such as ‘inconclusive’) may avoid confusion. Approximately two thirds of clinicians would prefer the use of numerical instead of qualitatively described PE probability. These findings are in line with the literature which advocates for less use of technical language (18,19,24). They also support the

inclusion of an explanation or standardized lexicon to clarify the meaning of reports, as advocated by Panicek and Hricak (27).

4.6 Effect of clinicians' interpretation of the presence or absence of VTE on further clinical management decisions

The clinicians' interpretation of the presence or absence of VTE will affect further investigation and clinical management of a patient. For inconclusive findings on V/Q scan, majority of the respondents (72%) would investigate further with CTPA (if there were no contraindications). However, if a CTPA is contraindicated then another strategy needs to be employed. The NM physician takes into account the pre-test probability of PE and contraindications to the performance of CTPA, before suggesting a course of action. Very few respondents (12%) selected the option of treating with therapeutic doses of anticoagulation and repeating the perfusion-only scan in 7-14 days to assess for resolution of defects. Resolution of defects will indicate that fibrinolysis has occurred and a diagnosis of PE is likely. This is an option for further imaging that may have utility when CTPA is contraindicated due to renal dysfunction, pregnancy or contrast allergy (28). The interval between the initial non diagnostic scan and repeat perfusion scan is not specifically recommended in any PE management guidelines. Initial fibrinolysis begins within 24 to 72 hours of thrombus formation (4). Even though complete fibrinolysis will take much longer, some noticeable restoration of perfusion is expected at seven to 14 days after anticoagulation is initiated. If CTPA is not absolutely contraindicated and the concern is more for avoiding radiation exposure (e.g. young female with radiosensitive breast tissue), this approach may also be suitable. The NM physician would have to include this recommendation in the report to make the clinician aware of possible courses of action that may not necessarily follow a strict diagnostic algorithm.

Usage of the phrases 'features of parenchymal lung disease' and 'cardiac outline is enlarged' in the body of the report led to further investigation and consideration of other diagnoses besides PE by most (93 and 98%) of the respondents. Only three (2 %) respondents would ignore the comments. This is in agreement with Lukaszewicz et al (24) who found that nearly all physicians felt obligated to further investigate abnormal findings mentioned in the report.

The performance of CTPA during the COVID-19 pandemic has been encouraged by many institutions to avoid virus transmission during the ventilation part of V/Q studies (6,14,15). Other institutions have recommended performing perfusion-only studies and omitting the ventilation imaging. Perfusion-only scans have a lower positive predictive value for PE (14). The lung changes due to acute COVID-19 pneumonia or post infection fibrotic changes also result in the chest radiograph or CT scan showing features of parenchymal lung disease. These changes may be quite extensive. This will decrease the sensitivity and specificity of the test (20). Although the addition of SPECT images or radiographic (chest radiograph or CT) images will increase the sensitivity, specificity for PE remains low in these patients (14,15). For this reason, some institutions will insist on a full V/Q study in all patients before a conclusion can be reached. In our setting, a shortage of appropriate personal protective equipment and the availability of only one or two gamma cameras means a full study is not always practical. The application of Bayes' Theorem (described in the initial chapter) and an increased pre-test likelihood of PE becomes very important for increasing the positive predictive value of the perfusion-only scan (14,15).

In this study, a negative V/Q scan in the context of a high clinical pre-test probability led most clinicians to consider an alternative diagnosis. However, there were still one in five clinicians who would either further investigate with CTPA or treat the patient as a confirmed PE. The p-value for the analysis of this question was statistically significant (p-value 0.008). This indicates that a significant number of clinicians still would not trust or understand the negative predicative value of a V/Q scan and would intentionally investigate further. This potentially exposes the patient to unnecessary further radiation and anticoagulation. Education of clinicians about the negative predictive value of V/Q scans is thus important. An efficient way to reach all clinicians reading the report may be to include a statement at the end of the report explaining the implication of a negative V/Q scan.

We anticipated that clinicians may not investigate for PE in the setting of confirmed limb DVT. This study found that just over half (55%) of respondents would not book a V/Q scan in this setting. A fifth of respondents (21%) would book a V/Q scan but for the wrong reason. They would inappropriately extend the duration of anticoagulation in the presence of PE. For this study, only 24% of respondents would correctly book a V/Q scan as a baseline in the setting of limb DVT.

Despite the high negative predictive value of V/Q scans, it must be remembered that there are rare occasions when the imaging report and clinical picture do not match. Krupinski (32) emphasized that human factors may ultimately affect the diagnostic accuracy of the test. Fatigue, strenuous workload and clerical errors resulting in incorrect patient details being assigned to a report, can all result in human error when interpreting images. Therefore, it may be prudent to investigate further or treat and repeat an investigation when the imaging report and clinical picture do not match.

4.7 Clinicians' interpretation of terminology used in V/Q scan reports

Clinicians' interpretation of terminology used in V/Q scan reports was assessed according to their understanding and knowledge of terminology used in the Modified PIOPED II criteria guidelines. Use of the specific term 'PIOPED criteria' was omitted in the questionnaire as many clinicians are not expected to be familiar with this terminology. When we are able to acquire both ventilation and perfusion images, our NM department predominantly uses this system for reporting routine V/Q scans. According to these guidelines, a high probability scan equates to >85% likelihood of PE (8) and a very low probability of PE on scan translates to <10% likelihood of PE (8). A normal V/Q scan excludes clinically significant PE irrespective of the pre-test diagnosis (8,9,22).

Most clinicians correlated the numerical likelihoods with the phrases correctly and understood the terms of the Modified PIOPED II criteria as intended. The correct interpretation of a high probability of PE scan in this study was found amongst 94% of respondents. This reflects findings by Gray et al (22) in their keynote article on lung scan interpretation. They found that 97% of clinicians understood the intended meaning of a high probability scan. However in their study, Gray et al (22) found that for a low probability scan, 43% of respondents still considered the diagnosis of PE uncertain or had a working diagnosis of PE. In contrast, this study found that for a low probability scan, only 13% of respondents would consider the diagnosis uncertain or still consider a working diagnosis of PE. A possible reason for this may be that since the time of the keynote study, the initial PIOPED criteria for low probability of PE (20% probability of PE) have been refined to increase the specificity.

Gray et al (22) found that only a third of physicians equated a normal lung scan with the phrase ‘PE highly unlikely’ and would not use anticoagulation. This may have been due to the high negative predictive value of a normal V/Q scan not being well recognized outside the NM specialty at that time. In our study, 77% (125) of clinicians agreed that a normal V/Q scan ruled out a clinically significant PE and would not use anticoagulation in these patients. Whilst the majority of clinicians in our study do realize the negative predictive value of a normal V/Q scan, there are still one in five clinicians who do not. These clinicians would presumably expose patients to additional radiation, unnecessary anticoagulation or overlook other potential diagnoses.

4.7.1 Effect of experience level on interpretation of V/Q scan reports

The experience and knowledge level of the clinician can influence their understanding of the medical report. Familiarity with PE investigation guidelines and commonly used phrases in reports is likely to be different depending on the frequency with which PE is encountered. For this study, experience level was categorized as intern, medical officer, registrar or consultant. The approximate number of years of experience for each category was one, two to five, six to ten and greater than ten years respectively.

Our study found that overall, 77-78 % of clinicians understood the intended meaning of the Modified PIOPED II guidelines. When correct answers were broken down into each experience category, registrars and medical officers scored the highest with 76-84% of each group answering correctly. The intern group had 70-76% of the group answering the questions on the guidelines correctly. The consultant group had 64 - 79% of the group answering the questions related to guidelines correctly. Consultants who did not select the correct likelihood of PE, were then more likely than the other groups to select the clearly stated options of PE present or absent instead of another likelihood option. This may be due to their experience level giving them the insight and confidence to commit to or rule out a diagnosis. This supports what Hartung et al (18) advise on how to create a great radiology report. They acknowledge that whilst the technical elements of a report are essential for the imaging specialist to assess a scan, the referring clinician is instead looking for a clear diagnosis or a differential diagnosis so that they can move on with the management of the patient.

4.8 Areas where V/Q scans may be improved

4.8.1 Other information found in the V/Q report

The results of this study showed 91(56%) clinicians do always read the 'findings' section of the report and 62(38%) of clinicians sometimes read this section. Overall, 94% of respondents did read the 'findings' section of the V/Q report either sometimes or always. The p-value for the analysis of this question was statistically significant (p-value 0.003). This underlines the importance of paying attention to what is included in this section, as almost all clinicians do choose to read this section despite their main interest being the conclusion section of the report. Very few respondents preferred the term 'abnormal V/Q scan' in the event of PE being present. This suggests that respondents understood that abnormal findings on a V/Q scan do not necessarily translate into PE being present and may represent other diagnoses. The challenge is to be clear and concise whilst also putting enough detail into this section so that the reader can have a clear picture of what the scan showed.

This study showed that two thirds of respondents rarely or never contacted the NM physician if they were unsure of a report. Junior clinicians tended to rely on their seniors to clarify a report and decide on further management. Several clinicians mentioned that although the name of the NM physician is listed, there is no direct contact detail listed. Busy clinicians may not have time to contact the NM department and then search for the relevant person who reported the scan. The practical implication of this lack of interaction with clinicians is that V/Q reports must be clear, unambiguous and standardized. Hartung et al (18) described the radiology report as the conversation the radiologist has with the referring clinician when physical interaction is not possible. It is thus worthwhile to review the report carefully to ensure it makes sense and communicates the findings clearly. Inclusion of the name and direct contact number of the reporting NM physician will encourage discussion between clinicians and NM physicians when the scan findings are indeterminate, unexpected or unclear.

4.8.2 Suggestion of further management by the NM physician

Most clinicians were in favour of receiving some advice on suggested further management related to all V/Q scan findings. They included clinicians from all

experience categories. This was consistent with the literature (24,26,31). Lukasewicz et al (24) found that a majority of physicians wanted specific recommendations on further imaging and follow up and would appreciate a time frame. They promote the use of a structured report with a dedicated ‘recommendations’ section. Lukasewicz et al (24) also emphasized that the way in which recommendations are phrased will determine if the clinician follows them. They found that most clinicians would follow recommendations if they were stated outright. However, if terms such as ‘if clinically indicated’ were used, less than half of clinicians felt obliged to follow them.

Only 75 (46%) clinicians had additional comments. This was a missed opportunity for getting feedback from the end-user which the literature encourages to meaningfully improve radiology reports (17,19,24,30). Aside from the factors mentioned above, common themes in the additional comments were academic presentations on V/Q scans and the collection of reports. A few clinicians felt that a presentation on V/Q scans would educate clinicians on how to make the best use of them. Many clinicians also suggested making the reports available on a Picture Archiving and Communication System (PACS). Currently, the NM department is able to load images but not reports onto the PACS system at CHBAH and CMJAH. This has no utility for clinicians and the NM department is working on making the reports database accessible to clinicians in practical locations. This will save a lot of time for clinicians, prevent unnecessary anticoagulation and avoid missed diagnoses of PE. It is also a wise direction to move to electronic archiving as recent experience at CMJAH with a devastating fire has shown how paper records can be destroyed within a few hours.

4.9 Limitations of the study

1. Data collection was done during the COVID-19 pandemic when face to face academic meetings were minimized. This caused missed opportunities to survey additional potential respondents and may have resulted in a lower response rate and smaller sample size.
2. Clinicians are understandably very busy and with the additional strain of the COVID-19 pandemic, some clinicians gave a very brief response to the last question which required a written or typed response. This restricted the meaningful feedback received on how to improve V/Q scan reports.

3. The respondents were limited to clinicians from the main academic hospitals affiliated with the University of the Witwatersrand. However, our NM department receives a number of V/Q scan referrals from smaller outlying hospitals. These clinicians were not surveyed and they are the group that may find it difficult to clarify V/Q scan reports as it is not possible simply to walk to the NM department and discuss a case. An assessment of this group in a future study is important to fully achieve the objectives of this study.

4.10 Recommendations

1. Preferred terminology: The use of clear and direct phrases relating to the presence or absence of PE is suggested. The V/Q scan which is considered non-diagnostic should be described as inconclusive. Very few clinicians preferred the term ‘non-diagnostic’ over an ‘inconclusive’ scan. The numerical value of likelihood ratios should be added in parenthesis to phrases such as ‘high’ and ‘low probability for PE’ to avoid any confusion.
2. Suggested further management: Inclusion of a suggested management plan (especially for inconclusive scans) should continue to be included in the conclusion. However, it should also be noted that clinical context will always guide definitive management.
3. Continuous Medical Education Program: An annual update on V/Q scans and the implication of reports should be incorporated into the academic programs of departments which frequently refer patients for V/Q scans. Clinicians need to be educated on the value of providing the pre-test clinical probability for PE and a recent chest radiograph. A review of what changes have occurred in V/Q scan interpretation during the COVID-19 pandemic will be useful for all clinicians to facilitate better understanding of reports and encourage the appropriate use of this investigation.
4. Emergency Bookings: A better system to accommodate clinicians who frequently book emergency V/Q scans (internal medicine and obstetrics) needs to be investigated. This will avoid waiting for many days before a V/Q scan is done and assist with planning clinical management.

4.11 Conclusion:

This research study set out primarily to assess the referring clinicians' interpretation of terminology and jargon used in V/Q scan reports. Since minimal interaction with clinicians occurs after the V/Q scan has been performed, the NM department had very little indication of how clinicians interpret our reports and if this affects clinical management decisions. Furthermore, limited data on the interpretation of medical reports by clinicians in the South African context has been published. We assessed referring clinicians' knowledge of the Modified PIOPED II criteria guidelines and their interpretation of particular phrases used in V/Q scan reports. We found that the majority (77-78%) of respondents understood the guidelines as intended.

Clinicians from various experience levels receive our reports and we expected interpretation to be affected by experience category. We found that medical officers and registrars were the groups most likely to interpret the Modified PIOPED II criteria guidelines as intended with specific likelihood ratios. Consultants were the group with the highest number of responses favouring decisive conclusions of PE present or absent. Medical officers, registrars and consultants all had similar proportions (76-81%) of understanding the negative predictive value of V/Q scans. The intern group had a slightly lower proportion than the other groups. This was not statistically significant (p value >0.05).

The clinicians' interpretation of the presence or absence of venous thromboembolism will impact clinical management decisions. This study found that scans with inconclusive findings, features of parenchymal lung disease and cardiomegaly would result in further investigation by a majority of clinicians.

The secondary objective of this study was to describe how V/Q scan reports may be improved to facilitate clearer communication of findings to the clinician. Some of the preferences of clinicians reading our reports were investigated. Preferred terminology and expressions of likelihood were determined. Our study showed that most clinicians appreciated some suggestion of further management depending on the scan findings.

Some of the factors encouraging and discouraging clinicians to choose a V/Q scan for investigating PE were also determined. Renal dysfunction and pregnancy were factors in favour of selecting a V/Q scan as anticipated. However, our findings

suggest that radiation dose is an overlooked factor and clinicians need to be educated about this. An abnormal chest radiograph and prolonged waiting period before the scan is performed were discouraging factors for clinicians as expected. It was found that clinicians may be unaware of the advantages of three-dimensional imaging in certain situations when the chest radiograph is abnormal.

The COVID-19 pandemic has had a profound impact on the way we practise medicine and the investigation of PE is just one such instance. Although we did not set out specifically to determine the impact of the pandemic on V/Q reporting, this study has highlighted that it has had an inevitable impact. This study will assist us to improve on the deficiencies in our V/Q reporting system, so that we can deliver reports with maximal clinical utility to our referring clinicians. It will help in improving the management of a serious condition which often has an evasive diagnosis.

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APPENDIX A

Ethics Clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Ayesha Ismail

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200320

NAME: (Principal Investigator)	Dr Ayesha Ismail
DEPARTMENT:	Radiation Sciences/Nuclear Medicine Charlotte Maxeke Johannesburg Academic Hospital Chris Hani Baragwanath Academic Hospital Helen Joseph Hospital
PROJECT TITLE:	Clinicians' Interpretation of Ventilation/Perfusion (V/Q) scan reports
DATE CONSIDERED:	27/03/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof MDTW Vangu, Dr S Dhoodhat and Prof M Wong
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	17/07/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

APPENDIX B

Ethics clearance amendment

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

2020/10/13

Dr A Ismail
School of Clinical Medicine
Department of Radiation Sciences
Division of Nuclear Medicine
Medical School
University

Sent by e-mail to: 03000044Y@students.wits.ac.za

Dear Dr Ismail

Re: **Protocol Ref No: M200320**
Protocol Title: *Clinicians' interpretation of ventilation/perfusion (V/Q) scan reports*
Principal Investigator: Dr A Ismail

Thank you for your letter of 2020/09/29.

I confirm that we have noted and approve of your proposal to conduct your survey online, to largely replace the distribution and collection of paper copies.

Thank you for keeping us informed.

Yours Sincerely

J. Burns

Mr I Burns
For the Human Research Ethics Committee (Medical)

CB Penny

Dr CB Penny, Chairperson, Human Research Ethics Committee (Medical)

APPENDIX C

Permission letters from hospital CEOs (CMJAH, CHBAH and HJH)

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:
Ms. N. Mzila
Office of the Clinical Director
Email: Nolwazi.Mzila@gauteng.gov.za
Tell: (011): 488-4812
5th May 2020

Dear Dr. Ayesha Ismail

STUDY TITLE: Clinicians' Interpretation of Ventilation/Perfusion (V/Q) Scan Reports

Permission to conduct above mentioned study is provisional approved. Your study can only commence once Ethics approval is obtained. Please forward a copy of your Ethics Clearance Certificate as soon as the study is approved by the Ethics Committee for the CEO's office to give you the final approval to conduct the study.

Supported / not supported

Dr. P. Africa
Acting - Clinical Director
DATE: 07/05/2020

Approved / not approved

Ms. S. Bogoshi
Chief Executive Officer
DATE: 10-05-2020

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 6th May 2020

TITLE OF PROJECT:

Clinicians' Interpretation of Ventilation/Perfusion(V/Q) Scan Reports

UNIVERSITY: Witwatersrand

Principal Investigator: Dr A Ismail

Department: Nuclear Medicine

Supervisor : Prof Vangu / Prof Wong

Permission Head Department (where research conducted): Yes

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- **Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.**
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

.....
Recommended
(On behalf of the MAC)
Date: 6/5/2020

.....
Approved/~~Not Approved~~
Hospital Management
Date: 07/05/2020

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Gauteng Department of Health
Helen Joseph Hospital
Enquiries: Dr. M. Mukansi
Research Committee: Chairperson
Tel :(011) 489-0306/1087
Fax :(011) 489 1038
E mail:Murimisi.mukansi@wits.ac.za

21 May 2020

To whom it may concern

Subject: HELEN JOSEPH HOSPITAL RESEARCH COMMITTEE APPLICATION

PROTOCOL TITLE: Clinician's interpretation of ventilation /perfusion (V/Q) scan reports.

Protocol Ref No: Ayesha Ismail

Ethics Clearance: Pending

Principal investigator: Ayesha Ismail

Department: Internal Medicine

Committee Recommendations
The Committee is giving you Conditional access while awaiting the final ethical clearance certificate from the University of Witwatersrand HREC.

It is the duty of the researcher to collect the data to the relevant department after the Research Committee approved the study.

Dr. M. Mukansi
Chairperson of HJH Ethic and Research Committee

APPENDIX D

Permission from the Head of School to conduct the study

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

WITS SCHOOL OF CLINICAL MEDICINE

15 October 2020

To Whom It May Concern

Re: CONSENT FORM TO ADMINISTER ONLINE QUESTIONNAIRE IN THE WITS SCHOOL OF CLINICAL MEDICINE: DR AYESHA ISMAIL (STUDENT NUMBER 03000044Y) – MMed RESEARCH TITLE: "CLINICIANS' INTERPRETATION OF VENTILATION/PERFUSION (V/Q) SCAN REPORTS", UNIVERSITY OF THE WITWATERSRAND

I hereby consent that Dr Ayesha Ismail can administer an online questionnaire for staff members in the Wits School of Clinical Medicine on condition that the Ethical clearance certificate for the study and a Permission Letter from the Registrar have been obtained.

Yours sincerely

Professor Daynia Ballot
Head of School: Clinical Medicine
Faculty of Health Sciences
University of the Witwatersrand

SCHOOL OF CLINICAL MEDICINE
7 York Road, Parktown, 2193
Tel +27 11 717 2038
Fax +27 11 717 2469
Faculty of Health Sciences / University of the Witwatersrand

APPENDIX E

Permission from the University Deputy Registrar to conduct the study

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

OFFICE OF THE DEPUTY REGISTRAR

29 October 2020

Ayesha Ismail
Student number (0300044Y)
MMed (Nuclear Medicine
School of Clinical Medicine

TO WHOM IT MAY CONCERN

"Clinicians' Interpretation of Ventilation/Perfusion (V/Q) scan reports"

This letter serves to confirm that the above project has received permission to be conducted on University premises, and/or involving staff and/or students of the University as research participants. In undertaking this research, you agree to abide by all University regulations for conducting research on campus and to respect participants' rights to withdraw from participation at any time.

If you are conducting research on certain student cohorts, year groups or courses within specific Schools and within the teaching term, permission must be sought from Heads of School or individual academics.

Ethical clearance has been obtained. (Protocol number: **M200320**)

Research duration: (6 months)

Nicoleen Potgieter
University Deputy Registrar

APPENDIX F

Ventilation, Perfusion and Radiographic Interpretive Criteria for Pulmonary Embolism			
PIOPED	**Modified PIOPED II**	**Perfusion-only modified PIOPED II**	**Perfusion-only PISAPED**
High likelihood ratio	**High likelihood ratio**	**PE Present**	**PE Present**
>2 large mismatched (V:Q) segmental defects	≥2 large mismatched (V:Q) segmental defects	≥2 large mismatched (Q:CXR) segmental defects	≥1 wedge-shaped Q defects
Intermediate likelihood ratio	**Nondiagnostic**	**Nondiagnostic**	**Nondiagnostic**
2 moderate or 1 large mismatched (V:Q) defect Difficult to categorize as high or low	All other findings	All other findings	Cannot classify as PE-present or PE-absent
Low likelihood ratio			
Nonsegmental Q defects			
Q defect substantially <CXR defect			
Matched V:Q defects, CXR negative			
Any number of small Q defects			
Normal	**Very low likelihood ratio**	**PE Absent**	**PE Absent**
No Q defects	Nonsegmental Q defect < CXR lesion	Nonsegmental Q defect < CXR lesion	Non-wedge-shaped Q defect
	1-3 small segmental defects	1-3 small segmental defects	Contour defect caused by enlarged heart, mediastinum or diaphragm
	Solitary matched (V:Q:CXR) defect (≤1 segment) in mid or upper lung	Solitary matched (Q:CXR) defect (≤1 segment) in mid or upper lung	Near normal Q Normal Q
	Stripe sign	Stripe sign	
	Solitary large pleural effusion	Solitary large pleural effusion	
	≥2 matched (V:Q) defects, regionally normal CXR		
	Normal		
	No Q defects		
V:Q = Ventilation-Perfusion; CXR = Chest radiograph; PE = Pulmonary Embolism			

Adapted from SNMMI guidelines for lung scintigraphy 4.0 (20)

APPENDIX G

Study information sheet & Questionnaire



Dear Colleagues, my name is Dr Ayesha Ismail and I am a registrar from the Nuclear Medicine Department. I am doing a study to assess how our referral clinicians interpret our V/Q lung scan reports and how we can improve them. This study is being undertaken for my Master of Medicine (MMed) dissertation. As many of our referrals for V/Q scans come from the (Internal Medicine/ Obstetrics and gynaecology/ Surgery) Department, your feedback is essential. Please assist by filling out the questionnaire attached. It will take about 10 -15 minutes to complete.

This study has been approved by the University of the Witwatersrand Ethics committee (Clearance no. M200320), the head of school, the university deputy registrar and the CEO offices (CMJAH, CHBAH and HJH). The questionnaire is self-administered and anonymous. Completion of the questionnaire is completely voluntary and will signal consent to participate in the study. A separate consent form will not be requested.

A few demographic details (such as where you work and your job title) will be requested so that we can correlate your responses with level of experience and referral patterns from various departments. No other identifying data will be included in the questionnaire.

You will not be disadvantaged in any way if you choose not to participate in this questionnaire.

The study will run until 31 May 2021, after which the results of the study will be available. You are welcome to contact me at the Nuclear Medicine Department (Charlotte Maxeke Johannesburg Academic Hospital) on 011 488 3500, if you would like to be informed of the study outcome or have any further questions.

Thank you for your time.

Dr Ayesha Ismail
011 488 3500
Department of Nuclear Medicine
University of the Witwatersrand

Questionnaire

Please circle / tick your response to the statements or questions below.

1. Level:
    a. Intern
    b. Medical Officer
    c. Registrar
    d. Consultant
    e. Other: (Please specify) _____
2. Years of experience post-graduation from medical school:
    a. 1
    b. 2 – 5
    c. 6 – 10
    d. > 10
3. Current hospital where you are based:
    a. CMJAH
    b. CHBAH
    c. HJH
4. Discipline:
    a. Internal Medicine
    b. Surgery
    c. Obstetrics and Gynaecology
    d. Other: (Please specify) _____

5. Which factors do you consider when you decide to book a V/Q scan? (May select > 1 option)
    a. Easy to get an appointment
    b. Renal dysfunction
    c. Pregnancy
    d. Radiation dose
    e. Contrast allergy
6. What are the reasons that discourage you from booking a V/Q scan when you suspect a pulmonary embolism (PE)? (May select > 1 option)
    a. Wait too long to get an urgent scan
    b. V/Q reports are unclear
    c. No nuclear medicine on site (HJH)
    d. CXR is abnormal
    e. Other: (Please specify) _____
7. I find V/Q scan reports easy to understand and clinically useful:
    a. Most of the time
    b. Sometimes
    c. Rarely
8. **No PE is seen** on V/Q scan. The most understandable language to communicate this is:
    a. Scan is negative for PE
    b. PE is absent
    c. No convincing evidence of PE on scan
    d. Normal V/Q scan
9. **PE is seen** on V/Q scan, the most understandable language to communicate this is:

a. Scan is positive for PE
b. PE is present
c. Findings are consistent with PE
d. Abnormal V/Q scan

10. If a V/Q scan does not meet the criteria for a positive or negative scan i.e. the findings are inconclusive, the most understandable language to communicate this is:
    a. Scan is indeterminate
    b. Scan is non-diagnostic for PE
    c. Scan is inconclusive
11. If a V/Q scan is reported as inconclusive for PE, what is your next step in patient management?
    a. Book a CTPA (if there are no contraindications)
    b. Treat with therapeutic anticoagulation and repeat scan in 7 -14 days to assess for resolution of clots
    c. Use my clinical judgement and treat as a confirmed PE
12. If a scan is reported as a high probability for PE, I consider this to mean:
    a. There definitely is a PE present
    b. > 85% likelihood of PE
    c. > 50% likelihood of PE
    d. Other: (Please specify) _____
13. If a V/Q scan is reported as a low probability for PE, I consider this to mean:
    a. There is definitely no PE present
    b. <10% likelihood of PE
    c. <50% likelihood of PE

d. Other: (Please specify) _____

14. I would prefer numbers instead of verbal probabilities of PE to be stated in V/Q reports:
    a. Yes
    b. No
    c. Neutral
15. If a scan is reported as a normal V/Q scan, a clinically significant PE is ruled out:
    a. Agree
    b. Disagree
16. I read the 'findings' section of the V/Q report:
    a. Always
    b. Sometimes
    c. Never. I'm only interested in the conclusion section.
17. If I am unsure about the meaning of a V/Q report, I contact the registrar or consultant listed on the report to clarify:
    a. Often
    b. Rarely
    c. Never (Please specify why) _____
18. If the V/Q report conclusion states that there are 'Features of parenchymal Lung Disease', your next step is:
    a. Treat the patient as a pneumonia
    b. Investigate further as the patient may have another condition causing their symptoms e.g. pulmonary TB or obstructive lung disease
    c. Ignore the comment, at least the patient doesn't have PE

19. If the V/Q report conclusion states that the ‘cardiac outline is enlarged’, your next step is:
    a. Confirm cardiomegaly on CXR
    b. Refer for cardiac evaluation
    c. Ignore the comment, we expect this with right heart failure and other medical conditions
20. If you have a high clinical index of suspicion for PE but the scan is reported as negative, what is your next step?
    a. Book a CTPA (if there are no contraindications)
    b. Consider another diagnosis to explain the patient’s symptoms
    c. Trust my clinical judgement and treat as confirmed PE
21. Is it useful if the Nuclear Physician suggests further management in the V/Q report (e.g. suggesting continuation of therapeutic anticoagulation and repeat scan in 7-14 days or a CTPA for an inconclusive study)?:
    a. Yes. It should be included in all reports.
    b. Yes. It should be included only for inconclusive studies.
    c. No. I am the clinician. Nuclear physicians should only look at scans and not tell me what to do.
22. In a patient with a confirmed limb DVT on doppler ultrasound, would you:
    a. Book a V/Q scan to exclude PE as the presence of PE will extend planned duration of anticoagulation.
    b. Book a V/Q scan to exclude PE. Presence of PE won’t affect duration of anticoagulation but it is necessary to confirm the diagnosis and have a baseline for future reference.
    c. Not book a V/Q scan as the patient has no symptoms suggesting PE

23. I find V/Q scan reports helpful for making clinical management decisions:

    a. >90% of the time

    b. 75-90% of the time

    c. 50-75 % of the time

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24. Any other comments, suggestions or questions regarding V/Q scan reports?

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APPENDIX H

Turn it in report

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