

**A STUDY ON ACCURACY OF PREDEFINED SCREENING
CRITERIA FOR SELECTIVE ORDERING OF CHEST
X-RAY IN ROUTINE MEDICAL EXAMINATION
AMONG STUDENTS ENROLLING INTO
HIGHER LEARNING INSTITUTION ATTENDING
HOSPITAL UNIVERSITI SAINS MALAYSIA**

BY

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ABBREVIATIONS

COAD	Chronic Obstructive Airway Disease
COPD	Chronic Obstructive Pulmonary Disease
CPG	Clinical Practice Guideline
CR	Computed Radiography
DR	Digital Radiography
HUSM	Hospital Universiti Sains Malaysia
JPA	Jabatan Perkhidmatan Awam
KRK	Klinik Rawatan Keluarga
MOH	Ministry of Health
PACS	Picture Archiving and Communication System
RME	Routine Medical Examination

ABSTRAK

PENGENALAN: Amalan melakukan ujian x-ray dada semasa pemeriksaan perubatan rutin (RME) masih banyak dilakukan di Malaysia walaupun kajian banyak memperdebatkan faedah melakukan ujian x-ray dada ke atas individu yang tiada tanda penyakit. Selain daripada itu, tiada borang RME yang seragam dan diterimapakai oleh semua institusi di Malaysia. Masih tiada garis panduan yang jelas mengenai siapa yang perlu menjalani ujian x-ray dada. Oleh itu, satu kriteria saringan perlu disediakan untuk memilih individu perlu menjalani ujian x-ray dada bagi mengurangkan perbelanjaan perubatan serta mengelakkan risiko radiasi yang tidak diperlukan.

OBJEKTIF: Tujuan kajian ini adalah:

1. Untuk menyediakan satu kriteria saringan yang tepat berdasarkan kepada penelitian bahan kajian. Tujuan kriteria saringan tersebut disediakan ialah untuk digunakan sebagai bahan penyaringan untuk pemilihan permohonan ujian x-ray dada semasa RME.
2. Untuk menentukan nilai sensitiviti, spesifisiti, nilai jangkaan positif dan nilai jangkaan negatif kriteria saringan tersebut.
3. Untuk menentukan prevalen x-ray dada yang tidak normal dalam pemeriksaan perubatan rutin (RME).
4. Untuk menentukan nilai sensitiviti, spesifisiti, nilai jangkaan positif dan nilai jangkaan negatif laporan ujian x-ray dada yang dilakukan oleh pegawai perubatan berbanding dengan laporan pakar radiologi. Persepakatan tentang keputusan x-ray dada di antara pegawai perubatan dan pakar radiologi juga akan ditentukan.

METODOLOGI: Seramai 408 orang pelajar yang datang ke Hospital Universiti Sains Malaysia antara 1 Jun 2004 dan 31 Disember 2004 terlibat dalam kajian ini. Semua pelajar tersebut disaring menggunakan kriteria saringan yang disediakan oleh penyelidik. Keputusan samaada pelajar tersebut perlu menjalani ujian x-ray dada ditentukan berdasarkan kriteria saringan tersebut. Laporan ujian x-ray dada akan dibuat oleh pegawai perubatan dan juga pakar radiologi.

KEPUTUSAN: Keputusan kajian ini menunjukkan bahawa sensitiviti, spesifisiti, nilai jangkaan positif dan nilai jangkaan negatif kriteria saringan yang disediakan oleh penyelidik masing-masing ialah 26.1%, 66.8%, 4.5% dan 93.8%. Prevalen ujian x-ray dada yang tidak normal ialah 5.64% (95% C.I: 0.03-0.08). Sensitiviti, spesifisiti, nilai jangkaan positif dan nilai jangkaan negatif laboran x-ray dada oleh pegawai perubatan masing-masing ialah 17.4%, 98.2%, 36.4% dan 95.2%. Persetujuan di antara pegawai perubatan dan pakar radiologi dalam laporan ujian x-ray dada adalah rendah ($\kappa=0.206$).

KESIMPULAN: Kesimpulan yang dapat dibuat daripada kajian ini adalah prevalen ujian x-ray dada yang tidak normal dalam pemeriksaan perubatan rutin (RME) adalah rendah. Kriteria saringan yang disediakan oleh penyelidik tidak tepat untuk diterimapakai sebagai bahan penyaringan bagi permohonan ujian x-ray dada semasa pemeriksaan kesihatan (RME). Walaubagaimanapun, nilai jangkaan negatif yang tinggi menunjukkan bahawa kebarangkalian bagi pelajar yang tidak memerlukan ujian x-ray dada berdasarkan kriteria saringan untuk mendapat keputusan x-ray dada yang normal adalah tinggi. Terdapat perbezaan yang ketara di antara laporan x-ray dada oleh pegawai perubatan dan laporan oleh pakar radiology. Keputusan ujian x-ray dada tidak memberi kesan terhadap keputusan

samaada pelajar adalah layak untuk melanjutkan pelajaran. Kajian lanjutan perlu dilakukan bagi meningkatkan ketepatan kriteria saringan yang disediakan.

ABSTRACT

TITLE: A STUDY ON ACCURACY OF PREDEFINED SCREENING CRITERIA FOR SELECTIVE ORDERING OF CHEST X-RAY IN ROUTINE MEDICAL EXAMINATION AMONG STUDENTS ENROLLING INTO HIGHER LEARNING INSTITUTION ATTENDING HOSPITAL UNIVERSITI SAINS MALAYSIA

INTRODUCTION: The practice of doing chest x-ray in routine medical examination (RME) is still prevalent in Malaysia although many studies argue the benefit of routine chest x-ray in asymptomatic individuals. There is no standardized RME form used by various institutions in Malaysia. There are also no clear guidelines on who should have a chest x-ray and who should not. Therefore, there is a need to develop a set of screening criteria for selective ordering of chest x-ray in RME to reduce health care cost and to avoid unnecessary radiation risk.

OBJECTIVES: The objectives of the study are:

1. To develop an accurate set of screening criteria from literature review.
2. To determine the sensitivity, specificity, positive predictive value and negative predictive value of the predefined screening criteria. The set of screening criteria is intended to be used as a screening tool for selective ordering of chest x-ray in RME
3. To determine the prevalence of abnormal chest x-ray in routine medical examination.
4. To determine the sensitivity, specificity, positive predictive value and negative predictive value of chest x-ray interpretation made by medical officers. The agreement between medical officers and radiologist is also determined.

METHODOLOGY: A total of 408 students who came to Hospital Universiti Sains Malaysia between 1st June 2004 and 31st December 2004 participated in the study. They were screened by the predefined screening criteria developed by the researcher. The decision on chest x-ray requirement was determined based on the screening criteria. All the chest x-rays were reported both by medical officers and an appointed radiologist.

RESULTS: The results from this study showed that the predefined screening criteria developed by the researcher has a sensitivity, specificity, positive predictive value and negative predictive value of 26.1%, 66.8%, 4.5% and 93.8% respectively. The prevalence of abnormal chest x-ray is 5.64% (95% C.I: 0.03-0.08). The sensitivity, specificity, positive predictive value and negative predictive value of chest x-ray interpretation by medical officers are 17.4%, 98.2%, 36.4% and 95.2% respectively. The agreement on chest x-ray interpretation between medical officer and radiologist was poor ($\kappa=0.206$).

CONCLUSIONS: From this study, it can be concluded that the prevalence of abnormal chest x-ray in RME is low. The set of screening criteria developed by the researcher is not accurate to be used as a screening tool for detecting abnormal chest x-ray in RME. However, the high negative predictive value means that the probability if a student is not indicated for chest x-ray to have a normal result is high. There is considerable discrepancy between medical officers' chest x-ray interpretation and that of trained radiologist. Chest x-ray findings did not influence the decision of fitness for enrolment. Further research needs to be done to improve the accuracy of the screening criteria.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

In Malaysia, routine medical examination (RME) is compulsory before enrolling into either public or private education centres. RME is done to ensure that individuals are free from any serious disease that may compromise performance or cause threat to others. Chest x-ray is usually done to detect cardiovascular or pulmonary diseases such as pulmonary tuberculosis. Previously, the major reason for obtaining routine chest radiography is for the detection of silent pulmonary tuberculosis. Other than being a routine pre-enrolment investigation, chest x-ray is also frequently done as a preoperative screening as well as required by law and regulations in high risk occupation such as aircraft pilots and athletes. It is used as an adjunct investigation in RME.

According to Stolberg (2005), the term “routine” chest x-ray is used when it is performed without any clinical indication or suspicion of morbidity based on patient history and physical examination. Robin and Burke (1986) in their article defined routine chest x-ray as a chest x-ray which is done without a specific medical indication. Most people who undergo routine chest x-ray are those who are healthy without a possibility that lung or heart disease is present. Some of the common circumstances which require routine chest x-rays are:

1. As part of preemployment physical evaluation.
2. As part of physical evaluation before enrolling in an institution.
3. As part of an annual or periodic examination.
4. As part of hospitalization.
5. In certain high risk groups for the possibility of early detection of various pulmonary and cardiac diseases.
6. As a baseline should cardiac or pulmonary disease developed in the future as well as for medicolegal reasons.

According to an article by Mohd Feroz Abu Bakar in Berita Harian 3rd June 2004, from 420,058 candidates who sat for Sijil Pelajaran Malaysia (SPM) in 2003, 10% obtained excellent results, 60% obtained average results and 30% obtained poor results. Assuming all students who obtained excellent and average results managed to get places in either public or private institutions, this will account for 294,040 students undergoing routine medical examinations which include chest x-rays. Some of the students who obtained weak results in Sijil Pelajaran Malaysia will also be offered in various training centres. These include Kolej Komuniti in which the intake was 3,300, Jabatan Tenaga Manusia, 16,150 and Institut Kemahiran Belia Negara (IKBN), 2,500. In 2004, there were 23,113 science stream Sijil Tinggi Pelajaran Malaysia (STPM) and matriculation candidates who were accepted into public universities. This was in addition to 15,230 students from art stream. There are also 2,700 postgraduate students who undertake Kursus Perguruan Lulusan Ijazah (KPLI) every year. Therefore, in 2004, these programmes had contributed to at least 357,033 candidates accepted in various institutions in Malaysia in whom all of them would

have a routine medical examination. This figure does not include those who go to boarding schools and those who pursue post graduate degrees.

Each year, the annual budget allocation for Ministry of Health has increased. For the year 2003, Ministry of Health was the fourth largest recipient of allocation after Ministry of Education, Ministry of Finance and Ministry of Defence. The Federal Budget in 2003 was RM109,801,554,460, an increase of 9.24% or RM9,283,048,340 as compared to the 2002 Federal Budget. An allocation of RM7,556,006,400 had been approved to the Ministry of Health representing 6.88% of the 2003 Federal Budget, an increase of 19.95% or RM1,256,932,630 as compared to the 2002 Federal Budget. From the Ministry of Health Report 2003, there were 2,599,577 radiological examinations done and 2,276,705 (87.6%) of these were general radiography. This reflects the major burden of workload and probably cost from general radiographs in which it includes chest x-ray. If we assume the direct cost of one chest x-ray is RM30 based on the amount charged to patients (Unit Kewangan, HUSM, 2005), that means for 357,033 students, at least RM10,710,990 was spent for routine medical examinations in 2004. This is obviously a large amount of resource. There are other indirect costs that should also be considered such as the time spent by radiographer for doing and processing the x-ray, medical officer for reviewing and reporting the x-ray and the time spent by the people undergoing the x-ray.

Although many studies showed that the prevalence of abnormal findings in routine chest x-ray was small, the current practice is, chest x-ray in RME is still compulsory. Finkel, (1973) suggested that college entrance chest roentgenogram was more valuable for students coming from lower socioeconomic groups. Evens (1996) in his comments did not

feel that chest radiographic examination as part of routine physical examination is justified. Gurney (1995) stated that chest radiography is done because it is a historical practice and suggested that it should only be carried out on those who will benefit from the investigation. The American College of Radiology in 2001 recommended generally against the use of routine chest x-ray examinations. In 1979, The Royal College of Radiologists had suggested possible guidelines for more rational use of routine preoperative chest radiography. Preoperative chest radiography should be used selectively in circumstances where the clinical history or signs place the patient at very high risk of postoperative pulmonary complication and investigation will provide important additional information.

1.1.1 Benefits

The benefit of a routine chest x-ray in general is to detect any cardiac or respiratory abnormalities and if so can be treated. It also prevents the spread of any communicable disease such as pulmonary tuberculosis especially when an individual is going to expose others to the disease such as in learning institutions. Although the number of tuberculosis cases in Malaysia showed a steady rise from 11,778 in 1995 to 15,057 in 2000, there was a slight improvement since 2000. There were 14,830 cases in 2001 and further dropped to 14,389 cases in 2002 (MAPTB, 2006). Other benefit of routine chest x-ray is to assess the baseline fitness of an individual especially in pre employment screening. However the questions of when is the baseline should be taken and how frequent it should be repeated is still unanswered. Even in a case where a disease is detected, whether it will affect the decision is still not clear. The impact of abnormal chest x-ray especially abnormalities which carry no risk or harm to the patient will not change any decision to accept a person to

work or enroll in an institution. In occupations where certain exposure carries a risk of developing pulmonary disease such as those who involve with asbestos, baseline chest x-ray is justifiable. There are occasions when routine chest x-ray is done too frequently and there is no clear guideline whether it is really necessary.

1.1.2 Disadvantages

According to Robin and Burke (1986), the disadvantage of routine chest x-ray is that it can lead to false positive and false negative results. False positive results can lead to anxiety to the individual and possibly put an individual on further evaluation from as simple as sputum induction to bronchoscopy. If the result necessitates a CT scan then it will add to more radiation exposure. In addition to that, further investigation will put an individual to unnecessary discomfort. The psychological effect of false positive results to the patient also should not be forgotten as it can be devastating. Another possible scenario that can happen is overlooking a disorder leading to interpretative error and false negative. It is quite common and may lead to false reassurance. The implication is that the person will not receive the necessary treatment.

1.1.3 Radiation risk

Knowing that chest x-ray is a common x-ray procedure, the hazard caused by it should also be considered. According to Robin & Burke (1986), the radiation exposure is more of a cumulative effect during lifetime and the risk of developing radiation cancer is linearly related to total x-ray exposure. There is also an inverse relationship between

radiation carcinogenesis and age. The younger the age, the higher is the risk. Smoking further increases the risk of radiation cancer by 1.5 to 2 times than that of a non smoker. The European Commission Directorate-General for the Environment (2001) in their guidelines stated that the lifetime risk for fatal cancer from a chest x-ray is 1 in a million. Gregg (1977), estimated that the risk of carcinogenesis for chest radiograph is 1.5 per one million examinations. Fager *et al.* (1984), in a study on screening for chest disease in college students, looked into the effect of radiation exposure from the screening chest radiography on the incidence of lung cancer, leukaemia, thyroid cancer and female breast cancer which are the neoplasm most likely to be induced by chest radiography. They estimated that 0.3 or fewer induced cases of lung cancer, leukaemia, thyroid cancer and female breast cancer will occur among 723,000 students that they studied over a 20-year period as a result of receiving chest radiograph. They concluded from their results that many students are receiving chest radiographs at substantial cost with questionable benefit. Stolberg (2005) commented that although with modern radiology the radiation exposure is considered to be negligible, people should not be exposed to ionizing radiation when it is unnecessary. This is similar to what was said by Swartz in 1974 that is, the use of radiation should be justified with good medical indication.

A common scenario in Malaysia is that a person as young as 12 years old will have a routine medical examination requiring chest x-ray before going to a boarding school. Later, at the age of 18 years, they will have another chest x-ray done before enrolling to a college for matriculation or A-level. Two years later, another chest x-ray is done before entering a university. After they have graduated, and start to work, they have to undergo another chest x-ray as pre employment requirement. Possibly later, if they decide to pursue

a postgraduate study, another chest x-ray will be required. Generally, nowadays, between three to five routine chest x-rays are required in a lifetime of most Malaysians. This does not include a medically indicated chest x-ray.

1.1.4 Costs

Although this study is not designed to calculate the cost effectiveness of doing a chest x-ray in RME, cost is an important factor when deciding a mean which affects medical resources. A study by Sebro *et al.* (2001) found the prevalence of abnormal chest x-ray in students entering University of West Indies was 3%. If we use this prevalence, then among 357,033 students who had RME in 2004, 10,711 students would have abnormal chest x-rays, leaving 346,322 students with normal chest x-rays. If we take RM30 (Unit Kewangan, HUSM, 2005) as an approximate cost for one chest x-ray, it means we had spent RM10,389,660 on “normal” chest x-rays. Archer *et al.* (1993), did a meta-analysis on the value of routine preoperative chest x-rays. In his review, the average frequency of abnormalities in the 14,390 patients subjected to routine pre-operative chest radiography was 10%. However, not all the abnormalities were unexpected. Some of the abnormalities were already known or expected from history and clinical examinations. In these patients, the average unsuspected abnormalities, i.e., cases which abnormalities would not have been found had a routine chest x-ray not been carried out was 1.3%. However another question that we should ask is how significant the unexpected abnormality is. Whether it would change any management, would depend on the abnormality found.

1.2 The process of routine medical examination

RME can be done by a doctor in a government or private clinic. However, most public institutions require a medical examination done by a doctor from a government clinic. When a student is offered a place in an education centre, the institution will provide the student with an RME form. The forms are prepared by the institutions and they can be different from one centre to another. Generally, the forms need to be completed by the candidate in the section specified for them. This section usually includes some questions related to the individual's health. There will be a section for a medical officer to complete after doing certain physical examinations and laboratory investigations. Common physical examinations include measurement of the height, weight and blood pressure, vision test, examination of the ears and examination of cardiovascular, respiratory, gastrointestinal, musculoskeletal, neurological and genitourinary systems. An example of common laboratory investigation is urine for sugar, albumin and microscopy. Some institutions require urine examination for morphine and cannabis, blood group and rhesus, Mantoux test and Hepatitis B screening. Radiological investigation which is commonly requested is chest x-ray. There is a section in the form where doctors will decide on the medical fitness of an individual for enrollment based on their clinical examination as well as laboratory and radiological examination. When an individual is found to have a medical problem, further management will be arranged. If the individual is medically unfit for enrolment, he or she can either postpone his or her enrollment or denied from enrolling into the institution. This decision is usually made by the institution based on the recommendation made by doctors. As the routine medical examination forms are not standardized, some still contain information which is no more relevant nowadays such as small pox vaccination.

The usual procedure for RME in a government clinic is that the student has to register at the registration counter indicating that he or she needs to do a routine medical examination. Upon registration, the student is given a chest x-ray form and later is required to make payment in which the amount depends on the extent of laboratory and radiological investigations. In most cases, chest x-ray and other required investigations are done in all students without prior assessment by the doctor. By the time the student is seen by the doctor, all the necessary investigations are ready for review. The doctor will perform the clinical examination and review the results. Chest x-ray reporting is made by the attending doctor. The majority of chest x-rays will not be reported by radiologist unless referred by the medical officer. Most medical officers do not have any formal training in radiology. The competence of chest x-ray reporting is based on their experience and knowledge.

1.3 Justification for the study

Pre-enrolment chest radiography remains prevalent in Malaysia. The problem with ordering routine chest x-ray by various institutions in Malaysia is that there is no clear guideline or recommendation on the use of routine chest x-ray. Where pre-employment chest x-ray is necessary as a baseline, the justification of routine chest x-ray in healthy young adults such as students entering university can still be questioned. Performing chest x-ray in routine medical examination should be selective and it should be done only on those who are medically indicated. This is to reduce healthcare cost which are already high as well as protect patients from unnecessary exposure to ionizing radiation.

At present, there are no standard routine medical examination forms which are universally used by all centres. The medical examination can also be repetitive. If a person changes from one institution to another within a short period, the person usually has to do another routine medical examination as well as another chest x-ray. Although some centres especially private institutions require only those who are medically indicated to have a chest x-ray, there are no proper high yield criteria for ordering a chest x-ray. Therefore, there is a need to develop a guideline or screening criteria for selective ordering of chest x-ray in routine medical examination.

CHAPTER TWO

LITERATURE REVIEW

2.1 The value of routine chest x-ray

Chest radiography is a common and useful procedure for the evaluation of cardiopulmonary disease in the general population and in selected high risk groups. It has been used in healthy populations as a baseline measure for evaluation of future radiographs. Compared to other diagnostic procedures, chest x-rays are relatively inexpensive, widely available and easy to do. When deciding on whether to order a routine chest x-ray, one should consider the benefit of finding clinically useful information against the cost and possible health risk of the procedure. This is due to the large number of patients involved resulting in a high amount of money spent on routine procedures. There are many studies looking at the usefulness of routine chest x-ray as a screening test for cardiopulmonary abnormalities

A study by the Royal College of Radiologists Working Party in 1992 suggested that at least one fifth of radiological investigations done in hospitals in the United Kingdom are clinically unhelpful. The Royal College of Radiologists (1990) in the guidelines for general practitioners recommended that pre-employment or medical screening chest x-ray is not justified except in high risk groups such as immigrants. Guidelines by The European Commission Directorate-General for the Environment (2001) also suggest similar recommendation. For the screening of tuberculosis, Centers for Disease Control and

Prevention in 1998 stated that routine chest x-ray is not required in asymptomatic, tuberculin test negative individuals.

Indications for chest x-ray as stated by the American College of Radiology in 2001 include those who have signs and symptoms related to the respiratory, cardiovascular, upper gastrointestinal system and the musculoskeletal system of the thorax. Chest x-ray is also done to comply with the government regulations that mandate chest radiography such as in immigrants, coal miners or other surveillance studies required by public health law. In 2003, the Public Service Department, Malaysia produced a circular encouraging government servants who are above 40 years old to have a medical examination (JPA, Pekeliling No.3/2003). However, routine chest x-ray was not included in the types of examination recommended.

Mangura and Reichman (1999), in their opinion on periodic chest radiography concluded that periodic chest radiography in follow up or as screening tool for tuberculosis should not be continued. Bearcroft *et al.* (1994), in his study designed chest radiography guidelines for general practitioners. From the guidelines, indications for chest x-ray that were found to have low yield were routine follow up of patients with chronic obstructive airway disease (COAD), patients with hypertension as the only indication, those under 40 years old with non-specific ill health, those under 40 years old with non-specific chest pain, routine pre-employment screening examination and routine immigration examination. In a study on the value of routine chest radiography in an acute geriatric ward by Denham *et al.* (1984), they found that even in the elderly group aged more than 60 years where cardiorespiratory diseases are more likely, routine chest radiography was of management

value in only 5% of patients. They suggested that routine chest radiography of all patients could be usefully abandoned and should be confined to those with cardiorespiratory symptoms or signs, toxic confusional state, and bone or thoracic pain.

In the National Study of the Royal College of Radiologists in 1979, of 10,619 who had routine preoperative chest x-ray, no evidence was found that the results ever influenced the decision to operate in 96.2% of patients with a normal report and 92% of patients with significant radiological abnormality. Of those having a preoperative chest x-ray, 25.7% proceeded to operation without radiological report being available even though in one quarter of these reports a significant radiological abnormality was observed. Fowkes (1986a) in a review concluded that routine pre-operative chest x-ray should be abandoned in elective non-cardiopulmonary surgery.

2.1.1 The cost for routine chest x-ray

In 2003, there were 1,049 RMEs done in Hospital USM. If we use the same estimated cost of RM30 per chest x-ray, the cost would be RM31,470. Sivalal and Jaudin (Unpublished, 1999) showed that in Hospital Kuala Lumpur and Hospital Tengku Ampuan Afzan, Kuantan, if chest x-rays were omitted from routine medical examination, the average annual saving on cost of chest x-ray films alone would be RM258,865.80 and RM79,156.60 respectively. Analysis of these studies by Ministry of Health Expert Committee recommended that radiographs should not be carried out for all routine medical examinations. The need for chest x-rays should be determined by history, signs and symptoms and clinical examination of the individual. However the recommendation does

not apply to special groups of people such as immigrants. Since the requirement for routine medical examination is set by the institutions, it is not known whether they are aware of this recommendation. It is also not known whether there is any agreement on these recommendations between Ministry of Health and learning institutions in Malaysia. Routine medical examination is done by doctors and most of them tend to comply with the examination required by the institutions. Although most doctors realise that some chest x-rays are unnecessary, they feel that they are not in the position to overrule the requirement.

Since one of the reasons for routine chest x-ray is to detect pulmonary tuberculosis, a study on chest x-ray screening for tuberculosis among arm force personnel in the Ministry of Defence, Malaysia showed that it was not cost effective. The number of x-rays needed to be done to detect one pulmonary tuberculosis case had increased from 1919 x-rays in 1975 to 6697 in 1978. When it is translated into cost, the cost to detect one pulmonary tuberculosis case was USD\$42,600 (Supramaniam, 1980).

2.1.2 The need to develop a screening tool

Many studies have looked into ways to reduce routine investigations. Perez *et al.* (1995) after reviewing the value of routine preoperative test suggested the need for selective and rational ordering of preoperative investigations. Tape and Mushlin (1986) proposed indications for ordering chest radiographs. They recommended that a chest radiograph should not be routinely indicated solely because of hospital admission, advanced age, for a preoperative evaluation before administration of anaesthesia, or for a baseline assessment. These patients should be identified based on clinical suspicion of

active disease after doing a history and physical examination. However, chest radiograph may be necessary in many elderly patients because of the high prevalence of chest disease in this age group. For patients undergoing intrathoracic surgery, chest radiography is generally indicated.

Fowkes and colleagues (1986b) had done a multicentre trial with the aim to reduce the request for preoperative chest x-rays in 5 hospitals in England and Wales. The study showed that introduction of guidelines and the monitoring of practice have had some effect to reduce the number of preoperative chest x-ray. De Vos Meiring and Wells (1990) studied the impact of guidelines for the use of radiology services. After the introduction of guidelines, there was an overall of 23% reduction in referral, with 32% reduction in chest radiograph examination. Keogan *et al.* (1992) studied 2017 patients referred for chest radiography by general practitioners and recommended more selective use of chest radiography through the application of selection guidelines. Providing guidelines to doctors significantly reduced the rate referral for radiological investigations (Royal College of Radiologists Working Party, 1992 & 1993). Similar result was shown by Oakeshott *et al.* (1994).

Rucker *et al.* (1983) proposed a list of risk factors that could predict the likelihood of having an abnormal chest x-ray in preoperative patients. The study found that, among patients who did not have any of the risk factors, only one had an abnormal chest x-ray. However, the abnormality did not affect the surgery. Gennis *et al.* (1989) did a study to identify sensitive clinical criteria to diagnose pneumonia. The study showed that abnormal vital signs (temperature > 37.8°C, pulse > 100/min or respirations >20/min) were 97%

sensitive for the detection of pneumonia. Tsai *et al.* (1993) validated a set of criteria for selective ordering of admission chest radiography in adult with COAD. His study found that the previously developed criteria have a sensitivity of 96% and a negative predictive value of 98% in determining whether chest x-ray was helpful in the management of patients with COAD. Rothrock and his colleagues (2001) did a study to develop a clinical decision rule to predict significant chest x-ray abnormalities in emergency department patients. They concluded that the presence of any of 10 criteria (age ≥ 60 years, temperature $\geq 38^{\circ}\text{C}$, oxygen saturation $< 90\%$, respiratory rate > 24 breaths/min, haemoptysis, rales, diminished breath sounds, a history of alcohol abuse, tuberculosis or history of thromboembolic disease) was 95% sensitive and 40% specific in detecting clinically significant abnormal chest x-rays.

2.2 Literature review for developing the screening criteria

A literature search had been done looking into routine chest x-ray in asymptomatic individuals as a screening for chest diseases for various requirements, for example pre-employment, immigration and others. The search was mainly using Pubmed database (<http://www.ncbi.nlm.nih.gov>), Ovid database (<http://gateway.ut.ovid.com>) and Yahoo and Google search engines (<http://www.yahoo.com> and <http://www.google.com>). The search was using various combinations of the words 'routine', 'chest x-ray', 'screening' and 'asymptomatic'. The search included identifying common diseases detected during screening to help the researcher in developing the screening criteria. The researcher was able to identify one study of similar sample (university entrant students) by Sebro *et al.* (2001). However, the study was particularly looking at tuberculosis findings. The

percentage of abnormal x-ray during screening was also presented in the study. There was no detail of the abnormal findings presented. However, among the common abnormal findings identified in the study were scoliosis and cardiomegaly. Another study of similar purpose (the percentage of abnormal findings and types of chest x-ray abnormalities detected) was done by Jachuck *et al.* (1988) on pre-employment chest radiograph. The percentage of abnormalities reported by the author was 0.8%. There were 8 abnormalities which were those involving the lungs (one each for pleural adhesion, bulla, COAD, 2 lung opacities), one left ventricular hypertrophy, one prominent pulmonary outflow tract and one resection of eighth rib. There were other studies on routine chest x-ray (Rees *et al.* (1976), Supramaniam (1980), Fink *et al.* (1981), Seymour *et al.* (1982), Rucker *et al.* (1983), Denham *et al.* (1984), Fowkes (1986), Tape and Mushlin (1986), Mendelson *et al.* (1987), Turnbull (1987), Taylor and Stein (1988), Chaturvedi and Cockcroft (1992), Archer *et al.* (1993), Perez *et al.* (1995), Pang (1998), Marks *et al.* (2001), Gatt *et al.* (2003), and Lim and Liu (2003)). However, these studies were looking at routine chest x-ray on different population or symptomatic patients; for example, as routine admission chest x-ray, pre-operative chest x-ray and screening for tuberculosis.

Because of the difficulties on finding related literature as a reference to develop the screening criteria, the researcher had looked into a different method of coming up with the proposed criteria. Literature search had been done on the possible signs and symptoms that might predict abnormalities on chest x-ray, using either different population or symptomatic patients; for example, pre-operative patients or pre-admission chest x-ray. Although it was expected that at the end of the study, some of the criteria might be found to be irrelevant, the proposed criteria could be used as preliminary data for future research.

There are many studies looking at factors that might predict the presence of chest x-ray abnormalities. However, some studies only confined to predict a specific diagnosis such as pneumonia (Gennis *et al.*, 1989, Heckerling *et al.* 1990, Metlay *et al.*, 1997). Although Rothrock and colleagues (2002) tried to predict any chest radiography abnormalities in emergency department population, most of their patients were symptomatic. On the other hand, majority of individuals who come for RME are asymptomatic. Therefore, prediction for abnormal chest x-ray was more difficult. Hence, the factors used for screening in RME were intended to identify varieties of unexpected pathologies that could lead to abnormal chest radiographic findings.

2.2.1 Heart disease

As shown by a study by Rothrock *et al.* (2002), 33% of patients who had significant chest x-ray findings were those who have past history of cardiovascular disease. Rucker *et al.* (1983) postulated that valvular heart disease, myocardial infarction and angina were among the risk factors which increased the likelihood of abnormal preoperative chest roentgenograms. In patients suspected to have valvular heart disease, chest x-ray is indicated for the initial evaluation or when there is a change in clinical picture (European Commission Directorate-General for the Environment, 2001). Tsai *et al.* (1993), suggested that chest x-ray was necessary in COAD patients with heart disease.

2.2.2 Lung disease

Rothrock *et al.* (2002) showed that asthma and COPD were present in 6% and 13% of patients with clinically significant chest x-ray findings respectively. History of previous chest disease correlated significantly with the presence of radiographic abnormalities in the whole population although the correlation was weaker in the below 40 group (Benacerraf *et al.*, 1981). Rucker *et al.* (1983), postulated that asthma, tuberculosis, chronic obstructive pulmonary disease and occupational exposure such as asbestos, fumes or ores increase the likelihood of abnormal preoperative roentgenograms. Pulmonary disease is one of the features of complicated COAD which needs chest radiography as shown by a study by Tsai *et al.* (1993).

2.2.3 Thoracic surgery

COAD patients with history of thoracic surgery will benefit from routine admission chest x-ray (Tsai *et al.*, 1993). From the study by Jachuck *et al.* (1988), one of eight chest x-rays which have abnormalities showed resection of the eighth rib but was not declared in the questionnaire.

2.2.4 Tuberculosis

Study from Rothrock *et al.* (2002) showed that history of tuberculosis was present in 5% of patients with clinically significant chest x-ray abnormality.

2.2.5 Cancer

According to the same study by Rothrock *et al.* (2002), 11% of patients with clinically significant chest x-ray abnormality had past history of cancer. Rucker et al (1983), postulated that certain risk factors would increase the likelihood of a serious abnormality in preoperative chest x-ray. One of the risk factors was history of cancer at any site.

2.2.6 Immunocompromised state

Positive HIV status was present in 4% of those with clinically significant chest x-ray findings (Rothrock *et al.*, 2002). In a study by Tsai et al (1993), immunosuppression was also a feature of complicated COAD needing chest radiography in the emergency department.

2.2.7 Chest trauma

Benacerraf *et al.* (1981), showed that history of recent chest trauma did not correlate with radiographic abnormalities in either the population as a whole or in the below 40 group. The Royal College of Radiologist (1990) and the European Commission Directorate-General for the Environment (2001) suggest a chest x-ray in patients with history of chest trauma only if it will alter the management.

2.2.8 Smoker/ex smoker

In the study by Benacerraf *et al.* (1981), it showed that smoking status had no predictive significance for either chronic or acute radiographic findings. Cigarette smoking however is one of the risk factors for abnormal preoperative roentgenogram postulated by Rucker *et al.* Keogan *et al.* (1992), reviewed 2017 chest x-rays ordered by general practitioners and found that positive smoking history either present or previous smoker as a strong predictor of abnormality in the presence of other symptoms. Significant abnormality was noted in 33% of patients who smoke.

2.2.9 Fever

Rothrock *et al.* (2002) showed that 21% of patients with clinically significant chest x-ray abnormality had temperature $\geq 38^{\circ}\text{C}$. The study also revealed that the mean temperature that gives rise to clinically significant chest x-ray finding is $37.2 \pm 1.1^{\circ}\text{C}$. Tsai *et al.* (1993), used history of fever as one of the features of adults with complicated COAD which necessitates chest radiography prior to admission from the emergency department. Study by Benacerraf *et al.* (1981) indicated that temperature above 37.8°C seemed to have considerable predictive significance for radiographic abnormalities in the whole population, but not for the patient under the age of 40.

2.2.10 Cough ± sputum

The presence of cough correlated with radiographic findings, particularly in the below 40 group (Benacerraf *et al.*, 1981). However, sputum production and the presence of purulent sputum did not correlate with radiographic abnormalities in either the population as a whole or in the below 40 group. On the other hand, Rothrock *et al.* (2002) showed that cough presents in 53% while sputum production presents in 20% of patients with clinically significant chest x-ray. Keogan *et al.* (1992), found that chest x-ray abnormality was noted in 30% of patients presented with cough, wheeze, breathlessness or a history suggestive of airway disease.

2.2.11 Haemoptysis

A study by Benacerraf *et al.* (1981), showed that the presence of haemoptysis correlated strongly with the chest radiographic abnormalities. In the total population, 70.8% of patients with haemoptysis had abnormal chest x-rays while in the under 40 group, 50% of patients with haemoptysis had abnormal chest x-rays. Another study by Keogan *et al.* (1992) showed clinically significant chest x-ray abnormality in 33% of patients with history of haemoptysis. In a study by Rothrock (2002), among patients with clinically significant chest x-rays, 6% had haemoptysis. European Commission Directorate-General for the Environment (2001) recommends that chest x-ray is indicated in patients presented with haemoptysis.

2.2.12 Weight loss

Rabinovitz *et al.* (1986) in a retrospective analysis of unintentional weight loss defined weight loss as of at least 5% of their usual weight. Bearcroft *et al.* (1994) showed that, of the 20 chest x-ray requested by general practitioners with a sole indication of weight loss, 5% showed significant abnormality. In a study by Keogan *et al.* (1992), only 3% of patients who presented with general ill health such as fatigue, lassitude, lethargy, sweats or weight loss had clinically relevant chest x-ray abnormality.

2.2.13 Dyspnoea

Rothrock *et al.* (2002) showed that 64% of patients with clinically significant chest x-ray findings had shortness of breath. Benacerraf *et al.* (1981), showed that dyspnoea showed considerable predictive significance for the whole population, but not for the patient under the age of 40.

2.2.14 Chest pain

In patients with clinically significant chest-ray abnormalities, 38% had chest pain, 19% had pleuritic chest pain and 7% had acute onset pain (Rothrock *et al.*, 2002). Chest pain showed considerable predictive significance for the whole population, but not for the patient under the age of 40 (Rothrock *et al.*, 2002).

2.2.15 Cyanosis

In a study by Rothrock *et al.* (2002), only 1% of patients with clinically significant chest x-ray findings had cyanosis.

2.2.16 Heart rate

From the study by Rothrock *et al.* (2002), the mean heart rate that resulted in clinically significant chest x-ray findings was 100.2 ± 22.8 beats per minute.

2.2.17 Respiratory rate

The mean respiratory rate that lead to clinically significant chest x-ray findings was 23.7 ± 9.2 breaths per minute as shown by Rothrock *et al.* (2002). The study also showed that the presence of respiratory rate of more than 24 breaths per minute will give clinically significant chest x-ray findings in 25% of patients. Gennis *et al.* (1989), in his study on guidelines for ordering chest roentgenograms in emergency department to detect pneumonia concluded that the presence of any of the vital signs which are temperature $>37.8^{\circ}\text{C}$, pulse more than 100 beat per minute or respiration more than 20 per minute were 97% sensitive for the decision of radiographically demonstrable pneumonia.