CT SCAN WAITING TIMES AND COST ANALYSIS FOR ADULT PATIENTS PRESENTING AT A TERTIARY HOSPITAL IN SOUTH AFRICA

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Declaration

I, Aadila Mehtar, declare that this research report is my own work and is being submitted for the degree of MMed (Diagnostic Radiology) at the University of the Witwatersrand, Johannesburg. I also declare that it has not been submitted before for any degree or examination at this or any other university.

Publications and presentations

This work has never been published and has never been presented at any congress

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Dr A Mehtar

On this 29th day of July 2019

Abstract

There has been a significant increase in the number of computed tomography (CT) scans requested and performed at the Chris Hani Baragwanath Academic Hospital (CHBAH) with a growing concern about the increased length of time patients wait for diagnostic imaging at this Hospital.

AIM: This study aims to calculate the average waiting time for CT scans in adult in-patients and to correlate this to the cost per day of hospital stay.

METHOD: A retrospective study was performed to evaluate the hospital in-patient records at CHBAH of adults booked for scans from January 2013 to June 2013. Request forms were analysed to ascertain the waiting time in days. This was correlated with the date of CT scan, the cost per day of hospital stay, which was adopted from a standardised costing model.

RESULTS: 787 record forms were reviewed. The average waiting time for patients was 11 days (±7). The average cost of hospital stay was estimated at R34 111 (±R21 707). National core standards for health institutions in South Africa recommend a target hospital stay of 5 days. There was a 100% correlation between the cost of hospital stay and waiting time with rising costs being directly proportional to the increased length of stay.

CONCLUSION: The average basic cost of hospital stay due to prolonged length of stay was R34 111 (±R21 707), which translates to R26, 845,357 over the 6 month study period. This could be utilised better to invest in human resources, equipment and IT infrastructure in the public sector to meet the demands of a system under severe constraint.

Reduced waiting times should continue to be a vital part of quality improvement efforts to ensure measurable improvement in service delivery and patient care in the public sector.

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List of abbreviations

ANOVA	Analysis of Variance test
ASAP	As soon as possible (Semi urgent scan)
BRS	Basic Radiology System
CAD	Computer Aided Detection
CEO	Chief Executive Officer
CT	Computed Tomography
CTPA	CT Pulmonary Angiogram
CHBH	Chris Hani Baragwanath Academic Hospital
DICOM	Digital Imaging and Communications in Medicine
ED	Emergency Department
GDP	Gross Domestic Product
HREC	Human Research Ethics Committee
IT	Information Technology
JPEG	A format for compressing image files
MRI	Magnetic Resonance Imaging
NEAT	National Emergency Access Target
NHS	National Health Service
PACS	Picture Archiving and Communication System
PDE	Patient day equivalent
PTE	Pulmonary Thromboembolism
RIS	Radiology Information System
V/Q scans	Ventilation-perfusion scan
WHO	World Health Organization
ZAR	South African Rand

1. Rationale

There has been a significant increase in the number of computed tomography (CT) scans performed at the Chris Hani Baragwanath Academic Hospital (CHBAH) in recent years. There has also been a growing concern about the increased length of time patients wait for diagnostic imaging, as the demand for CT is high. The reasons for this are manifold. The increased demand could be due to the increasing indications for diagnostic CT, the increase in the reliance by clinicians on diagnostic imaging to assist with patient diagnosis, management and follow-up due to improved image quality and diagnostic ability of CT. The rising demand could also be due to equipment shortages, breakdowns and prolonged machine down time resulting growing back logs and demand outweighing supply. It is most likely a combination of the above factors.

The aim of this study was to calculate the average waiting time for CT scans in adult in-patients and correlate this to the cost per day of hospital stay at CHBAH. This study is important to provide information that will highlight the dynamics as well as the costs involved and will endeavour to make recommendations on more efficient resource utilisation.

2. Introduction

2.1. Quality improvement in Radiology

Quality improvement is an all-encompassing term that comprises of quality assurance programmes to ensure on-going improvement in quality, measures to improve personnel and patient safety, and procedures to improve the expertise of the staff in all arenas in order to ensure better healthcare delivery to all patients(1-3).

Quality improvement in radiology essentially involves measures to improve the performance of diagnostic medical imaging by ensuring better selection processes of an investigation, better management of provided services (and human resources) and higher quality and safety standards(1). Patients' waiting times are a measure of the state or level of quality of care within a radiology department (4-6).

In quality improvement projects that concern service delivery and queuing, the simulation models allow research leaders the ability to assess the effectiveness of an intervention without major resource expenditure and without disruptions in the workflow(7).

In a systematic review assessing the efficacy of Service Delivery Initiatives at improving patient's waiting times in diagnostic radiology departments, most studies demonstrated improved outcomes with quality improvement strategies which included the Six Sigma, Lean and continuous quality improvement methods with only one study showing non sustainability and yet another study showing increased waiting times despite implementation of the methodology(5).

2.2. Diagnostic Radiology in Africa

Diagnostic radiological services, CT and MRI in particular are, for the most part, not readily available in developing countries (8-10). Although it is increasingly becoming an essential component of healthcare and patient management, it is associated with escalating costs and increasing demand (11). The Basic Radiological System (BRS) implemented by the World Health Organization (WHO) was intended to address the limited resources in developing countries by ensuring a cheaper, more resilient and workable solution by providing a basic radiological unit which comprises of a simple ultrasound and X-ray machine (12). This, however, is only accessible to 220 million people residing in developing countries (12). Providing and servicing specialised equipment proves to be too costly in underdeveloped areas with poor infrastructure (12). South Africa fairs better across all imaging modalities in terms of resource availability in the public sector when compared to a low income country like Tanzania and spends 12 fold more on healthcare. Availability of general radiography units within the public sector in Tanzania is inversely proportional to the cost per imaging modality unit which does not hold true in private sector where a 5-fold disparity is present between the most and least equipped regions. The least equipped region within the private sector still has more available units than the best equipped region within the public sector(13).

The basic imaging needs for rural Sub-Saharan African countries such as Uganda, Kenya, Tanzania, Malawi, Ghana and Zambia, which account for more than 80% of the region's population, are ultrasound and plain film, neither of which have been sufficiently met(14) . Poorer socioeconomic circumstances in these countries set the scene for a higher disease burden which in turn requires imaging (14). Inadequate services have been provided in this regard due to the lack of training of human resources in these rural communities(14). Diagnostic imaging is given less of a priority in Sub-Saharan Africa, with the emphasis shifting to infectious disease prevention, thereby accounting for the scarcity of imaging equipment

(14). There is a greater need for basic radiological units than other imaging modalities like CT, MRI and Nuclear Medicine (14). Tanzania is a low income country with 5.7 units of diagnostic radiology equipment assigned per million people with CT comprising of only 0.08 units. This falls far below the WHO recommendation and stipulation set out of 20 units per million people(13). The cheapest imaging modalities are the most available with CT only available in half of the geographical areas defined in this study which were the densely populated urban areas (13). Furthermore, the existing equipment is more likely to be old and malfunctioning with poor/or no servicing contracts (12, 14).

2.3 Diagnostic radiology in South Africa

South Africa is a middle income country with 19.6 units of general diagnostic radiology equipment assigned per million people, CT representing 1.7 units. This almost matches the standards set out by the WHO of 20 units per million people (13). South Africa fairs better across all imaging modalities in terms of resource availability in the public sector when compared to a low income country like Tanzania and spends 12 fold more on healthcare (8.5% of GDP) (13). Based on findings from a recent analysis conducted in 2015 of diagnostic imaging resources in South Africa, capacity within the private sector is greater than that within the United Kingdom whilst resources within the public sector are significantly lower comparatively.

South Africa has a population of 53 million people, 9 million (17%) of whom has access to private care whilst 44 million people (83%) are dependent on state healthcare. South African public healthcare is divided into public and private sectors, with public sector further divided into primary (district), secondary (regional) and tertiary (central) hospital (15). There are precise hierarchical guidelines for referrals between these hospital levels. Primary level hospitals only provide general X-ray services with some hospitals providing fluoroscopy and basic ultrasound services (15). Secondary level hospitals provide extra services like CT and ultrasound, whilst tertiary level hospitals provide an array of specialised interconnected with occasional cross-over of services between the two sectors causing interruption in the continuity of care with resultant financial and clinical implications (15). In the public sector it is imperative that the clinician identifies the most appropriate investigation of choice to deal with the diagnostic dilemma at hand and the scan request is justified by providing evidence based clinical reasoning behind it (15). This does not hold true for the private sector where diagnostic radiology services are obtained by means of financial incentives and radiological expertise is sought irrespective of the level of care provided at the hospital (15). Patients in private often have direct access to specialist care through general practitioners. Within the public sector, the intricacy and severity of the case, access to specialised services and clinical proficiency ultimately dictate progression through all levels of care (15). Health service providers interact with each other at all levels of care and even within the same level of care with access to specialised care and advanced imaging modalities being controlled in a stepwise fashion by first ensuring utilisation of basic generalised services and imaging modalities before referral for specialist care (15).

The private sector utilises approximately 5.1% of GDP on healthcare and employs 70% of medical specialists (12). Severe inequalities exist between the provision of specialised radiological equipment and staff in the public and private health sectors in South Africa, with the public sector usage placed under an enormous amount of strain (12). There is an inhomogeneous distribution of fluoroscopy, mammography, CT and MRI resources within different geographic regions in South Africa with an 11-fold disparity between the best and least equipped regions and a 13-fold discrepancy between the public and private sector. CT distribution equates to 5 units per million people while fluoroscopy is 6.6 units per million, mammography is 4.96 units per million and MRI is 2.9 units per million(16). General radiographic units are the most evenly distributed and available resource (34.8 units per million people) between different provinces and between public and private sector (16). CT distribution within Gauteng is 8.8units/million with a great discrepancy found between the public (2.2units/million) and private (21.1units/million) sectors(16).

The WHO states that the rates of diagnostic imaging should be tailored to the needs of the local population depending on the category and size of the hospital, the number and type of patients in terms of disease variety, and the capacity in terms of human resources, equipment and IT infrastructure (17).

2.4. The project in context: Comparison to literature on the topic

There has been a significant increase in the number of CT scans performed in recent years (17, 18). The NHS England figures demonstrate that the total number of CT examinations have increased by 10 to 12 % yearly for the past 10 years from under 2.0 million CT examinations performed in 2003-2004 to 5.2 million examinations in 2013-2014. According to the census, the demands are often not met (19, 20). This increase is on the rise due to technological advances replacing obsolete and invasive investigations with faster more improved CT equipment with better detector technology, and improved imaging protocols, which have made services more effective and valuable albeit rendering them more costly (17, 18). According to MacDonald *et al*. (2013), it appears that the reason for the long waiting times for CT examinations is due to the demand not being met by the supply of diagnostic imaging (21). The increase in the number of diagnostic procedures, cross sectional imaging and cardiovascular CT in particular, witnessed over the years undoubtedly raises concern about a probable overuse of these procedures (17).

The European referral guidelines allude to the causes as being due to procedures being repeated, the performing of unnecessary and inappropriate procedures, which do not alter patient management, and/or the conducting of procedures too early in the course of patient treatment (18). The capabilities of CT's have improved, thus increasing the utilisation of such investigations for indications not previously imaged (18). Repeat monitoring in certain patient categories (patients with cancer, for example) have also led to the rise in imaging. Better resolution has resulted in early detection rates for probable cancers and thus prolonged surveillance periods with CT (18). Over-utilization to reassure both patients and clinicians alike has also been documented as one of the main cause of unnecessary investigation together with improper clinical and referral information(22). In a mailed questionnaire directed to radiologists of the Norwegian Medical association in 2009 regarding the potential causes of over utilization of imaging, wrong or repeat examination were not underscored. The leading causes were in fact increased capacity, increased patient demands and assurance from clinicians(23).

In a study performed in an academic emergency department in New York, the rate of CT usage from January 2001 to December 2007 have risen slowly and gradually, the greatest increases detected in neck and chest CT imaging with a 5-fold increase(24). This was primarily due to increased rates of CTPA's performed for suspected PTED within the emergency department (24). Neck CT increases were due to greater diagnostic accuracy of ruling out traumatic C-spine injuries as opposed to using radiographs for detection(24). Recent studies have found that cervical spine CT offers a greater diagnostic accuracy in detecting injury when compared to cervical spine radiographs (25-28).

It however remains uncertain whether missed diagnosis on cervical spine radiographs are clinically significant(29). This steady increase was shown in numerous other studies which found that the reasons for this growing trend was the increased demand for fast and reliable diagnosis, increased indication, minimally invasive procedures, medical malpractice concerns and increased knowledge and perception by patients and clinicians of ever improving CT scan capabilities and availability(29-32). The advantage of CT scans providing a fast and correct diagnosis when compared to other imaging modalities like V/Q scans have also been cited in this study(32).

There has been an increase in CT utilization rates within the emergency departments even though the ED visit rates remained constant (33). The easy availability and promptness of a CT scanner was shown to affect the CT usage rates (34). CT utilization rates increased after installing a CT unit in an academic emergency department in an urban hospital (34). The reasons are manifold an include the convenience associated with easy access, the ability to make a swift diagnosis and manage accordingly by using minimally invasive means/techniques, concerns regarding medical malpractice litigation and lastly improved awareness by the layman regarding the potential benefits of a CT scan (34). It is imperative to recognize the circumstances around utilization variance so that one may improve processes (33). Ordering a CT scan is multifaceted and depends primarily on the clinical context for which a particular diagnosis is sought, the indelible risks associated with the scan, the repercussions of missing the diagnosis and the locality and patient population (33). It was shown that patients with restricted access to primary health care were more likely to undergo a CT scan examination in an emergency department within a tertiary institution compared to their counterparts with CT head and CT abdomen/pelvis being the most commonly ordered CT scan (33). Headache, abdominal pain, renal colic, chest pain and lower respiratory tract disease accounted for majority of the scans performed (33). This was merely due to the improved benefit in detecting true pathology as opposed to missing it with dire consequences and delayed primary care follow up (33). A negative scan on the other hand was insignificant with no adverse clinical consequence (33).

A study conducted in Oman examining trends in CT requests, associations and outcomes in the paediatric emergency department within a tertiary hospital demonstrated a 56% rise in the rate of CT scans performed over a 5 year period from 2010 to 2014 (35). This was out of proportion to the rate of rise in visiting patient volume (35). CT head and abdomen formed majority of the scans performed followed by the other body regions (35). CT of the cervical spine demonstrated the greatest rate of increase of 600 % (35). There was also an increased rate of admission among patients who underwent CT examinations of 44% (35).Steadily rising CT scan costs were observed which doubled over the study period (35). There was a progressive increase in the waiting time observed during this period (35). The longest waiting time documented was 6 hours (35). Increased use was attributed to readily obtainable non invasive imaging, improved imaging quality, and greater accuracy in diagnosis(35). Moreover requesting doctors may not be cognizant of the risks of radiation or may be concerned about medico-legal aspects (35).

Many radiology departments are having difficulty in coping with the increased demands due to pressure from clinicians for shorter waiting times (17) .The growing number of CT examinations has rendered CT as one of the most substantial sources of radiation(36). Potential pitfalls include misuse, escalating costs, duplicate procedures and related costs, overdiagnosis and overtreatment of benign conditions and unnecessary costly workup of incidental findings (36). The ethical prerequisite that benefit of a medical procedure must outweigh the risks to the patient undergoing the procedure may be disputed by excessive overuse of imaging (22).

Requests are often made without taking into account the side effects of radiation (17). This is the greatest during childhood but persists into adulthood (36). The effects of exposure to ionizing radiation are classified as either deterministic or stochastic. The tissue weighting factor (W_T) is a value ascribed to a specific organ/tissue based on differing tissue susceptibility to the ill effects of ionizing radiation, categorising specific tissues into different risk categories and relatively measures the stochastic effects of that particular tissue type. Stochaic effects are effects that occur by chance, the probability being proportional to the dose whilst the severity of the effects is independent of the dose. Cancer is a good example in this context. Deterministic effects, on the other hand, recognizes a threshold dose above which the incidence and severity of the physical signs and symptoms resulting from the effect on a particular tissue type increases. CT imaging produces a significant amount of ionizing radiation with effective dose from this modality approximated to be 1-10 mSv (37). 10 mSv effective dose has a 1 in 2000 chance of cancer (37). The effective radiation dose is higher in children, owing to their reduced body size (37). The prime focus of attention in dealing with increased doses has been careful acceptance of scan requests based on appropriate clinical grounds and reasoning as well as better optimization of dosing parameters (35, 37). CT scans should thus be conducted after careful consideration by both the requesting doctor and radiologist to ascertain if a particular scan is more beneficial than harmful and to seek an alternative imaging approach, like MRI and ultrasonography which eliminates the risks associated with radiation (35, 37). If CT is still deemed to be necessary, careful imaging techniques should be employed to ensure that minimal dose is delivered. This could be achieved by adjusting the dosage parameters, limiting the scan to the body region of interest, preventing repeat examinations and adjusting scan protocols by limiting the phases performed (35).Timely access should be provided whilst ensuring that there is no unnecessary radiation exposure and repetition of examinations (17).

The benefits far outweigh the risks in most instances, allowing us to rule out, diagnose and guide procedures and biopsies or determine the disease burden even before a patient may be clinically symptomatic. It may also be used to assess chemotherapeutic response and assess for disease recurrence once a patient is in a remission (22). A study in Eastern Health Newfoundland showed that shorter CT scan waiting times impacted positively on the prognosis of non-small cell lung cancer due to decreased tumour size and earlier staging (38). Moreover, diagnostic imaging can be used as an adjunct to or can substitute more traditional investigations (eg. Conventional angiography) as well as provide safer and less invasive options to conventional surgery (22).Recent studies have found that cervical spine CT offers a greater diagnostic accuracy in detecting injury when compared to cervical spine radiograph. It however remains uncertain whether missed diagnosis on cervical spine radiographs are clinically significant (25-28).The benefits associated with increasing imaging have however been contested, with some being of the opinion that the increased rates of imaging are reflective of better patient management, whilst others have argued that the costs involved are out of keeping with the proposed benefits (18, 22). If used responsibly and correctly, the benefits are distinct/indisputable (18, 22). If however used excessively, the overall benefit to the greater good may be challenged because of misbalance between the considerable cost and overall outcome (18, 22). In a mailed questionnaire directed to radiologists of the Norwegian Medical association in 2009 regarding the potential causes of over utilization of imaging, wrong or repeat examination were not underscored (23).

The volume and intensity of repeat imaging studies have however grown considerably in the last decade (39). Increased abdominal imaging repeat rates were observed at an academic tertiary hospital (39). The reasons for this was multifactorial and included patient's age, sex, existing co-morbidities, and recommendation by radiologists (39). Primary investigations were often shown to be bypassed for more advanced imaging modalities, like CT, thereby increasing the rate of repeat follow up scans (39). Repeat CT imaging in oncology patients for assessing disease recurrence and or disease stability was yet another reason (39). Radiologist recommendation for follow up repeat scans provided a small, yet significant increase in repeat imaging (39). At a particular institution, 31% of costly diagnostic imaging were repeat studies using the same imaging modality and same body region, performed within a 7 month timeframe(40). Another study showed increased repetition rates of 6.7% within a period of 30 days and 9.5% within a period of 60 days (41).Reduced repeat imaging rates have been on the agenda for policymakers as means to curtail wastage and cost and improve healthcare (41). Unnecessary radiology imaging was estimated to amount to $3.2 billion in the USA in 2004 (42). A study conducted between 2010 and 2014 at St James's Hospital in Dublin, Ireland demonstrated that an increase in CT scan waiting times translated to prolonged hospital stays which was independent of the clinical complexity of the patient and which inevitably impacted on the total hospital costs incurred (43).

In a study conducted in New Zealand by SL MacDonald *et al* , delays due to long waiting times, together with a large number of unreported investigations, resulted in increased bed usage, deferred patient management and delayed patient presentation or delayed follow up at outpatient departments (21). Due to poor service planning, the demands could not be met as management was not able to accurately forecast the required human resources and equipment needs to meet these demands (21). The identified constraint in that particular study was the confined working hours of the radiologist (21). Outsourcing radiological examination (CT and MRI) becomes a plausible solution (44).Many hospitals outsource after hour radiology service both within and out of the country.

Teleradiology, a form of partial outsourcing is a concept whereby a structured radiology report is provided by skilled, easily affordable and readily available radiologist from an external location to where the radiologic examination was performed (45). This has indeed become a valuable cost effective and competitive alternative for providing after hour diagnostic radiologic services in limited resource settings (45). Complete outsourcing is when both the performance and interpretation is conducted by an external source, some hospitals only outsourcing a certain percentage of radiological examinations. There is limited evidence in literature regarding contracting a radiology service out of the confines of an institution (46). A study assessing the impact of outsourcing Magnetic resonance examination both within and out of a stipulated timeframe showed reduced waiting times for MRI that did not honour the stipulated timeframe(46).In yet another Ph.D study conducted in Stockholm, contract based outsourcing of CT examinations was shown to be a cost effective way of reducing patient waiting time(44). Providing financial incentives to radiologists to reach certain targets in order to improve turnaround times showed favourable results (5, 22, 47).

This, however, has to be weighed against the costs of providing such incentives and services. Teleradiology makes use of standard data and computer network whereby technologies such as internet, wide area network, local area network, telephone lines and cloud computing is employed. Advanced expert technology systems like graphics processing units, voice recognition, robotics and JPEG lossy compression are utilized. DICOM (Digital Imaging and Communication in Medicine) is a standard communication system used for storing and transferring medical images incorporating multiple imaging tools and devices such as image viewers, display stations, CAD (computer aided detection systems), 3D volume-rendered reconstruction, image printers, film scanners and picture archiving and communication systems (PACS), providing storage and easy access to images, reports and related data worldwide using multiple source devices. PACS and radiology information system (RIS) are key processes in ensuring improved workflow, reduced waiting times and rapid diagnosis due to quick and easy access to images and interpretations via the digital system (5, 45). Radiologist are able to improve diagnostic efficiency by comparing prior studies and images available on PACS(45). The biggest challenge however is to ensure it is cost-effective and the net benefits received are favourable. An incremental cost analysis study undertaken in Kwa-Zulu Natal comparing the cost of digital PACS with conventional radiology in two private sector radiology departments demonstrated increased capital outlay costs but overall real productivity gains with reduction in costs for PACS compared to conventional radiology with cost saving of 5% and 14.2% for pre and post CT brain scans (45). This ensures increased revenue with better profit margins, radiographer user satisfaction, increased throughput with high quality end results (45). The costs incurred were greatest when PACS and digital X-ray equipment were acquired at the same time (45). Acquiring digital imaging equipment prior to implementation of PACS could prove be a more cost effective strategy (45).

A study conducted in one of the largest public hospitals in Denmark revealed a reduction in the CT scan waiting times for both in-patients and out-patients from 12 weeks to 4 weeks with minimal associated costs by applying the Lean methodology. This entailed identifying and addressing core customer values, better time management and organization skills and elimination of wasteful activity thereby ensuring smooth workflow (5, 48).

The manufacturing fraternity, on the other hand, has been successful in handling constraints by applying the dictum of lean rationale whereby gains are maximised and misuse is curtailed; the theory of constraints, whereby there is one limiting factor present in achieving the objectives set out in a particular targeted system; and production planning processes, whereby the utilisation of resources is optimised to ensure productivity (21). This was successfully applied to the radiology department in the abovementioned study to reduce the effect of the radiologist as the limiting factor whilst optimising the resource capacity available, thereby ensuring shorter waiting times and improved turnover of reports (21). In addition to the above, workflow functions also played an integral role in ensuring the successful completion of a scan (14). By targeting a crucial component of the workflow structure such as the radiographer's competency and productivity, optimal capacity was achieved (14).

The disparity between increased demand and available CT was shown to have a strong effect on patient waiting times for patients who underwent a head CT examination at a large academic emergency department in Boston (49). In order to deal with the increased demand for CT scans whilst maintaining cost effective methods, many emergency medical departments search for novel solutions to improve the process, thereby making it more simple (49). This is nevertheless difficult and entails organizing and integrating a number of activities and tasks to ensure an effortless and well ordered systematic undertaking.

Acquisition times in obtaining a head CT in this hospital, which was operational for 24 hours a day utilizing 2 CT scanners was analysed(49). CT processes in an emergency department need to occur in a stepwise fashion (49). 7 time periods were identified using the ED RIS system (49). This was further divided into 4 key time constituents, dividing the elapsed time from patient entry to provisional CT report completion (49). There is always a limiting factor preventing a process from reaching its full potential, thereby reducing the work output (49). While there may be many obstacles within the system, only a single step is responsible at a time for causing constraint on the system and thereby reduced output (49). This is referred to as the "bottleneck" (49). Bottlenecks occurred from time of patient arrival to time of report completion (49). The reality of the situation is that each patient passes through each step of the process at a different rate to each other resulting in a median of 39 mins of extra waiting time due to delays and backlogs from bottlenecks, the bottleneck being different for each patient (49). Hold-ups primarily occurred at 3 of the 4 key steps in the process which each took 45-60 minutes (49). Improved flow was however noted between when the scan was requested and when it was scheduled (49). The median time from patient arrival in the department to the provisional report issuance was 3 hours and 13 minutes (49). The disparity between demand and available capacity resulted in a 20% wait time increase of 39 minutes, which ultimately had a negative effect on the patient waiting times with over 225 surplus days (49). By identifying the limitation and its effect on the patient waiting times, emergency physicians are able to improve the performance of the entire system by either eliminating the limiting step or enhancing its performance, thereby ensuring shorter waiting times, cost reduction, better quality of care, more efficient resource allocation and overall improved patient satisfaction (49). In the Ontario Wait Time Information Programme, an information system utilised to monitor, measure and publicly report wait times across the province, the demand for the increasing number of scans was met by purchasing new scanners, increasing the time that the scanner was utilised and increasing the rate at which patients were scanned (50). Lean methods were adopted using Toyota's manufacturing tenet, which aims to produce only that which is needed in the correct quantity, adequate quality and at the correct time (50). Some of the aims of this method included operating the scanners throughout the day and night with urgent scans reported by the registrar after hours, whilst workup and staging scans as well as non urgent scans would be reported during the normal working hours. The intention was to increase the adequacy and productivity by ensuring that faster imaging protocols were developed whilst eliminating less useful sequences, purchasing superior machines, and expediting the flow of patients through the department (50).

Earlier imaging and increased imaging capacity was shown to have a more favourable outcome (51, 52). Although there is limited evidence regarding appropriate benchmarks, the Ontario Wait Time Group Initiative, after experiencing prolonged wait times since 2004, found the reference of a 28-day waiting period to be adequate for scans that were classified as 'non-urgent' or priority 4 scans(50). The benchmark waiting times for what we are classifying as ASAP (example malignancy workup and staging) was 10 days (priority 3). Urgent scans (priority 1) were expected to be performed immediately. Studies like acute cholecystitis and renal colic (priority 2) were expected to be done within 48 hours(50). A study recently conducted at St James's Hospital in Ireland predicted the baseline length of hospital stay for all in-patients to be 8.1 days increasing to 9.3 days and 10.8 days for differing illness severities (43) There were no other comparable benchmarks available in the literature.

National Emergency Access Target (NEAT) initiative established in Australia is a concept based in the United Kingdom whereby the goal was to ensure that time from admission into a public hospital emergency department to disposition occurred within the 4 hour target time frame set thereby ensuring shorter waiting times and better prompt quality care (53). This initiative was met with condemnation due to lack of scientific evidence and resource deficits. In addition, increased transfer disposition as well as increased length of inpatient hospital stay was noted (53). The rate of admission for low priority cases was shown to increase (53). This created strain within various other departments within the hospital (53). A study conducted in Australia evaluating imaging request patterns before and after the implementation of NEAT demonstrated a 60% increase in general imaging requests which was far more than the number of ED encounters with CT being the most requested modality when compared to other imaging methods (53). The time from when radiology request was submitted to termination of the radiological investigation was shown to have a negligible effect on the length of stay within the emergency department setting (53). The time period post radiological investigation was largely responsible for NEAT target not being met(53).

There has been a significant increase in CT utilization rates in recent years. Ordering a CT scan is multifaceted and depends primarily on the clinical context for which a particular diagnosis is sought, the indelible risks associated with the scan, the repercussions of missing the diagnosis and the locality and patient population (33). Radiation exposure, increased department throughput times, risks of anaphylaxis with intravenous contrast, psychological stress, increased costs, increased incidental findings and unintended consequence of further investigations for incidental findings are some of the risks associated with increased utilization rates (34). Benefits include improving cancer diagnosis and treatment, determining when surgical intervention is necessary,eliminating the need for exploratory and invasive surgeries, premature unmasking of unfavourable pathology, guiding early treatment of medical emergencies, directing effective medical treatment thereby reducing length of hospitilisation and improving patient disposition into appropriate care settings(34). It is imperative to recognize the circumstances around increased waiting times and utilization variance so that one may improve processes (33).

3. Aim

This study aims to calculate the mean waiting time for CT scans at Chris Hani Baragwanath Academic Hospital, Gauteng, South Africa, and correlate it to the cost per day of hospital stay.

4. Study Objectives

Primary Objectives:

1. To determine the average waiting time for CT scans in adult in-patients at the CHBAH.

2. To correlate the average waiting time for CT scans in adult patients with the cost per day of hospitalisation at the CHBAH.

Secondary Objective:

1. To determine the association between the waiting time and type of CT scan.

5. Methods

5.1. Research paradigm

A retrospective, quantitative,cross-sectional descriptive study was performed to evaluate the hospital in-patient records (radiology request forms) of adult patients booked for a CT scan under the following categories: CT abdomen and pelvis, CT chest, CT head and neck, CT extremities and CT of multiple regions over a 6 month study period from January to June 2013. Urgent in-patient scans were not included in the study as these were generally performed on the same day as requested. ASAP scans are limited scan slots that are honoured sooner than the mainstream in-patient bookings due a semi urgent medical or surgical condition and are booked approximately 7-10 days in advance. ASAP scans were included in this study. CT scans of the head and body included those without contrast, with contrast, with and without contrast and CT angiograms.

Data was captured in an electronic spreadsheet (Microsoft Excel) using patient allocated numbers as identification of the entry. The following information was collected: age of patient in years, gender of patient, the type of CT scan/body region, the clinical discipline ordering the scan (e.g. surgical discipline, internal medicine, obstetrics and gynaecology and psychiatry), the date of booking and the date the study was performed. From this information, it was possible to determine the waiting period of a scan in days. The cost per day of hospital stay used in this research was adopted from the *Gauteng Provincial Government Annual Report 2012/13.* The cost per day of hospital stay is the amount of money it costs the hospital per day in rand value to keep a patient in the state hospital. The expenditure per patient day equivalent (PDE) actual achievement in 2012/13 at Chris Hani Baragwanath Academic Hospital according to Gauteng provincial Government Annual 2012/13 report was R3101. Average length of stay during this period was 5.5 days.

5.2. Sample

The study population included the adult patients who presented for CT scans at the CHBAH radiology department. The Ontario Wait Time Group Initiative found the reference of a 28-day waiting period to be adequate for scans that were classified as 'non-urgent' (25). Proposal of priority subsets allowed a standard deviation of about 18 days for scans that were associated with cancer workup and staging (25). Assuming that the mean waiting time was longer at the CHBAH (30 days or longer), an effective sample size of 787 was required to detect a difference of 2 days longer at 5% level of significance with a power of 80%.

5.2.1. Inclusion criteria

A retrospective, quantitative, cross-sectional descriptive study was performed to evaluate the hospital in-patient records (radiology request forms) of all adult in-patients who were booked for a CT scan under the following categories: head and neck, chest, abdomen and pelvis, extremities and multiple regions, from January to June 2013. An adult is defined, in this study, as a person who is 18 years and older.

5.2.2. Exclusion criteria

Patients with incomplete data or illegible documentation were excluded from the study. This included the date the scan was booked, the date the scan was performed, the referring discipline and the demographic data.

5.3. Materials and Methods

Radiology reports of 787 adult in-patients who were booked for CT scans at the CHBAH radiology department from January 2013 were utilised in this study. Two CT scanners were utilized during the period of the study, the specifications as follows:

Table 1: Specifications of CT machines used during the study

Make	No. of slices	Location	Type/Model	Capacity	Year of Installation
Toshiba	64	Radiology Department	Aquilion S64	kVp 80, 100, 120,135 power rating MAS 60	March 2011
Toshiba	128	Radiology Department	Aquilion CX128	kVp 80, 100,120,135 power rating MAS 60	March 2011

During the period of study, the radiology department was staffed by at least 2 radiology consultants, 3 to 4 radiology registrars and 2 to 3 radiographers were allocated to CT during the working day (8 am -4 pm). The call team would then take over after this time. This included a registrar who was on duty for the entire night till 8am the following morning, a registrar on late duty who worked up until 10pm . There were no medical officers employed during the period of the study. Due to restriction on the number of afterhours radiographers could work, there were limited radiographers allocated to night shift and only 1-2 radiography staff were available to work in the CT department-often resulting in the use of only one machine during this shift.

Urgent CT scan for patients with acute life threatening emergency conditions (priority 1) were seen immediately on the same day as requested and were excluded from this study. ASAP scans were priority 2 semi-urgent inpatient cases, which would require management within a week with a fixed number of allocated slots filled early during the week of the study. These studies were included in the study population.

5.4. Ethics

Strict confidentiality was maintained throughout the entire study period, held in trust by the investigator, research staff and study institution. Study patients were identified using consecutive serial numbers and no personal identification details was recorded. Information concerning the patient's data was not released to any unauthorized third party. This ensured confidentiality of patients. Permission was obtained from the head of department and CEO. The University of the Witwatersrand approved the research protocol. Application for ethics clearance was made to the Wits HREC, the clearance certificate number of which is M150621 (Appendix A).

5.5. Data collection

Data was obtained from the filed archives of radiology reports in the CHBAH radiology department. The relevant data was obtained from the CT reports where the date of booking and the date of actual scan were well documented. The waiting time was then calculated in days. The data was recorded on a data sheet (Appendix B).

6. Data analysis and statistics

The first objective was achieved using basic descriptive analysis to obtain the mean, median and standard deviation and the range of the waiting times.

The second objective was achieved using the Pearson coefficient of correlation between the waiting time in days and the cost per one day of hospital stay expressed in South African Rand.

The secondary objective was achieved using the student’s t-test for independent samples to test if the mean waiting time was equal between the types of CT scans.

We ran the Bonferroni post hoc test to assess if there was statistically significant difference in the waiting time between surgical discipline requests and psychiatry.

Stata 13 is the data analysis and statistical software program that was used for analysis.

7. Results

The study sought to determine the average waiting time for Computed Tomography (CT) scans in adult in-patients attending CHBAH in Johannesburg. This study also looked at the correlation between the waiting time for CT scans and the cost of hospital stay.

Data was collected from 787 files of in-patients who were booked for CT at CHBAH between January 2013 and June 2013.

7.1. Study demographics

Table 2 provides a detailed description of the patients' characteristics in terms of gender, age, region of the body scanned, the cost supported by patients and also a description of the departments that ordered the exam.

Table 2: Description of the characteristics of the patients and CT scans

Variable	Frequency (n=787)
Mean Age of patients (SD)	49 (16)
Gender (%)	
Male	371 (47.14)
Female	416 (52.86)
Department Ordering CT Scan (%)	
Internal Medicine	277 (35.20)
Surgical Disciplines	394 (50.06)
Obstetrics and Gynaecology	30 (3.81)
Psychiatry	86 (10.93)
Body Region scanned (%)	
Abdomen & Pelvis	173 (21.98)
Chest	106 (13.47)
Extremities	35 (4.45)
Head and Neck	312 (43.58)
Multiple Regions	130 (16.52)
Waiting Time in Days(SD)	11 (7)
Cost in SA Rand (SD)	34 111 (21 707)

As expected in the protocol and shown in Figure 1 below, the average age of the patients was 49 years with a standard deviation of 16 years. Of the 787 patients, 47.14% were males against 52.86% of females. The average waiting time was 10 days (±7). We then obtained the cost of hospital stay by multiplying the length of stay by the cost per day of hospital stay, which was R3 101, and we found that the average cost of hospital stay was estimated at R 34 111 (±R21 7070). In terms of body regions scanned, head and neck was the most scanned region with 43.58% of the scans ordered and performed. The least scanned region were the extremities (i.e. upper and lower limbs) at 4.45%. In addition, the surgical disciplines stand out as the department that ordered most of the CT scans (50.06%), followed by internal medicine department (35.20%), with the obstetrics and gynaecology department ordering only 3.81% of the 787 CT scans.

Figure 1 below demonstrates that the age of participants was distributed mainly around age 49 years, and ranged from 18 to 91 years. Although the above figure portrays a fairly right skewness (p- value Shapiro Wilk test: 0.001), given the large sample size, it was assumed that the theorem of central limit applied to the sample and we approximated the age distribution to a normal distribution.

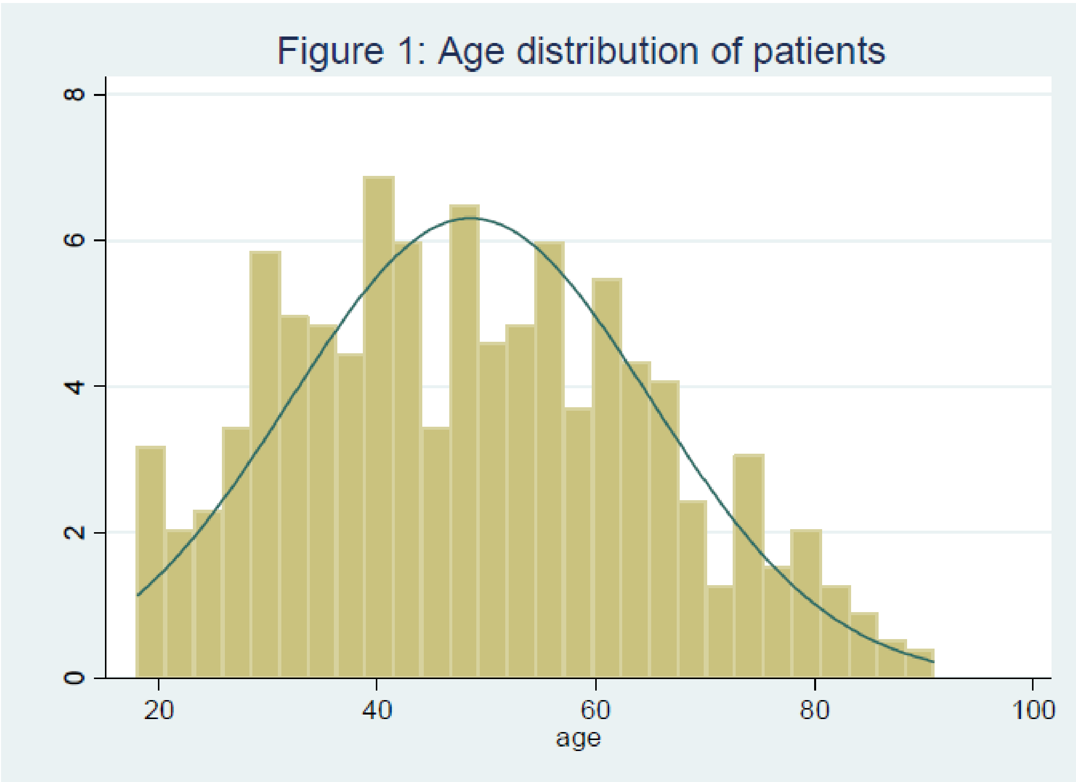

Figure 1: Age Distribution of Patients

Figure 2 portrays the distribution of the waiting time and suggests that this varies largely between 1 and 53 days of hospital stay. However, the average length of waiting time was 11 days as presented in Table 2.

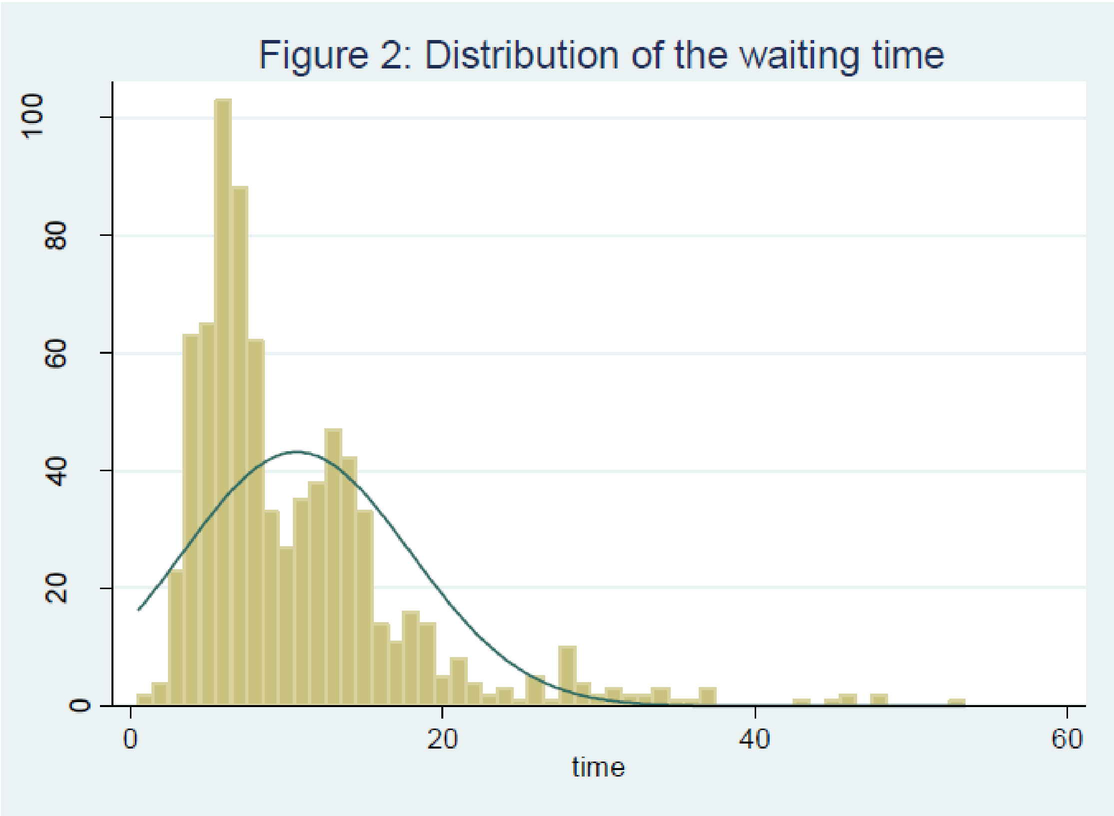

Figure 2: Distribution of Patients' Waiting Time

We were also interested in investigating associations between patients' characteristics and the waiting time with regard to gender, major department ordering the scan (Internal medicine, surgical disciplines, obstetrics and gynaecology, and psychiatry), and body regions scanned (abdomen and pelvis, chest, extremities, head and neck and multiple regions.)

Table 3 and the following graphs provide results of these investigations.

Table 3: Associations between patients' characteristics and waiting time

Characteristics	Waiting time in days	p-value
Gender		
Male (Mean)	10.43 (8.99)	0.370 t-test
Female (Mean)	10.89 (9.48)	
Department Ordering CT Scan		
Internal Medicine (Mean)	10.55 (7.35)	0.011 anova
Surgical Disciplines (Mean)	11.31 (7.30)	
Obstetrics and gynaecology (Mean)	9.7 (5.19)	
Psychiatry (Mean)	8.52 (7.14)	
Body Region scanned		
Abdomen & Pelvis (Mean)	12.13 (7.29)	0.029 anova
Chest (Mean)	11.10 (7.92)	
Extremities (Mean)	9.74 (5.94)	
Head and neck (Mean)	10.04 (7.44)	
Multiple regions (Mean)	10.31 (6.30)	

Results in Table 3 show that there was no statistical difference in the waiting time between the CT scans of male and female patients. The surgical department experienced the longest waiting times with a mean of 11.31 days whilst Psychiatry mean waiting time of 8.52 days was the shortest. CT Chest, abdomen and pelvis had relatively longer waiting times compared to Ct head and neck, CT extremities and CT of multiple body regions.

One of the objectives was to correlate the cost of hospital stay (in South African Rand (ZAR)) with the waiting time. We ran the Spearman correlation coefficient and found overwhelming evidence that there is a perfect linear relationship between the cost of hospital stay and waiting time (coef. Correlation = 1). This is clearly shown in Figure 3, which suggests that a unit increase in the waiting time increases the cost of hospital stay by about the daily cost of hospital stay, which is R1 384.

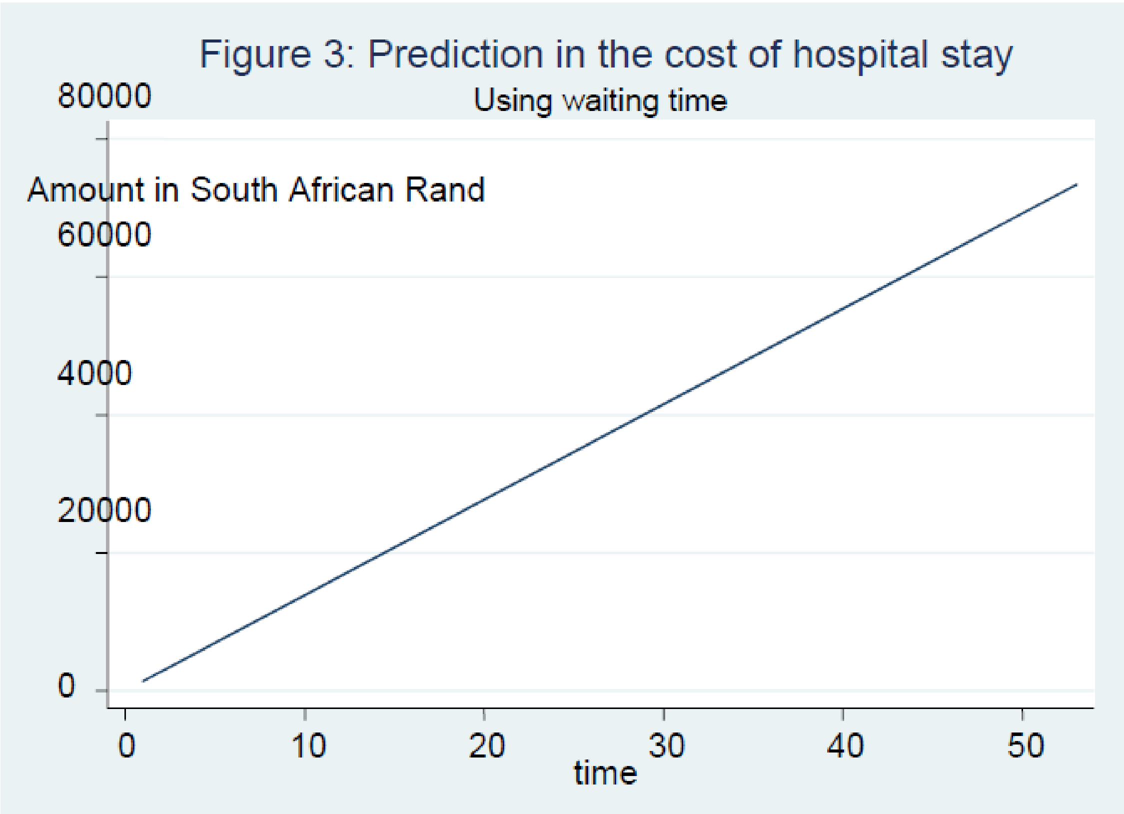

Figure 3: Prediction in the cost of hospital stay

However, the analysis of variance tests (ANOVA) show that the waiting time varies significantly based on the department from which the ordered scan originated (p-value: 0.011). We ran the Bonferroni post hoc test, which revealed that, at 5% level of significance, there was a statistically significant difference in the waiting time between surgical discipline requests and psychiatry (p-value: 0.008). Figures 4 and 5 portray these differences.

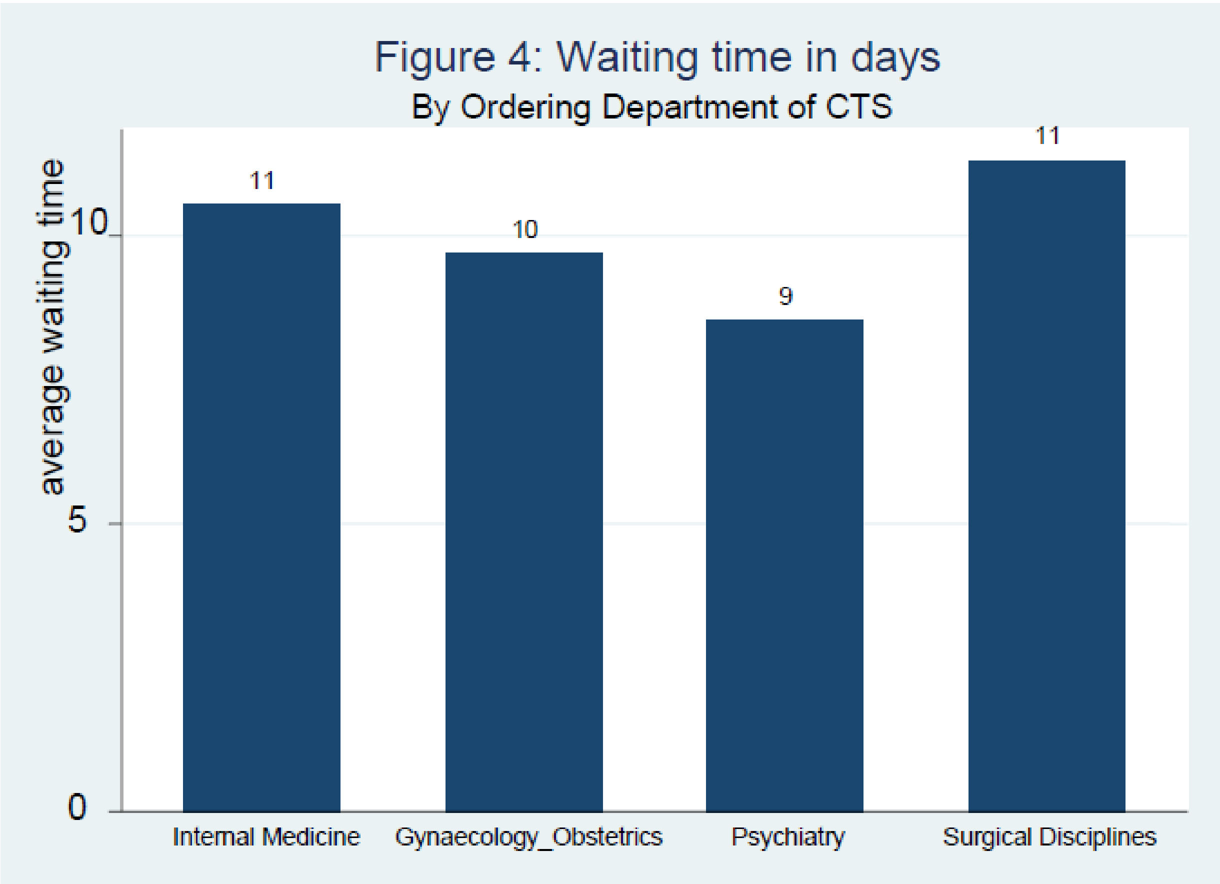

Figure 4: Waiting time in days between various clinical departments

As shown in Figure 4, all departments seems to have their average waiting time around 10 days. However, the only noticeable difference in the waiting time is between CT scans ordered from Psychiatry (8.5 days ≈ 9 days) and those ordered from surgical disciplines (11 days). For the remaining departments, as shown in Figure 4 they were not significant.

In terms of type of CT scans, as presented in Table 3 and Figure 5 , we found that at least one type of CT scan was statistically significantly different from the others (p-value: 0.03). A pairwise comparison using Bonferroni correction revealed that CT scans for head and neck, the average waiting time (10 days) was significantly less than the average waiting time for CT abdomen and pelvis (12 days). For the remaining CT scan types, there wasn't any difference in terms of waiting time.

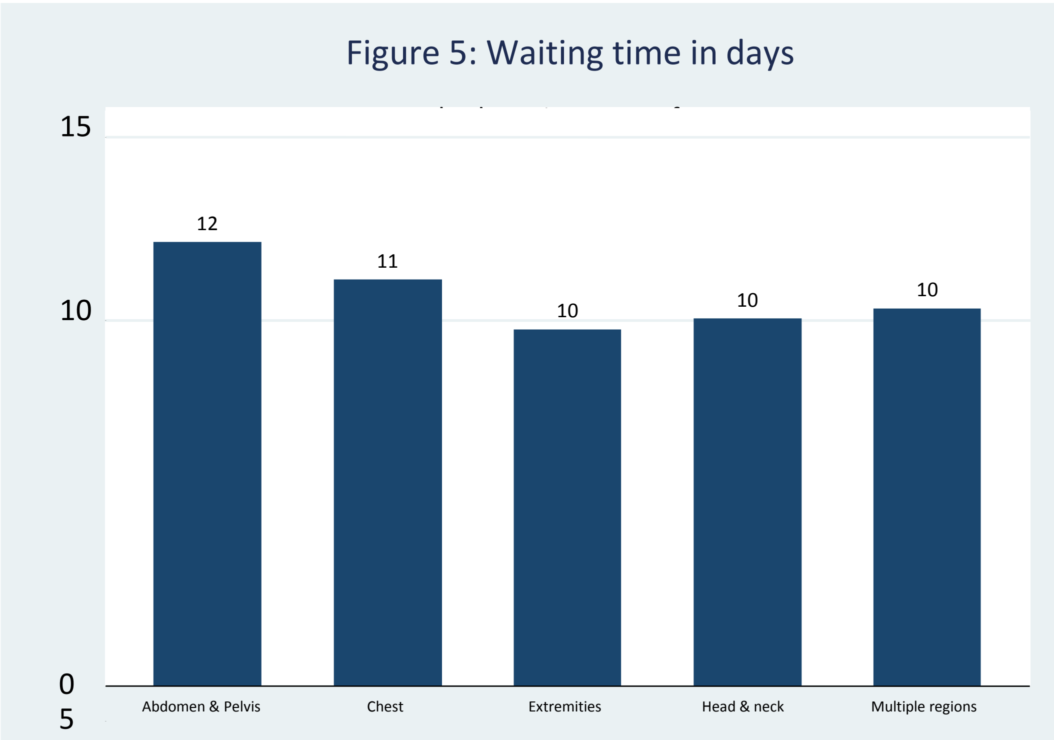

Figure 5: Waiting time in days according to body region scan

We finally strove to predict the waiting time for CT scan, using a linear regression model. Results of the regression is presented in Table 4 below.

Table 4: Linear regression model for prediction of waiting time, by department of origin and body region.

Characteristics	Coefficient	p-value
Department Ordering CT Scan		
Internal Medicine	Ref	
Surgical Disciplines	0.98	0.11
Obstetrics and Gynaecology	-1.89	0.19
Psychiatry	-1.50	0.12
Body Region scanned		
Abdomen & Pelvis	Ref.	
Chest	-0.62	0.51
Extremities	-2.85	0.04
Head and neck	-1.69	0.02
Multiple regions	-1.89	0.03

The model shows that the waiting time for CT requests of extremities, the average waiting time was reduced by about 3 days (coef. 2.85; p-value: 0.04) compared to CT request of abdomen and pelvis. Besides, multiple regions and head & neck had a reduced waiting time compared to abdomen and pelvis CT requests.

Nevertheless, it should be underscored that this model suggests that both body region and ordering department, could explain only 2% of variations in the waiting. This implies that the two factors (variables) are not sufficient to explain variations in waiting time. One reason could be that the nature of the relationship between the waiting time and each of the two explanatory variables is not linear in nature.

8. Discussion

8.1 Results in context

CT scans have become an integral part of present-day medicine providing unassailable diagnostic support. There has however been a general growing concern over the significant increase in the length of time patients wait for diagnostic imaging at the CHBAH. Clinical decisions are often delayed due to prolonged waiting times causing the necessary interventions to also be delayed (28). By addressing this, better services can then be rendered to patients with improved clinical outcomes and shorter hospital stays (28).

In this study there were 787 radiology reports of CT scans of adult in-patients attending the CHBAH in Johannesburg that were reviewed. From this study it is evident that the average waiting time of 11 days is comparable to the benchmark figure of 10 days suggested by the Ontario Wait Time Group for priority 3 scans for in-patients. (25). A study recently conducted at St James's Hospital, the largest state funded university hospital in Ireland predicted a comparable baseline length of hospital stay for all in-patients to be 8.1 days increasing to 9.3 days and 10.8 days for differing illness severities (21). There were no other comparable benchmarks available in literature. The waiting times in the CHBAH radiology department is only marginally longer in comparison with the waiting times stipulated in this study. In-patients at CHBAH are however very sick and CT requests for in-patients should actually be classified and compared to the benchmark waiting times for urgent cases (priority 1) or priority 2 cases rather than priority 3 subset. CT rendering services in Canada have also been under a huge amount of strain in the last 10 years and internal targets have not been met since their benchmark timeframes were set. CT scan times have soared as a consequence and wait times have exceeded the national standards (29).

It is also evident that correlation between the waiting times for CT scans and the cost of hospital stay is 100%, with a linear relationship demonstrated in Figure 3. The average cost of hospital stay was estimated to be R34 111 (±R21 707), which equated to approximately R26, 845,357 over the period of the study. This is a considerable amount. This amount could have been used, in accordance with the planned departmental and clinical portfolio, to purchase more CT equipment such as a 64slice CT scanner (the estimated cost is between 11–15 million ZAR). It could also have been used to invest in adequate IT infrastructure and IT support as well as additional staffing. There is a significant shortage of radiologists, radiographers and support staff (including IT, clerks, porters, nurses etc.) in the hospital.

The exploratory analysis indicated that there was a statistically significant difference in the waiting times between surgical discipline and psychiatry requests with CT bodies waiting longer than CT head and neck. This could be due to the predominant ordering of CT brains (CTBs) for workup of mental conditions which are quicker and easier to perform as opposed to CT bodies which have much longer scanning times. In terms of type of CT scans, as presented in Table 3 and Figure 5 above, longer waiting times were encountered for CT bodies (CT chest, abdomen and pelvis) compared to CT head and neck, and extremities. This could be due to earlier dates generally allocated for CT brains as well as imaging of extremities for orthopaedic surgery. These cases are often absorbed onto already full lists as they are quick studies to perform and often do not require the administration of intravenous contrast and can be performed by radiographers without the support and assistance of radiologists and nursing staff.

8.2 Bias

In this study a period was chosen when both of the CT scanners were operational with very little down time due to broken machines. This could have contributed to shorter waiting times. This period was specifically chosen though so as to reflect optimum throughput by both scanners.

Comparing our average waiting time to the benchmark suggested by the Ontario Wait Time Group could have diminished the value of our study. This is because recent Canadian national government and ministries of health websites as well as Calgary and Canadian news agencies that were perused suggest that the previously failing system has current wait times which, albeit demonstrating improvement in recent years, still exceed the national standards that were previously set. Also they are looking at non urgent scans and our cases should be classified as urgent as these are in patients whose management depends on the outcome of the CT scan, ideal waiting time of no longer than 48-72 hours.

CHBAH is the largest hospital in South Africa and Sub Saharan Africa with a 2888 bed capacity (54) and it requires more than 2 CT scanning machines to meet its service demands. Resource allocation needs to be revised to ensure strategic, needs based equipment procurement processes are applied at both Provincial and National levels. Partnership and consultation with radiology departments during the procurement process will further ensure appropriateness of equipment purchases and their distribution.

8.3 Limitations of the study

There were intervals when one of the two CT scanners were not functioning due to planned service maintenance event, or unplanned system failure event or delays in the availability of spare parts. This could have contributed to longer waiting times, however this is the reality of the situation at the hospital (and most government hospitals) where machine down times are frequently encountered. Callouts are also commonly delayed due to the fact that technicians are not paid timely by the State.

Patients were sometimes admitted to fast-track investigations and 'jump the queue' and this could have negatively impacted on the veracity of the data.

As this was a retrospective study, some data may not be available due to inaccurate records or insufficient information on the CT request form. A detailed analysis of the clinical context, indication, choice of modality and outcome of the results for each CT request was not possible. This study failed to differentiate between non contrast and IV contrast CT scans and analyse the costs thereof.

The cost per day of hospital stay used in this research is the Expenditure per Patient day Equivalent (PDE) adopted from *Gauteng Provincial Government Annual Report 2012/13* and is the amount of money it costs the hospital per day in Rand value to keep a patient in the state hospital. It is affected by price rises for items such as medication, laboratory and blood services, surgical consumables, salaries and food. It is beyond the scope of this report to further analyse the costs related to specialised high, intensive or chronic care, complications arising in hospital, procedures and investigations performed, medications received and diagnostic variations.

The information obtained from this study does not allow one to assess the positive and negative effects of CT in the study population. Temporal disease patterns over the study period may have affected CT usage rates. Results are derived from a single large academic centre within a quaternary central hospital which might not be valid and cannot be extrapolated in other imaging centres such as non-central and non-academic institutions. The study period was in 2013 and since then, Chris Hani Baragwanath Academic Hospital has purchased a third scanner and installed a PACS system. Staffing remains largely unchanged from 2013 with cycles of instability and steady improvement witnessed in between. This study may therefore only be partially relevant in the current context.

8.4 Recommendations for future studies

The results from the model highlight the need for further investigation into a full spectrum of variables (factors) that influence the waiting time. Looking at those factors goes beyond the scope of the present dissertation, but could prompt further research questions.

This study provides a platform for future studies could explore another observational period when the CT scanners are not functioning at their optimal capacity.

A review of the operations of the CT Unit at CHBAH would assist in identifying and specifically targeting bottlenecks in the system and the measuring of the impact of quality improvement efforts to improve workflow, patient throughput and the quality of service.

Assessing the impact of the introduction of simple initiatives such as bringing in additional staff to assist in taking patients on and off the table would increase patient through-put as this process often takes longer than the actual CT scanning time. These staff members would require minimal and basic training on how to move patients safely and position them for the different CT studies. Comparing the cost of employing these additional staff members and the impact on CT waiting times (and the cost savings involved) would tangibly demonstrate the cost benefit ratio. Sweating machinery and running all scans on a 24 hour basis would also increase throughput.

In addition, studies can be performed to evaluate the in-patient waiting times for different modalities (MRI, sonar, intervention, etc.). Such audits will further assist in identifying bottlenecks and inefficiencies in operations in the radiology department and will guide/inform future quality improvement efforts.

9. Conclusion

There has been a growing concern over the increased length of time patients have to wait for diagnostic imaging at CHBAH. Our study showed that the average waiting time for CT scans for in-patients was 11 days (±7). The advised maximum hospital stay for in patients at the hospital is 5 days. The average basic cost of hospital stay was estimated to be R34 111 (SD ±R21 707), which equated to a substantial amount of R26, 845,357 over the period of this study alone. This money could be better utilised to invest in human resources, imaging equipment and IT support that could assist in increasing productivity and efficiency in the CT unit. This would help meet the service demands of an overloaded system under significant resource constraints.

Understanding CT scan waiting times and utilization/usage rates does not have a direct effect/outcome on current practice but can help influence future decision making processes thereby ensuring best practice in the future. Reducing wait times should continue to be a goal of quality improvement efforts to improve the CT unit operations and service delivery at CHBAH. Continued efforts that are supported and funded by Hospital management, who controls resource allocation, are needed to ensure that the framework is patient-centred while maximising the use of the currently available resources.

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11. Appendices

Appendix A. Human Research Ethics Clearance Committee Clearance certificate.

R14/49 Dr Aadila Mehtar

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150621

NAME: (Principal Investigator)	Dr Aadila Mehtar
DEPARTMENT:	Diagnostic Radiology Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	CT Scan Waiting Times and Cost Analysis for Adult Patients Presenting at a Tertiary Hospital in South Africa
DATE CONSIDERED:	26/06/2015
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Linda Hlabangana
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	09/12/2016

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

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Administrators in Room 301, 302,304,Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193,University of the Witwatersrand

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. I agree to submit a yearly progress report. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in June and will therefore be due in the month June each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Mehtar

Principal Investigator Signature

Date 15/12/2016

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B: Data collection sheet

	1	2	3	4
Patient identification code				
Age of patient				
Gender of patient				
Date of study				
Date of booking				
Clinical discipline ordering the scan/ward				
Type of CT scan/Body region				

Appendix C. Letter granting permission to conduct research at Chris Hani Baragwanath Academic Hospital

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 5th June 2015

TITLE OF PROJECT:

CT SCAN WAITING TIMES AND COST ANALYSIS FOR ADULT PATIENTS PRESENTING AT A TERTIARY HOSPITAL IN SOUTH AFRICA.

UNIVERSITY: Witwatersrand

Principal Investigator: Dr Aadila Mehtar

Department: Radiology

Supervisor : Dr L.T Hlabangana

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: 5/6/2015

....
Approved/Not Approved
Hospital Management
Date: 10/06/15

Appendix D: Plagiarism declaration

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Aadila Bibi Mehtar (Student number: 0200885E) am a student registered for the degree of MMed Diagnostic Radiology in the academic year 2017.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: ____________ Date: 23 October 2017