AN AUDIT OF PRACTICE OF NEUROSURGERY AT THE KLERKSDORP TSHEPONG HOSPITAL, NORTH WEST PROVINCE

A 5 YEAR AUDIT OF THE NEUROSURGICAL SERVICES AT KTHC

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Declaration

I, Donjoon Moon, declare that this dissertation is my own work. It is being submitted for the Degree of Master of Medicine in the branch of Neurosurgery. It is being submitted at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Signature : Donjoon Moon, 17day of February 2024 in Johannesburg.

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Abstract

It is difficult to establish a neurosurgery center in a low-income country, particularly in rural Africa. Africa's neurosurgical workforce falls well short of global standards. The current study details the Klerksdorp-Tshepong Hospital Complex (KTHC) neurosurgery unit's five-year audit, which ran from 1 January 2017 to 31 December 2021, at the KTHC in the Northwest province. In all, 1016 patients were treated by the unit during the study period. Out of the 1016 patients, 492 underwent neurosurgical interventions of which 404 were adult patients and 88 were paediatric patients.

Of the 492 procedures linked to adults, 45,52% (n = 224) had to do with trauma, 12,60% (n = 62) with spine related conditions, 11,99% (n = 59) with infectious causes, 9,55% (n = 47) with tumours, and 2,43% (n = 12) with vascular disorders.

Out of the 88 paediatric related procedures, 68 (or 77,27% of the total) were related to congenital problems, 11 (12,50%) to trauma, and 9 (10,22%) to infection.

Overall, most procedures (n = 235) were due to trauma, congenital problems (n = 68), spine (n = 62), infections (n = 68), tumours (n = 47), and vascular conditions (n = 12). Of the total, 59,7% (n=292) were related to emergency procedures. The KTHC neurosurgical unit saw 8884 patients during the course of the study.

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List of Abbreviations

1. ICU: Intensive Care Unit
2. LMIC: Low-Middle Income Countries
3. KTHC: Klerksdorp-Tshepong Hospital Complex
4. TBI: Traumatic Brain Injury
5. DALY: Disability -Adjusted Life Years
6. OT: Occupational Therapy
7. PT: Physiotherapy
8. ST: Speech Therapy
9. JST: Job Shimankana Tabane Hospital
10. CMJAH: Charlotte Maxeke Johannesburg Hospital
11. CHBAH: Chris Hani Baragwanath Academic Hospital
12. HJH: Helen Joseph Hospital
13. MO: Medical Officer
14. NWDOH: North West Department of Health
15. NDOH: National Department of Health
16. CUSA: Cavitron Ultrasonic Surgical Aspirator
17. CT: Computed Tomography
18. MRI: Magnetic Resonance Imaging
19. SDH: Subdural Haematoma
20. EDH: Extradural Haematoma
21. ICH: Intracranial Haematoma
22. AVM: Arteriovenous Malformation

23. DAVF: Dural Arteriovenous Fistula
24. SICH: Spontaneous Intracranial Haematoma
25. SDE: Subdural Empyema
26. TB: Tuberculosis
27. MRS: Modified Rankin Score
28. OPD: Outpatient Department
29. D&E: Debridement and Elevation
30. ANTFR: Anterior Fossa Repair
31. VPS: Ventriculo Peritoneal Shunt
32. BX: Biopsy
33. TSS: Trans-sphenoidal
34. OCJ: Occipital Cervical Junction
35. ACDF: Anterior Cervical Decompression Fusion
36. ACCF: Anterior Cervical Corpectomy Fusion
37. Dec & Fusion: Decompression & Fusion
38. MMC: Myelomeningocoele
39. ETV: Endoscopic Third Ventriculostomy
40. EDAS: Encephaloduroarteriosynangiosis
41. SCI: Spinal Cord Injury
42. HCP: Hydrocephalus
43. GSW: Gunshot Wound
44. MVA: Motor Vehicle Accident
45. PVA: Pedestrian Vehicle Accident
46. FFH: Fall From Height
47. COVID: Coronavirus Disease

1. INTRODUCTION

The medical and surgical specialty of neurosurgery treats patients of all ages for illnesses that may alter the central nervous system's ability to function or behave (1).

Neurosurgery is a highly specialized surgical subspeciality, very technically demanding, and requires ample neurosurgical workforce (2,3). The individuals involved include; neurosurgeons, neuroanaesthesiologists, neurocritical care intensivists, neuroradiologists, specialized neuro scrub sisters, intensive care (ICU) nurses and ward sisters. The practice of neurosurgery is also a very resource intensive exercise, requiring specialized operating theatres, specialized neuroimaging, ICU facility and high care beds (3–5). Therefore, a solid and consistent training program, competent associated specialties, and an infrastructure that can support and accommodate the advancement of surgical technology are other crucial aspects of modern practice of neurosurgery.

According to a study conducted by the Lancet Commission on Global Surgery, five billion people, primarily in low- and middle-income countries (LMIC), lack access to safe and affordable surgical and anaesthetic treatment (2,6–9). This discrepancy is most evident on the African continent, where people who are primarily from LMICs still struggle to get access to neurosurgical care. Only 1% of the world’s neurosurgery workforce is available to treat patients in Africa, despite the continent accounting for 15% of unmet neurosurgical needs worldwide. An extra 23 000 neurosurgeons are needed to address the population’s needs since 5 million people in LMICs need neurosurgical care annually but are unable to obtain it due to constraints in capacity and resources.

The primary socioeconomic issues preventing people from seeking neurosurgical care in Africa are cost, lack of infrastructure, and human resource shortages, which still comprise the core of the region’s inadequate health care system (2,3,6–8,10–15).

Due to this, the practice of neurosurgery has found itself limited to well-resourced areas, which are usually in the major cities and central academic hospitals (16). Rabiu et al. mentioned that African neurosurgeons are, almost exclusively, in urban

centers (5). Tiwari et al. showed that the surgical workforce in South Africa is predominately in urban areas (17).

As a result, the practice of neurosurgery is now restricted to well-resourced locations, which are typically large cities and central academic medical facilities (6).

Unfortunately, the vast majority of patients who need these neurosurgical services do not reside in the major cities (2,4,17–19). This causes several challenges in terms of access to care, as most of these patients have to commute long distances in order to receive the necessary lifesaving services. These long distances lead to delayed treatment and, subsequently, poorer outcomes, especially in the case of emergencies. Families are also unable to visit their loved ones if they are admitted to a facility far from home.

The neurosurgical workforce is critical for addressing the growing burden of neurosurgical diseases such cerebrovascular accidents and traumatic brain injuries, which are rapidly rising owing to global growth and lifestyle changes (2,17). Pathologies including brain and spinal cancers, congenital abnormalities, and traumatic spinal injuries are also taking up a substantial portion of morbidity and mortality (2).

The challenges described above have led to a push to establish neurosurgical centres in the periphery or rural areas. This study will look at the establishment of the Klerksdorp Tshepong Hospital Complex (KTHC) neurosurgical unit and analyse the work that is being done in this unit.

2. LITERATURE REVIEW

2.1 Neurosurgical workforce: global, regional, and local

In 2015, the Lancet Commission on Global Surgery outlined the challenges facing the delivery of optimal, effective, and quality surgical care around the globe (2,6–10). According to the commission, 5 billion people do not have access to safe, affordable surgical care when needed. Access is worst in LMICs, where nine of ten people cannot access basic surgical care. The commission noted that 143 million additional surgical procedures are needed in LMICs each year to save lives and prevent disability (2). Of the 313 million procedures performed worldwide annually, only 6% take place in the poorest countries, home to more than a third of the world's population (2).

Neurosurgery continues to be a major surgical specialty that contributes to the worldwide surgical care shortage. An average of 22.6 million people worldwide require neurologic care each year for conditions such as traumatic brain injury (TBI), stroke, brain tumours, and epilepsy, of which 13.8 million require surgery. They are the leading cause of disability-adjusted life-years (DALYs) lost and the second leading cause of death worldwide (11). More specifically, according to research by Mediratta et al., there are currently 69 million new cases of TBI reported yearly worldwide, with the bulk of these cases occurring in LMICs. Furthermore, it is estimated that the global neurosurgical case coverage is 11.1 million, and that there is an outstanding deficit of 5.2 million cases (16). Nearly half of the unmet neurosurgical need worldwide is found in low-income countries, mostly in Africa and the Eastern Mediterranean regions (2,16).

Barriers to accessing, obtaining, and receiving care are to blame for this high surgical unmet need. These include inadequate surgical capacity brought on by a shortage of facilities and skilled workers (2,4,15,18). Thus, among the several solutions proposed by the Lancet Commission to meet current and projected population demand by 2030 was the need for urgent investment in human resources for health and scale-up of specialist surgical workforce and services (2). The current study by Ukachukwu et al. indicates that there are only 106 neurosurgery training

facilities in Africa. When the lack of neurosurgeons is considered in the African context, the outcome is far worse.

According to a 2014 study by Ellagala et al., the region of Sub-Saharan Africa has the worst scarcity, with one neurosurgeon for every nine million people in 18 countries and none at all in the other 11 nations.

Based on a comprehensive study and meta-analysis by Ukaechukwu et al., with a population estimated at 1.3 billion, there are now 1974 expert neurosurgeons working in Africa, translating to a workforce density of 0.15 per 100,000 and a ratio of one neurosurgeon to 678,740 people. Furthermore, the overall number of neurosurgeons practicing in Africa is unevenly distributed, with the majority practicing in northern and southern parts of Africa (64.4%). In the same study, Ukaechukwu et al. noted that in the African continent, there were only 488 neurosurgeons providing care for nearly 1 billion people out of the estimated 49,940 specialist neurosurgeons globally in 2016. This equates to a ratio of 1 neurosurgeon per 2 million people, which is way below the recommended ratio.

With a density of 0.61 per 100,000 and a ratio of 1 neurosurgeon to 163,022, northern Africa has the highest concentration of neurosurgeons, with 1271 (64.39%) treating 207.2 million patients. The region that follows is southern Africa which has 250 neurosurgeons (12.66%) for 184.1 million people, representing a density of 0.14 per 100,000 and a ratio of 1 neurosurgeon for every 736,286 people.

The most profound deficiency exists in Sub-Saharan Africa, with 1 neurosurgeon per 9 million population, and no neurosurgeons at all for some countries (15).

South Africa has 180 neurosurgeons which equates to a density of 0.40 per 100,000 (17). Most of these neurosurgeons are practising in the major urban centres or in central academic hospitals (4,17,19,20). A study by Tiwari showed that most of the South African surgical workforce was in urban areas (17). Rural provinces such as Limpopo and North West were at the bottom in terms of surgical specialist density (17).

Unfortunately, these central academic hospitals have reached maximum capacity in terms of caseload that they can process. There is a shortage of beds and theatre time. Increasing theatre time would mean increasing infrastructure spending to

expand the physical theatre space. This leaves us with a need for neurosurgical services to expand out of academic hospitals. This expansion will help to increase capacity of neurosurgical services and relieve pressure on the overburdened central academic hospitals.

2.2 Setting up a peripheral neurosurgical centre; strategies and challenges

Novel approaches to establishing neurosurgical institutions in remote places, especially in Africa, have been the subject of numerous investigations. However, realistic approaches and solutions to the various obstacles and complexities involved in setting up neurosurgery centers are, nevertheless, limited.

According to Morgan and Nwatuzor, opening a neurosurgical practice in a rural area is very challenging (20). They published their experience of setting up a rural neurosurgical center in Irrua, Nigeria which, prior to this, did not have any neurosurgical services. Through the presentation of their 18-month work, they have demonstrated the importance of establishing a neurosurgery unit in the rural area. Throughout the study period, they have seen and cared for 450 patients who would not have had neurosurgical care otherwise. The challenges identified included shortage of workers, inadequacy in critical care, intervention supplies, theater space and post-operative care, in addition to inefficient coordination and communication amongst all members of the medical staff, all of which contributed to a substantial amount of time being lost on patient care (20).

A study was carried out by Okon-Udoh to document the establishment and functional status of a neurosurgical unit within a tertiary institution in Benin City, a small peripheral city in the South of Nigeria (4). The study centered on the local hospital which is 300km away from a tertiary hospital with neurosurgical services. For many years, patients from this region in need of neurosurgery were referred to central hospitals, which were far from their homes. This study showed that despite the challenges, a functioning and expanding neurosurgical unit can be established in resource-limited areas of West Africa (4). Much-needed ward and operating room equipment was purchased by forming a collaboration with a global organization with the common goal of developing and improving neurosurgery (4). By providing

programs like academic support for aspiring young neurosurgeons, staff training for neurosurgical nurses, and ancillary staff development (OT, PT, and speech therapy), the recently established neurosurgical unit was able to advance towards becoming a capable, self-maintaining facility (4).

The experience of establishing a neurosurgery unit in a remote area was discussed by Rabiu and Komolafe (5). Ido-Ekiti is a remote and rural suburb in Southwest Nigeria, home to an estimated 5 million inhabitants in its catchment region. Their article demonstrated that neurosurgery can be effectively performed in these remote regions. They also highlighted the variety of tasks they managed to finish and the outcomes they achieved in the peripheral site.

A case study of neurosurgical workforce was published by Kamounye et al. It was noted that there are not enough neurosurgeons in Cameroon, and the country's neurosurgical workforce is not evenly distributed geographically. This is demonstrated by the study, which found that the workforce density in Cameroon was 0.09 per 100,000 people. It further mentioned that of the 25 neurosurgeons practicing in Cameroon, 19 (or 76%) are found in the country's administrative and commercial centres. The paucity of neurosurgeons in some areas of Cameroon is not surprising. In these impoverished communities, general practitioners and surgeons treat manageable neurological disorders with very little support. When they cannot provide neurosurgical care that satisfies their patients' needs, they refer them to other areas for appropriate management. Sadly, only those patients who can pay the expenses and endure the difficult traveling conditions in conventional vehicles end up making the trip to the areas with adequate neurosurgical facilities.

A Tanzanian study on the advancement of neurosurgery capabilities in developing and low-income nations was published in 2014 by Ellagala et al. Tanzania had just three board-certified neurosurgeons serving its 39 million citizens prior to the adoption of the study's training model. It was an experimental method which required a qualified neurosurgeon to teach medical doctors and/or paramedical staff interested in neurosurgery. While offering specialized teaching, practical training, research opportunities, and general advocacy to interested medical doctors or paramedical professionals, the neurosurgeon also resides in the community they serve. Training is hands-on, intensive, and patient-centered. Despite having

achieved a significant increase in surgical capacity, the approach may be criticized for training participants outside of an official residency program in neurosurgery. There are strong ethical arguments for and against this practice. Nonetheless, the train-forward neurosurgery approach, which equips local physicians with the capacity to carry out life-saving treatments, may be of utmost importance for the group of 43 nations worldwide where the ratio of neurosurgeons to patients is 1:1 million.

One way to develop and grow neurosurgical workforce is via global neurosurgery, a collaborative effort between countries to create and expand the neurosurgical workforce. It is defined as “a field of study, research, practice, and advocacy with a focus on achieving health equity and improving health outcomes for all individuals globally who require neurosurgical care or are affected by neurosurgical conditions.” Plans to promote universal neurosurgical access are put forth by global neurosurgery, which also supports the need for funding for neurosurgical care. Research in this field generates data that is used to develop, monitor, evaluate, and modify policies in order to improve access to neurosurgical care through initiatives focused on the six surgical system domains: infrastructure, workforce, service delivery, financing, information management, and governance.

An integral part of global neurosurgery is research. It can help with policy formation, education promotion, and the spread of new ideas. Research also informs the public about illness trends, treatments, results, and potential obstacles to high-quality, secure, accessible, and reasonably priced healthcare, especially in developing nations. However, studies show that LMICs are underrepresented in research publications despite having a significant disease burden.

A study by Kamounye et al. suggests that cooperating closely with the international neurosurgical community, i.e. Global Neurosurgery, would benefit local communities and the world at large. The authors noted that Cameroon, as is in other LMICs, faced many of the same difficulties when practicing neurosurgery. The authors clarify and provide evidence throughout the study that they should collaborate with other neurosurgeons worldwide to devise innovative solutions to problems involving subpar transitional care, insufficient rehabilitation, loss to follow-up, and untrustworthy referral systems.

For instance, the three most prevalent neurosurgical conditions—TBI, stroke, and epilepsy—occur primarily in LMICs, where patient treatment is delayed and resources are scarce. But as the authors of the book acknowledge, the guidelines for these common neurosurgical problems were developed in non-LMICs and are based on non-LMIC neurosurgical practices. This has made applying these ideas to LMICs difficult and often impracticable. The study goes on to say that locally produced scientific data ought to help neurosurgical practice in LMICs by offering clinical recommendations that are appropriate for the local setting. More locally driven and relevant scientific research will open doors for collaboration between neurosurgeons in developed and developing nations to provide solutions that are sustainable, egalitarian, and supported by data relevant to the specific context.

A paper by Heng et al. showcased their achievements and challenges of establishing a rural neurosurgical center in Malaysia. The focus of the research is the neurosurgery unit of Sibu Hospital, which provides care to more than a million people. It had many challenges, such as deficiency of qualified neurosurgeons and equipment particular to neurosurgery, as well as lack of facilities like ICU and general neurosurgical beds. The starkest obstacle, though, was the dismal number of neurosurgeons working in rural areas. Heng et al. noted that the main barrier to a neurosurgeon treating patients in remote areas are inadequate training in subspecialty at the tertiary center and lack of advanced technology, which is further compounded by a detachment from expert supervision.

Fuller et al. presented a study in 2016 outlining strategies for boosting the neurosurgical capacity in LMIC environments. The joint effort between the neurosurgery department at Duke University and the local neurosurgical unit in Uganda has produced a replicable model that can meet the requirements of both organizations. The authors call it the threefold approach to building neurosurgical capacity; technology, twinning and training performed together in a top-down approach. The results are quite outstanding. The approach, according to the research, allowed the Ugandan neurosurgery unit to grow surgical cases by over 300% and produce 5 neurosurgeons from 0 over a 5-year period. These remarkable accomplishments are not without difficulties, which need to be considered for potential future applications. One of the main challenges identified was the lack of government support. A country suffering from higher prevalence of communicable

diseases finds it difficult to fund a specialist division like neurosurgery as their healthcare system is already constrained with resources. They had to contend with lack of equipment and facilities to increase surgical capacity.

Numerous common obstacles have been identified by these studies on the establishment of neurosurgery units in rural areas. These include a lack of dedicated neurosurgical nurses and ancillary staffing, inadequate facilities for operations (theatre, critical care), negative perception toward neurosurgery among the local population, geographical challenges (such as the distance patients need to travel), and most importantly, the lack of trained neurosurgeons, which is a definitive hindrance for providing neurosurgical service to the rural areas (3–5,15,20). However, the resilience of global need of neurosurgical care has shown the potential strategies to meet the demand with the help of individuals, organizations and universities.

3. KLERKSDORP TSHEPONG HOSPITAL COMPLEX

3.1 Demographics & Geographic profile

Klerksdorp Tshepong Hospital Complex is located in Klerksdorp in North-West Province, fourth smallest province in South Africa with estimated population of 4 million people. It is situated centrally and in the northwest of South Africa, roughly 160 kilometers southwest of Johannesburg, as shown in the map below. Its neighbouring province to the north is Limpopo, Mpumalanga to the north-east, Gauteng to the east, Free State to the south-east, and Northern Cape to the south-west and it shares its borders with Botswana to the west and north. Dr Ruth Segomotsi Mompati, Dr Kenneth Kaunda, Ngaka Modiri Molema, and Bojanala are the four districts that make up the province.

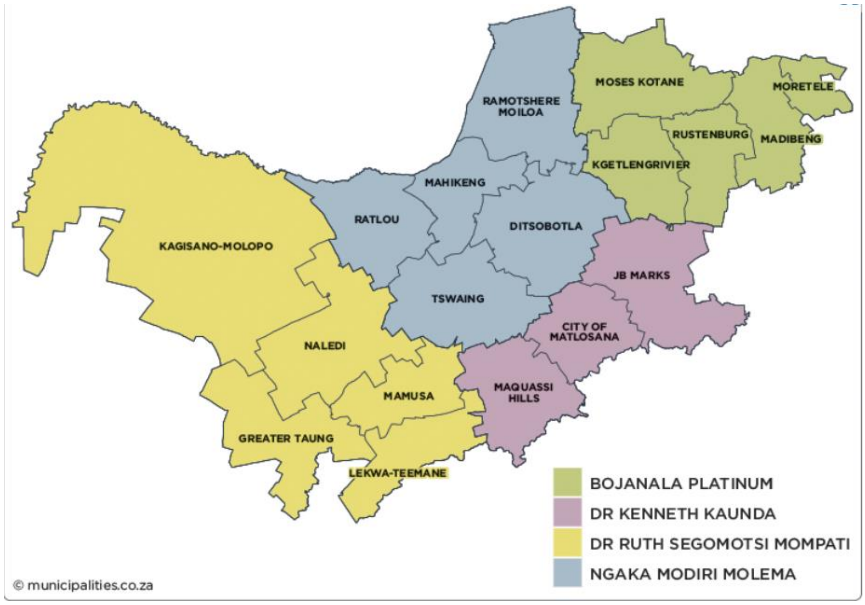

Figure 1: Map of the North West Province (21)

3.2 Tertiary referral structure pre-KTHC neurosurgery

All patients in the Bojanala District who require tertiary care are referred to Job Shimankana Tabane (JST) Hospital as per the referral pattern for tertiary services (22). Patients are typically directed to Klerskdorp-Tshepong Hospital Complex, George Mukhari, or Steve Biko Academic Hospitals if Job Shimankana Tabane Hospital is unable to provide the specialized tertiary care they need (22).

There have been instances where they have had to refer patients to Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) or Chris Hani Baragwanath Johannesburg Academic Hospital (CHBAH) when the aforementioned facilities are unable to provide the needed services due to capacity issues. Since these hospitals are not part of JST's natural referral chain, sending such patients to Chris Hani Baragwanath and Johannesburg Hospital can be challenging (22). All three other districts, as well as regional hospitals including Mahikeng Hospital, Potchefstroom Hospital, and Joe Morolong Memorial Hospital in Vryburg, refer patients to KTHC for tertiary care. Limited tertiary services are offered by Mahikeng Hospital.

Klerksdorp/Tshepong serves as the primary tertiary referral centre for majority of the North Western region. For tertiary services that it does not offer, Klerksdorp/Tshepong further sends patients to CHBAH and CMJAH. In certain instances, Mahikeng and Potchefstroom Hospitals refer directly to CHBAH and CMJAH when those services are not available in Klerksdorp Hospital (22).

3.3 Early experience of KTHC neurosurgical unit

Prof Girish Menon, a neurosurgeon from India, and Prof Binu Luke, the head of tertiary and academic services at KTHC, can be credited with establishing the neurosurgical unit at Tshepong hospital in 2012. Prof Menon chronicled his experience of setting up the unit in his local university journal, Chitra Dhwani. In this article he discussed some of the challenges he faced (23).

Prior to his arrival, neurosurgery was nonexistent in Klerksdorp and all patients used to be referred to Johannesburg, CHBAH in particular. The facility lacked a specialized neurosurgery ward, staff (including neurosurgeons, general sisters, theatre sisters), and equipment, despite having enough bed capacity and all the fundamental medical and surgical specialties.

During Prof Menon's early tenure at KTHC, a major advancement in the equipment required to start the neurosurgery unit occurred in accordance with the North-West Providence tertiary services expansion plan (12). Prof Luke, who was leading the project, recruited his MBBS classmate, Prof Menon, to realize the dream of establishing a neurosurgical unit as a satellite site of the central hospital unit in Johannesburg, CHBAH (24). After an unsuccessful attempt to establish a neurosurgery center in Mafikeng Provincial hospital, the hospital administration consented to move the collection of already bought neurosurgical consumables to Tshepong hospital.

On top of the various challenges he faced, neurosurgery's mystique and lack of awareness by the staff posed the biggest issue for Prof Menon (23). It was exceedingly challenging to convince the staff of the value of promptness in action and that with appropriate intervention, lives can be saved. However, once the team was able to realize the lifesaving potential of the neurosurgical interventions, the staff

were inspired and persuaded to adopt the neurosurgical mentality (23). It was quite clear that making the unit work and moving through mystification toward brilliance was a difficult task for him.

Despite all obstacles, Prof Menon was successful in training three local medical officers (MO) who had never conducted neurosurgery. By the time he departed, the MOs could perform simple neurosurgical procedures including craniotomies and burr holes. A dedicated ward, theater and outpatient department was set up and all essential equipment were procured. All this was made possible due to the funding provided by the National Department of Health (NDOH) and North West Department of Health (NWDOH), namely the National Tertiary Services grant and Health Professionals Training and Development grant (25).

3.4 Klerksdorp Tshepong hospital complex neurosurgery

KTHC is comprised of two hospitals, Klerksdorp and Tshepong, located only 7km away from each other. According to Luke et al., the overall approved bed capacity of the hospital complex is 1015 with 904 open beds. Established in 2012, it is the only neurosurgical center in the North-West. The neurosurgical unit is currently comprised of 20 beds, including 4 high care beds, and have access to 10 ICU beds in Tshepong which is shared by other medical and surgical disciplines. Currently, the department is headed by two consultants qualified at Wits University, two registrars from Wits circuit and one community service medical officer. First year interns rotate from the department of surgery. The patient traffic is very high with about 80 – 120 inpatients, 20 – 40 procedures (Includes emergency and elective cases) and about 200 outpatients per month (22).

Tshepong neurosurgery has its own dedicated neurosurgical theatre and anaesthetic team. One theatre nurse who trained and worked in Australia as a neurosurgical theatre sister for several years is now sharing her skills and expertise at the hospital.

In terms of the theatre equipment, there is a modern microscope, an Aesculap drill, a complete Karl-Storz neuroendoscope and a neuro operating table. A CUSA machine as well as a neuronavigational unit was purchased in 2023. The hospital complex has two CT scans, a 64-slice scanner, and a 160 slice CT scanner, adequate for most neurosurgical needs, and equipped with software for CT angiography studies.

The hospital also has a 1.5 Tesla MRI scanner with turnaround time (time from booking of the scan to getting the report) of roughly 45 minutes (22). In addition, the KTHC is planning to have the biplane hybrid catheterization laboratory commissioned in February 2024.

Tshepong neurosurgery department competency has grown and evolved from performing basic neurosurgical procedures such as ventriculo-peritoneal shunt for hydrocephalus, intracerebral abscess drainage and craniotomies for emergency trauma cases, to covering a wider scope of neurosurgical procedures including craniotomies for intracerebral tumors, clipping of aneurysms, neuroendoscopic procedures as well as spinal procedures such as spinal decompression & fusion.

Currently, the KTHC supports number of clinical departments in cooperation with the University of the Witwatersrand. The departments of medicine, surgery, anaesthesiology, pediatrics, radiology, oncology (medical and radiation), obstetrics & gynecology, family medicine, psychiatry and orthopedics are the supported departments and between 2-10 registrars rotate through each department for different time intervals (22,26).

KTHC neurosurgery, being a primary neurosurgical center, provides much needed neurosurgical service to the surrounding areas/hospitals, which includes Matlosana (Klerksdorp, 434308 population), Potchefstroom Hospital (53km from Klerksdorp, 123,669 population), Mafikeng Hospital (167km from Klerskdorp, 336,522 population), Joe Morolong Hospital of Vryburg (215km, 52482 population), Delareyville Hospital (128,8km, 10630 population) and Taung Hospital (233,2km, 175,000 population) (25). This translates to a ratio of 1 neurosurgeon to just over 566,305 population (for two qualified consultants). This ratio is five times lower than the optimum ratio proposed by Surgical Services for the United States back in 1977. Surgical Services for the United States states that for effective neurosurgical decision-making, there should be one neurosurgeon for every 100 000 population(27).

Other challenges which hinder the potential growth and building of fully functional independent neurosurgical unit include lack of ICU beds, particularly neuro-specific ICU facilities, as well as staffing and service shortfall as a result of the ICU being

split between two hospital sites (Pediatric and Pediatric ICU is located at Klerksdorp complex).

However, one positive characteristic of Klerksdorp-Tshepong neurosurgical unit is that there is no need for most of the patients to be referred to central hospitals. This provides enriching and rewarding working opportunities for registrars in training based at the hospital complex. And since the facility is closer to the local community, this allows for families to visit the patients instead of travelling hours to the central hospitals (CHBAH/CMJAH).

4. AIM

The aim of the study is to audit the KTHC neurosurgery unit and to assess its impact on the local population.

5. OBJECTIVES

1) To identify patient demographic and outpatient department (OPD) numbers.
2) To analyze annual number of theatre procedures performed and types of disease.
3) To identify morbidity/mortality cases to aid in future reduction of unfavorable outcomes.

6. METHODS AND MATERIALS

6.1 Study design

A retrospective cohort study of the KTHC neurosurgery unit for a 5-year period from 2017 – 2021.

6.2 Study sites

The study was carried out at KTHC.

6.3 Study population

Patients referred directly/indirectly to KTHC for neurosurgical management for the study period.

6.4 Inclusion criteria

The following inclusion criteria were used:

- All patients admitted to KTHC neurosurgical wards for neurosurgical management for the study period of 2017-2021.
- All patients followed up at KTHC neurosurgical OPD for the study period.

6.5 Exclusion Criteria

The following exclusion criteria was used:

- Patients with missing or incomplete data

6.6 Data sources & collection

Details of patients who presented with a neurosurgical condition in KTHC during the study period was collected from the neurosurgical ward database as well as the hospital archives. The patient records were then reviewed and clinical, radiological and laboratory data were extracted and analysed. The following variables were used to collect the data:

- Demographics (age, gender)
- Date of admission
- Presentations: GCS /15, headache/ seizures/ focal deficit/ coma
- Neurosurgical condition

- Trauma:
  - TBI: SDH/EDH/ICH
  - Traumatic spinal injury: CCJ/ sub axial c-spine/ thoracolumbar, central cord/ anterior cord/ brown sequard/ posterior cord
- Paediatrics: tumour/ hydrocephalus/ dysraphism/ encephalocele/ craniosynostosis
- Vascular: aneurysm, AVM, DAVF, cavernoma, SICH
- Oncology
  - Primary
    - Intrinsic: low grade glioma/ high grade glioma
    - Extrinsic: meningioma/ pituitary adenoma, vestibular schwannoma
  - Secondary: breast/lung/git/renal/melanoma
- Infections: SDE/Brain abscess
- Spine:
  - Degenerative: cervical spondylosis, lumbar spine stenosis, spondylolisthesis
  - Infection: TB spine/ discitis

- Neurosurgical intervention done:
  - Emergency/elective
  - Cranial: burrholes/craniotomy/craniectomy
  - Spinal: anterior/posterior, cervical/thoracic/lumbar/sacral, decompression – laminectomy/ discectomy, decompression and fusion,
- Monthly breakdown of number of patients seen at OPD.
- Outcome: Modified Rankin Scale – good outcome MRS 0 – 2, poor outcome MRS 3 – 5

6.7 Data management

The data was collected & filed and then transferred onto an excel spreadsheet.

7. DATA ANALYSIS

The use of descriptive statistics was employed to analyse the data and the following data were compared for the study period of 2017-2021:

- Total annual number of admissions at KTHC
- Total annual number of neurosurgical procedures (types as mentioned done at KTHC
- Total annual number of OPD patients seen at KTHC
- Average length of stay for neurosurgical patients at KTHC
- Average age for patients who received intervention at KTHC
- Admission vs intervention rate will be computed and compared for KTHC. This is to demonstrate the turnaround time and efficacy of theatre.

All the above statistical analysis was performed in STATA version 16 for statistical analysis.

8. ETHICAL CONSIDERATIONS

An application for ethics clearance was submitted to the Human Research Ethics Committee (Medical) at the University of Witwatersrand. The study was approved and a clearance certificate **M230608** (Appendix A) was obtained. Consent from the Department of Health North-West Provincial Government was obtained (Appendix B). Consent to use hospital patient records was obtained from the medical superintendent as well as HOD of neurosurgery at the KTHC (Appendix C). Consent was obtained from the HOD of neurosurgery at the University of Witwatersrand to conduct research on the neurosurgical unit at the KTHC (Appendix E).

9. LIMITATIONS

The following are the limitation of the study

1. Lost patient details/files for the KTHC patients for the study period.
2. Lack of information regarding functional status of discharged patients (e.g. GCS on discharge summary/use of modified rankin scale to assess functional outcome of patient).

10. RESULTS

10.1 Total annual number of admissions at KTHC

A total of 1016 patients were admitted to the neurosurgery unit at KTHC between 2017 and 2021, the research period. Of the patients admitted, 24,7% were female, 60,03% were male, and 18,6% were paediatric patients. 308 transfers from nearby hospitals with insufficient neurosurgery capacity made up 30,3% of all admissions.

Variables	2017	2018	2019	2020	2021	Total	%
TOTAL	**227**	**173**	**311**	**141**	**205**	**1016**	
MALE	117	91	189	90	123	610	60,03%
FEMALE	67	40	59	31	54	251	24,70%
PAEDS	43	42	57	19	28	189	18,6%
REFERRED	82	52	93	40	41	308	30,31%

Table 1: Demography of admissions and transfer-in for the KTHC from 2017-2021

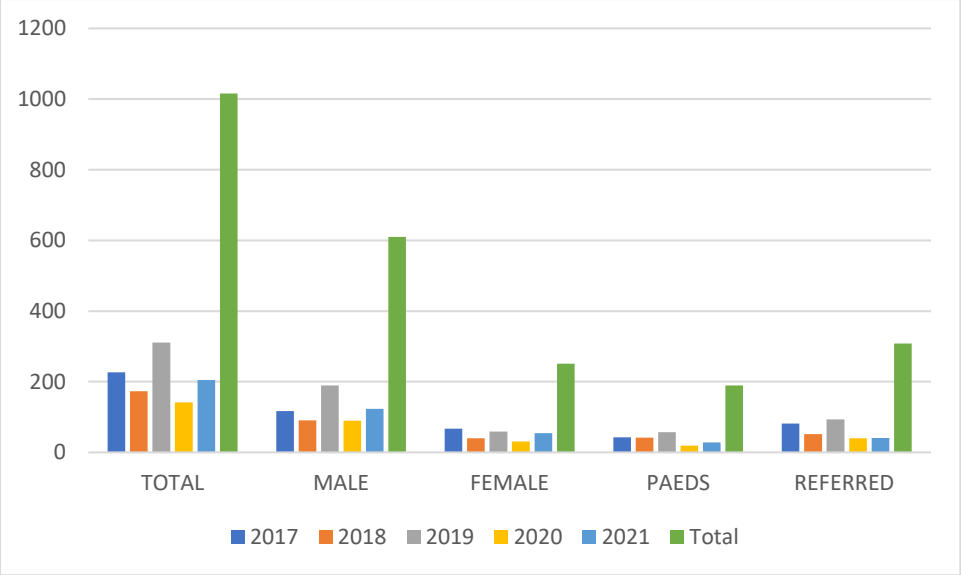

Fig 2: Demography of admissions and transfer-in for the KTHC from 2017-2021

10.2 Total annual number of neurosurgical procedures performed

In all, the highest number of procedures performed were craniotomies (n = 235; 35,76%), followed by burr holes (n = 150; 22,83%). Majority of craniotomies were used for adult trauma-related conditions (n = 182; 77,44%) and tumour-related conditions (n = 33; 19,3%).

The most common procedure for the spine was ACDF (n=23; 34,84%), which was followed by decompression and fusion (n=20; 30,3%). Majority of surgeries performed on paediatric patients (n=46; 52,27%) were linked to VPS.

Variables	2017	2018	2019	2020	2021	Total
Trauma	**68**	**70**	**78**	**55**	**90**	**361**
Craniotomy	30	40	41	24	47	182
Burr holes	24	21	26	16	31	118
Craniectomy	4	3	2	2	5	16
D&E	5	4	5	5	4	23
ANTFR	1	0	1	3	0	5
VPS/Revision	3	1	1	2	0	7
Cranioplasty	1	1	2	3	3	10
Infection	**18**	**17**	**19**	**15**	**14**	**83**
Craniotomy	3	4	3	4	6	20
Craniectomy	1	4	2	2	1	10
Burr holes	7	5	7	2	2	23

Debridement	3	2	4	4	3	16
VPS/Revision	4	2	3	3	2	14
Tumour	**12**	**5**	**10**	**8**	**12**	**47**
Craniotomy	9	4	6	7	7	33
Stereotactic bx	0	1	4	1	2	8
Tss	3	0	0	0	0	3
Omaya res	0	0	0	0	3	3
Spine	**12**	**11**	**16**	**11**	**16**	**66**
OCJ Fusion	1	0	0	1	1	3
ACDF	4	4	6	2	7	23
ACCF	1	3	2	2	0	8
Laminectomy	3	1	5	2	3	14
Dec&Fusion	3	3	5	4	5	20
Peds	**21**	**23**	**20**	**10**	**14**	**88**
Craniotomy	1	2	3	1	2	9
Burr holes	2	1	3	1	2	9
D&E	0	1	1	0	0	2
VPS/Revision	7	15	10	6	8	46
MMC Repair	5	4	2	1	2	14
ETV	6	0	1	1	0	8
Vascular	**4**	**1**	**5**	**0**	**2**	**12**
Clipped	3	1	5	0	2	11
EDAS	1	0	0	0	0	1
Total	**117**	**110**	**129**	**84**	**134**	**657**

Table 2: Type of procedures done at KTHC neurosurgery 2017-202

10.3 Disease profile

527 patients (51,8%) had illnesses related to trauma, making trauma the most common reason of presentation. Table 3 shows that 439 patients (43,2%) and 88 patients (8,6%) had head and spinal injuries, respectively. Assault accounted for the majority of trauma cases (n = 299; 56,7%), with vehicle-related accidents, such as MVAs and PVAs (n = 130; 24,6%) following closely. Additional traumatizing factors were falls from height (n = 72; 13,6%), stab wounds (n = 20; 3,8%), and gunshot wounds (n = 6; 1,1%) [Table 4].

Variables	No	%
Trauma	**439**	**43,20%**
Haemorrhagic	328	32,28%
Skull fractures	111	10,90%
Spinal Injury	**88**	**8,60%**
Cervical	40	3,90%
Thoracic	5	0,50%
Lumbar	12	1,20%
SCI/Haemorrhagic	23	2,70%
TB Spine	8	0,70%
Spondylosis	31	3,10%
Tumours	**114**	**11,20%**
Brain	105	10,30%
Spine	5	0,40%
Skull	4	0,30%
Infection	**83**	**8,20%**
Vascular	**45**	**4,40%**
Aneurysm	36	3,50%
AVM	6	0,60%
Cavernoma	3	0,20%
Paeds	**182**	**17,91%**
Trauma	75	7,40%
Infection	9	0,88%
HCP	64	6,30%
MMC	21	2,00%
Tumours	13	1,20%
Others	**34**	**3,30%**

Table 3: Pattern of disease condition at KTHC neurosurgery 2017-2021

Mode of injury	No	%
Assault	**299**	**56,7**
GSW	6	1,1
Stab	20	3,8
Vehicle Accidents	**130**	**24,6**
MVA	85	16,1
PVA	45	8,5
FFH	**72**	**13,6**

Table 4: Mode of injury at KTHC neurosurgery 2017-2021

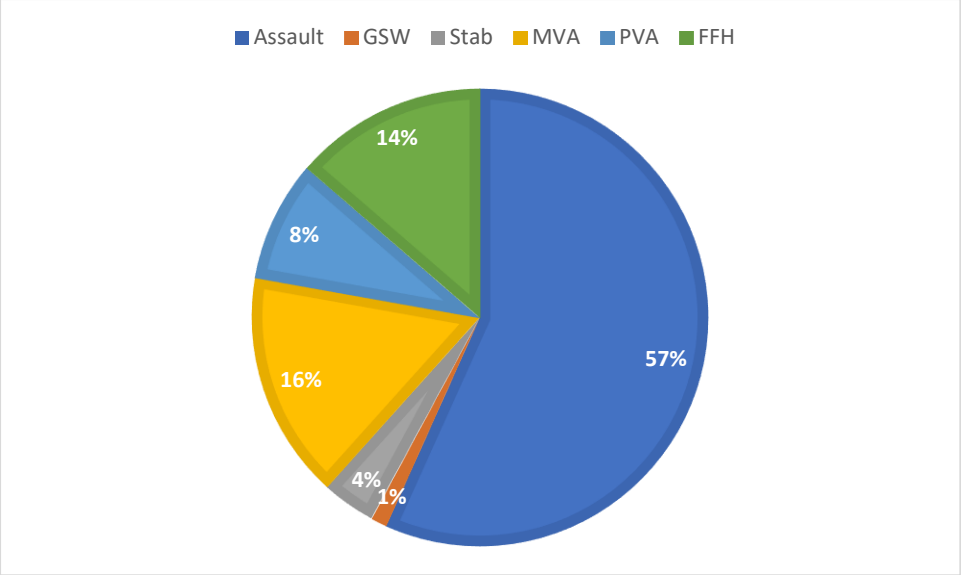

Fig 3: Mode of injury at KTHC neurosurgery 2017-2021

10.4 Total annual number of OPD patients seen at KTHC

During the study period 2017-2021, the KTHC neurosurgical unit treated a total of 8884 patients in the outpatient clinic. The least number of patients were seen in 2020 which coincided with the COVID-related restrictions and lockdowns. The OPD were held twice a week (Tuesdays & Thursdays) which has been changed to a once-a-week OPD Clinic on Thursday.

Variable	2017	2018	2019	2020	2021	Total
Total OPD	1945	1790	1831	1561	1757	8884

Table 5: Total number of Clinic-OPD patients seen at KTHC

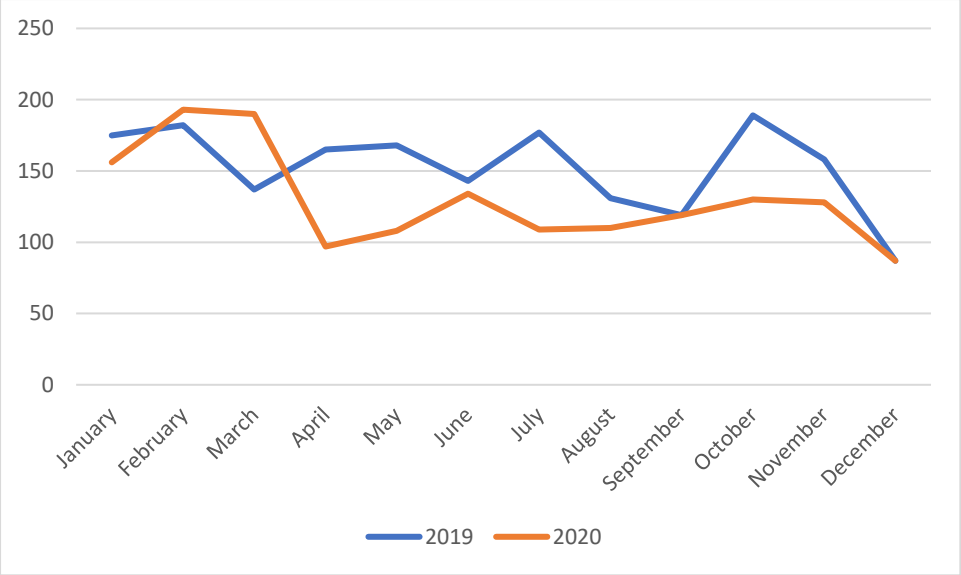

Fig 4: OPD numbers for 2019 & 2020

10.5 Average length of stay for neurosurgical patients at KTHC

The patients stayed for an average of 10,4 days at the KTHC neurosurgical unit. Of the conditions, an average of 13,24 days were spent by the infection patients, vascular patients stayed an average of 12,7 days followed by tumour patients who spent an average of 12,42 days at the KTHC neurosurgical unit. The exact number of days spent by patients who were referred to CHBAH, CMJAH OR HJH were not known. This may influence the overall average length of stay for neurosurgical patients at KTHC.

Variables	2017	2018	2019	2020	2021	Average
Trauma	6,5	7,4	6,8	7,9	6	6,92
Infection	13,6	13,6	13,2	11	14,8	13,24
Spine	8,2	11,6	12,2	10,6	11,5	10,82
Vascular	10,1	21,5	14,4	5,3	12,2	12,7
Tumor	13,6	13,2	12,4	12,2	10,7	12,42
Paeds	7,3	5,8	6,9	4,8	7,2	6,4
	9,8	**12,18**	**10,98**	**8,6**	**10,4**	**10,42**

Table 6: An average length of stay at KTHC neurosurgical unit

10.6 Average age for patients who received intervention at KTHC

The mean age of adult patients receiving intervention at KTHC was 41,3 years old. The average age of paediatric patients was 4.2 years old.

Variables	2017	2018	2019	2020	2021	Average age
Trauma	40	35,8	40,8	32,9	44	38,7
Infection	32,2	33,8	28	25	30,4	29,88
Spine	39	44	46	46	39	42,8
Vascular	54,3	41	44	48,7	39,2	45,44
Tumor	45,2	49,1	52	53	50	49,86
Paeds	4,2	3,8	4,5	3,4	5	4,18
	35,8	**34,5**	**35,8**	**34,8**	**34,6**	

Table 7: An average age for patients who received intervention at KTHC

10.7 Admission vs intervention rate for KTHC.

For the 1016 patients admitted to the KTHC neurosurgical unit between 2017 and 2021, a total of 657 neurosurgical procedures were carried out. The intervention rate for patients admitted for neurosurgical procedures was found to be 64,66% on average.

Variable	2017	2018	2019	2020	2021	Total
Admitted	227	173	311	141	205	1016
Intervention received	117	110	129	84	134	657
Ratio	51,50%	63,58%	41,47%	59,57%	65,36%	64,66%

Table 8: Ratio between admission & intervention for the patients admitted to KTHC

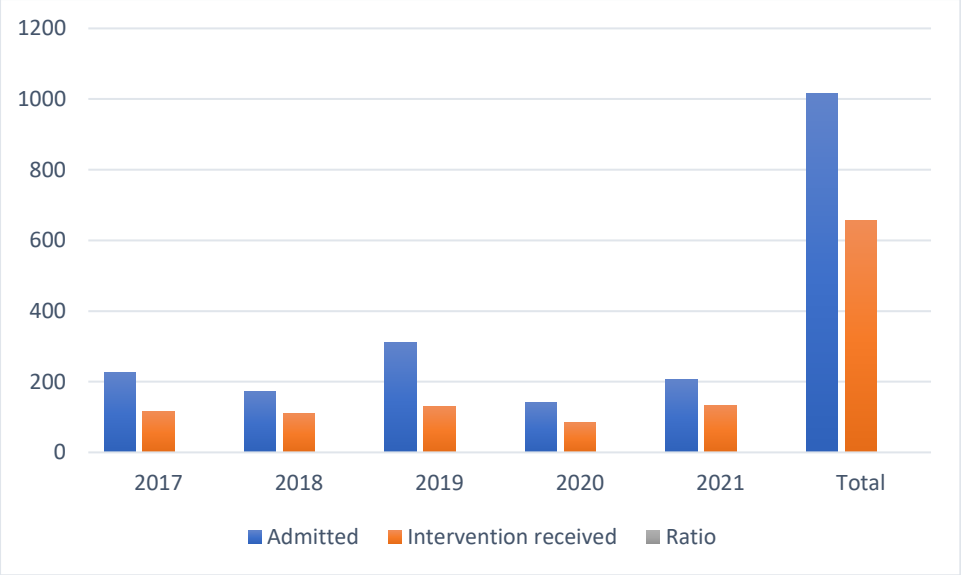

Fig 5: Graphic representation of the ratio between admission & intervention

10.8 Morbidity and mortality

The KTHC death rate was 138 (13,58%) between 2017 and 2021. Upon closer examination, TBI (n = 74) accounted for the greatest number of fatalities, trailed by illnesses relating to the spine (n = 29), oncology (n = 18), infection (n=11) and vascular (n = 6). Paediatric group had 11 deaths. High cervical injuries accounted for all of the spine fatalities.

123 patients in all had unsatisfactory outcomes (mRS 3-5). The group with the highest number, TBI patients (n = 60), was followed by patients with spine-related disorders (n = 29), vascular (n=11), oncology-related conditions (n = 9), infection-related conditions (n = 8), and pediatric-related conditions (n = 6).

Variables	2017	2018	2019	2020	2021
TBI	16	13	15	17	13
Paeds	3	3	2	1	2
Spine	6	6	8	7	2
Vascular	2	1	2	0	1
Infection	3	2	3	1	2
Oncology	3	2	4	4	5
Total	**33**	**27**	**34**	**30**	**25**

Table 9: Mortality rate for the KTHC 2017-2021

Variables	2017	2018	2019	2020	2021
TBI	10	9	12	15	14
Paeds	2	2	1	0	1
Spine	5	6	3	8	7
Vascular	2	2	3	3	1
Infection	3	2	2	1	0
Oncology	2	0	2	3	2
Total	**24**	**21**	**23**	**30**	**25**

Table 10: Number of poor outcome patients measured by mRS score

11. DISCUSSION

11.1 Demographics of KTHC neurosurgery

There were noticeably more adult patients than pediatric patients, according to the data. Of the adult patients, male patients constituted majority of the admission followed by females and pediatrics. High proportion of the admitted patients required some form of neurosurgical procedures (64,66%), which is in keeping with the data from the published journals (8,18,20). The high ratio of intervention is achieved at KTHC neurosurgery as the unit has 3 elective theatre slots per week. This theatre slots are reserved for elective cases. However, it is made available when emergency case is needed to be prioritized. While certain emergency cases that need attention have improved as a result, the completion of elective instances has been hampered. As a result, some of the patients had to stay in the hospital for longer than necessary, increasing their risk of contracting healthcare facility acquired infections.

Trauma-related injuries are the leading cause of patient presentation to KTHC neurosurgery (51,8%), followed by pediatric-related neurosurgical condition (17,0%) and tumors (11,2%). These findings are in keeping with other literatures from LMIC. It is worth mentioning that 30,31% of admitted patients were referred to KTHC neurosurgery from the hospitals lacking the neurosurgical services. These patients would have been referred to the hospitals with neurosurgical services that are much further away.

It has been suggested, according to Mediratta et al., that the public should have access to referral facilities capable of handling neurotrauma no later than four hours following a traumatic brain injury (TBI). While some of the recommended hospitals are within this time frame, most patients are delivered to KTHC neurosurgery well after the recommended 4-hour window from the onset of TBI due to the time it takes for doctors to communicate, secure an EMS vehicle, and actually travel.

In addition, the OPD-Clinic at KTHC neurosurgery now operates once a week instead of twice a week as previously scheduled. Due to logistical and budgetary difficulties, we had lost a great number of our patients who were reluctant to follow up due to travel costs. Therefore, by providing a once-weekly OPD-Clinic, it made the follow-up both affordable and accessible.

11.2 Impact of COVID-19 on neurosurgical workforce.

The effects of the COVID-19 pandemic on various aspects of our academic center's neurosurgical service were comparable to a number of cases documented at other institutions (28–37).

According to a study done by Ridwan, on average, there was a 68.8% reduction in the overall volume of neurosurgical activity compared to the pre-COVID-19 practice. A drop of 54 ± 31.3% was observed in cranial surgery, 71 ± 31% in spine surgery, and 35 ± 3.3% in emergency surgery. Similarly, Lubansu et al., showed in his study that the total operated cases decreased from 308 to 154 and emergent surgeries showed a decrease from 75 to 29 compared with a similar period in 2019. Idowu et al.’s research shows that curing the onset and peak of the pandemic in Laos, Nigeria, there was an overall decline in surgery volume of more than 60%. According to a study carried out by Munda et al., a decrease of 25.7% was recorded in all neurosurgical procedures in 1 year following the declaration of COVID-19 compared to 1 year before.

In KTHC, we found a 34,88% reduction in the number of neurosurgical procedures done during the COVID-19 pandemic compared to the previous year. Furthermore, our data showed a reduction of trauma-related cranial procedures were reduced by 29,48% from the previous year prior to the COVID-19 pandemic.

Numerous reasons may be responsible for the decreased surgical load. Firstly, the KTHC neurosurgical unit only offered surgical interventions to acute and semi urgent traumatic cases. All elective non-urgent cases were cancelled.

The South African government's implementation of the five-level risk-adjusted alert system resulted in a dramatic drop in trauma-related procedures, including those for spinal and traumatic brain injuries. This decrease was likely brought on by a decline in workplace and traffic accidents during the lockdown. This unintentional consequence of the lockdown—which was primarily publicized as a strategy to stop the spread of viruses—lessened the workload for our critical care units and freed up resources for the COVID-19 emergency.

11.3 Impact of COVID-19 on OPD numbers

The findings show that during the COVID-19 pandemic from January to December 2020, fewer outpatient visits were made in each month starting in March 2020, after the South African government imposed a nationwide lockdown at midnight on March 26. Our result show that in February 2020 the number of OPD patients was higher than in the same months before the pandemic. In January and February of 2020, the government did not release an appeal to curtail activities outside the home, thus a large number of patients continue to visit medical facilities. This can be due to that fact that the COVID-19 cases in South Africa remained relatively low compared to the rest of the world which was also noted in the study conducted by Setyono et al.

A study conducted by Singh et al. reported that the average daily attendance in the neurosurgery OPD in January and February (before the pandemic) was 166 patients, whereas after the pandemic it was 133 patients.

Another study in keeping with our findings is a study done by Sharma et al., which found that, in June 2020, there were only 77 OPD patients seen after the lockdown, compared to 475 patients in March 2020 – the month before the Indian government implemented the National Lockdown.

11.4 Benefits of KTHC neurosurgery

The brain is made of time; in the event that an emergency occurs, a patient's nervous system will quickly and irreversibly die. How long it takes to go to a neurosurgery center and how well neurosurgical cases turn out depends largely on these factors. Quick intervention is crucial (5,18).

It has been demonstrated that neurosurgery patients who experienced a post-operative delay of more than five hours had a greater death rate (18). In a prospective research conducted in Australia, Simpson et al. discovered that 77% of patients who had to travel more than 50 km cited distance as a major cause of delay.

The three primary causes of delays that result in less access to neurosurgery have been delineated by Mediratta et al. Most of these delays were noted in LIC, particularly in African regions. The most common excuses were lack of funds for travel, distance to travel, and lack of access to healthcare.

The only neurosurgery facility in the province of North-West is the KTHC neurosurgery unit, as mentioned in the earlier section. The closest location for neurosurgical care is around 160 kilometers southwest of Johannesburg. This is significantly further than what Simpson et al. discovered. Patients in dire need of neurosurgical procedures have benefited from the province's KTHC neurosurgical unit. This can result in time savings for neurosurgical care and a reduction in travel expenses for patients and their families. OPD-Clinic services, which KTHC neurosurgery offers, help patients' travel expenses and time even more.

11.5 Challenges

Despite establishing KTHC neurosurgery to provide much needed service to the local population, there are immense challenges. A sufficient number of neurosurgeons is needed, which is a crucial prerequisite for the safe, economical, and long-term delivery of high-quality neurosurgical care (6,10). Ukachukwu demonstrated in his study that the current number of neurosurgeons in Southern Africa region is far short of projected number of neurosurgeons necessary based on demographic requirements, the required workforce, and the burden of neurosurgical diseases. He projected that by 2020, there would be 180 certified neurosurgeons, up

from 86 in 2001. However, despite the gain, the gap will keep widening over time. There are now little over 300 neurosurgeons practicing in South Africa.

Harrichandparsad's investigation demonstrated the growing gap and scarcity of neurosurgeons in South Africa (38). According to his study, Inkosi Albert Luthuli Central Hospital (IALCH), which has 7 full-time neurosurgical consultants, 12 registrars, 2 medical officers, and 2 supernumerary registrars, is the only neurosurgical referral center in the public sector for KwaZulu-Natal and portions of the Eastern Cape.

KTHC neurosurgery, being a primary neurosurgical center, provides much needed neurosurgical service to the surrounding areas/hospitals, which includes Matlosana (Klerksdorp, 434308 population), Potchefstroom Hospital (53km from Klerksdorp, 123,669 population), Mafikeng Hospital (167km from Klerskdorp, 336,522 population), Joe Morolong Hospital of Vryburg (215km, 52482 population), Delareyville Hospital (128,8km, 10630 population) and Taung Hospital (233,2km, 175,000 population)(25). This translates to a ratio of 1 neurosurgeon to just over 566,305 population (for 2 qualified consultants). This is 5 times worse than the optimum ratio proposed back in 1977. Surgical Services for the United States, based on study done in 1977, state that good neurosurgical decision making depends on the ratio of 1 neurosurgeon per 100 000 population (27).

Another issue is that neurosurgeons have responded terribly to practicing in a rural environment (12,17,18). The majority of these neurosurgeons work in core academic hospitals or large metropolitan areas (4,7,9,11). Similarly, the main teaching units are connected to university hospitals located in urban areas in South Africa. For instance, whilst there is only one neurosurgical unit in the Northwest, there are five in Gauteng that are connected to Wits University. According to a Tiwari survey, the majority of South African surgeons worked in cities (7). The surgical specialist density was lowest in rural regions like North West and Limpopo (7).

Other challenges which hinder the potential growth and building of fully functional independent neurosurgical unit include lack of ICU beds, particularly neuro-specific ICU facilities, as well as staffing and service shortfall as a result of the ICU being split between two hospital sites (Pediatric and Pediatric ICU is located at Klerksdorp complex). An intensive care unit is essential to neurosurgery practice. From

monitoring ICP to offering ventilatory support, the requirement may vary. KTHC lacks both a neurosurgery-specific intensive care unit and neuro-ICU trained staff. Due to the ongoing competition among other surgical and medical specialties for the limited number of intensive care unit beds, this impedes the advancement and treatment of neurosurgery patients.

However, one positive characteristic of Klerksdorp-Tshepong neurosurgical unit is that there is no need for most of the patients to be referred to central hospitals. This provides enriching and rewarding working opportunities for registrars in training based at the hospital complex. And since the facility is closer to the local community, this allows for families to visit the patients instead of travelling hours to the central hospitals (CHBAH/CMJAH).

11.6 Future way forward for KTHC neurosurgery

The realm of practice of neurosurgery in rural settings is a tenacious and yet an obtainable challenge. It is truly a blessing in disguise. There are ways to improve and consolidate the presence and practice of neurosurgery in rural settings. According to Malaysian study carried out by Heng et al., it is promising that the tertiary center regularly and actively participates in more complex cases. In KTHC neurosurgery, challenging and difficult cases were aided by senior consultants from tertiary neurosurgical units such as CHBAH/CMJAH. Often the visiting senior consultant will visit the KTHC unit to conduct an academical ward round with locally based medical officers, rotating registrars as well as ward sisters. This is notably beneficial to the young trainees as it serves as a platform to learn and motivate to succeed in neurosurgery.

Learning of the essential neurosurgical skills to execute common life-saving procedures is a paramount component. Often medical officers are expected to learn these critical skills in a relatively short time frame. Young medical officers and rotating registrars have the opportunity to enhance their surgical skills and learn new ones at the KTHC neurosurgical unit. This is achieved by enabling them to participate in the surgeries and gain hands-on experience. The two locally based consultants use each elective and emergency case to demonstrate and instruct young trainees.

Another aspect of enhancing the rural neurosurgical service is teleconsultation/telecommunication. Often neurosurgeons are expected to make a decisive clinical decision with limited information. The clinical information and radiological images are sent to neurosurgeons via WhatsApp platform to aid neurosurgeons' call. With the newly improved system at the KTHC, reports and radiological images, including non-contrasted CTB, can be seen on cellphones. Clinicians at KTHC must register and log in using the authorized account and password. As a result, the referring team now regularly meets neurosurgeons after viewing the radiologist's report, which has improved decision-making and decreased waiting periods. By virtue of having a neurosurgical unit, the awareness of how to manage neurosurgical patient can be taught and transferred to other clinical and non-clinical departments. Often the KTHC ICU manpower is provided by junior medical officers including community service medical officers who have limited knowledge in managing neurosurgical patients. Encouragement of combined neurosurgery and ICU ward rounds will improve interdepartmental collaboration and increase awareness of the important significance of neurosurgery, particularly in a small rural teaching hospital like KTHC.

It is essential to emphasize the significance of upgrading the postoperative care facility, including the availability of intensive care unit beds and, in particular, mechanical ventilators. In addition to lengthening hospital waiting lists and increasing the risk of morbidity and death, inadequate ventilator assistance also makes it impossible to deliver the finest emergency care.

A delayed medical seeking behaviour should be discussed and dealt with. The everyday practice of neurosurgery demonstrates this, especially in a place like KTHC where patients often arrive late because they lack the finances for transportation, are oblivious to the importance of their symptoms, and even choose to consult local traditional healers over modern medical care.

Establishing a community education campaign with local counsellors, chiefs, and community members is an economical way to increase knowledge of their symptoms and the importance of getting care as soon as feasible. Wits University is using a similar strategy, assigning final-year medical students on a six-week rural rotation. Following their visits to several rural communities, these medical students instruct

the locals on the significance of general medical health issues and how to get assistance.

A strong collaboration between hospital administration and the local government would provide much-needed assistance. This could aid in obtaining much-needed funding for community outreach initiatives, neuro staff training, and the construction of a neuro intensive care unit in KTHC. This would eliminate the need for patients to be denied care because there would be post-operative intensive care units.

Lastly, the national health committee can adopt the KTHC model to build new rural units since it is effective, and locally accepted. As a result, additional neurosurgical units would be located in rural areas, removing the most common obstacle—geographical distance.

12. CONCLUSION

Services for neurosurgery are hard to come by and are getting harder to get. Neurosurgical services should be available in both rural and urban areas, with a special emphasis on the former. The KTHC neurosurgical unit is the first outlying institution in the Northwest to offer these desperately needed procedures. The number of OPD patients, admissions, interventions, and other data in the study demonstrate the KTHC unit's consistent expansion. Reducing effort and burden at the Johannesburg-based tertiary centers is one of its benefits, in addition to lowering neurosurgery patients' morbidity and mortality rates. If these identified issues could be resolved, neurosurgery in rural areas would have a promising future. In order to establish neurosurgery services in a remote area, states or nations might greatly benefit from the model provided by the neurosurgery unit at Klerksdorp-Tshepong Hospital Complex.

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APPENDIX A

No.	DOA	DOD	LOS	DOB	Age	Gender (M/F)	Diagnosis/ Pathology	Mode of injury in case of head injury	Presenting GCS	Intervention Received	Outcome during the admission period		
											Death	Full recover	Recovery with disability ?Disability score

APPENDIX B

	2017	2018	2019	2020	2021
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Total					

APPENDIX C

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research and Innovation)

TO: Dr D Moon
School of Clinical Medicine
Departmemt of Surgery
Division of Neurosurgery
Medical School
University

E-mail: donjoon81@gmail.com

CC: Supervisor: Drs R Khohomela and I Human; Professor B Luke
<rambsta@gmail.com>
and <HREC-Medical Research Office@wits.ac.za>

FROM: Mr Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 2023/11/06

REF: R14/49

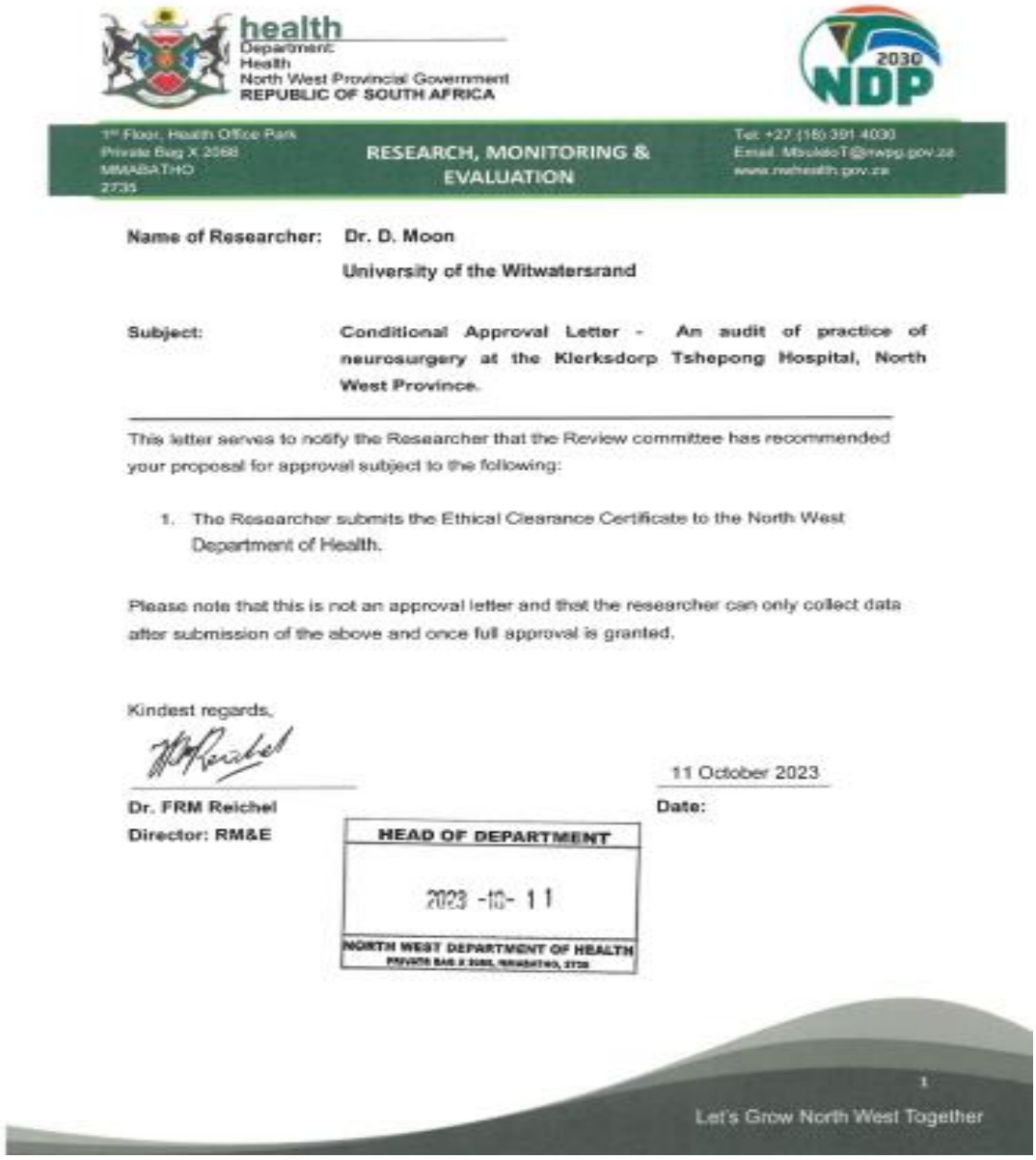
PROTOCOL NO: **M230608** (This is your ethics application reference number. Please quote it in all enquiries, oral or written, relating to this study.)

PROJECT TITLE: *An audit of the practice of neurosurgery at the Klerksdorp Tshepong Hospital, North West Province*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

APPENDIX D



health
Department:
Health
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

2030 NDP

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Private Bag X 2068
MMABATHO
2735

RESEARCH, MONITORING & EVALUATION

Tel: +27 (18) 391 4030
Email: MbulaloT@nwpg.gov.za
www.nwhealth.gov.za

Name of Researcher: Dr. D. Moon
University of the Witwatersrand

Subject: Conditional Approval Letter - An audit of practice of neurosurgery at the Klerksdorp Tshepong Hospital, North West Province.

This letter serves to notify the Researcher that the Review committee has recommended your proposal for approval subject to the following:

1. The Researcher submits the Ethical Clearance Certificate to the North West Department of Health.

Please note that this is not an approval letter and that the researcher can only collect data after submission of the above and once full approval is granted.

Kindest regards,

Dr. FRM Reichel
Director: RM&E

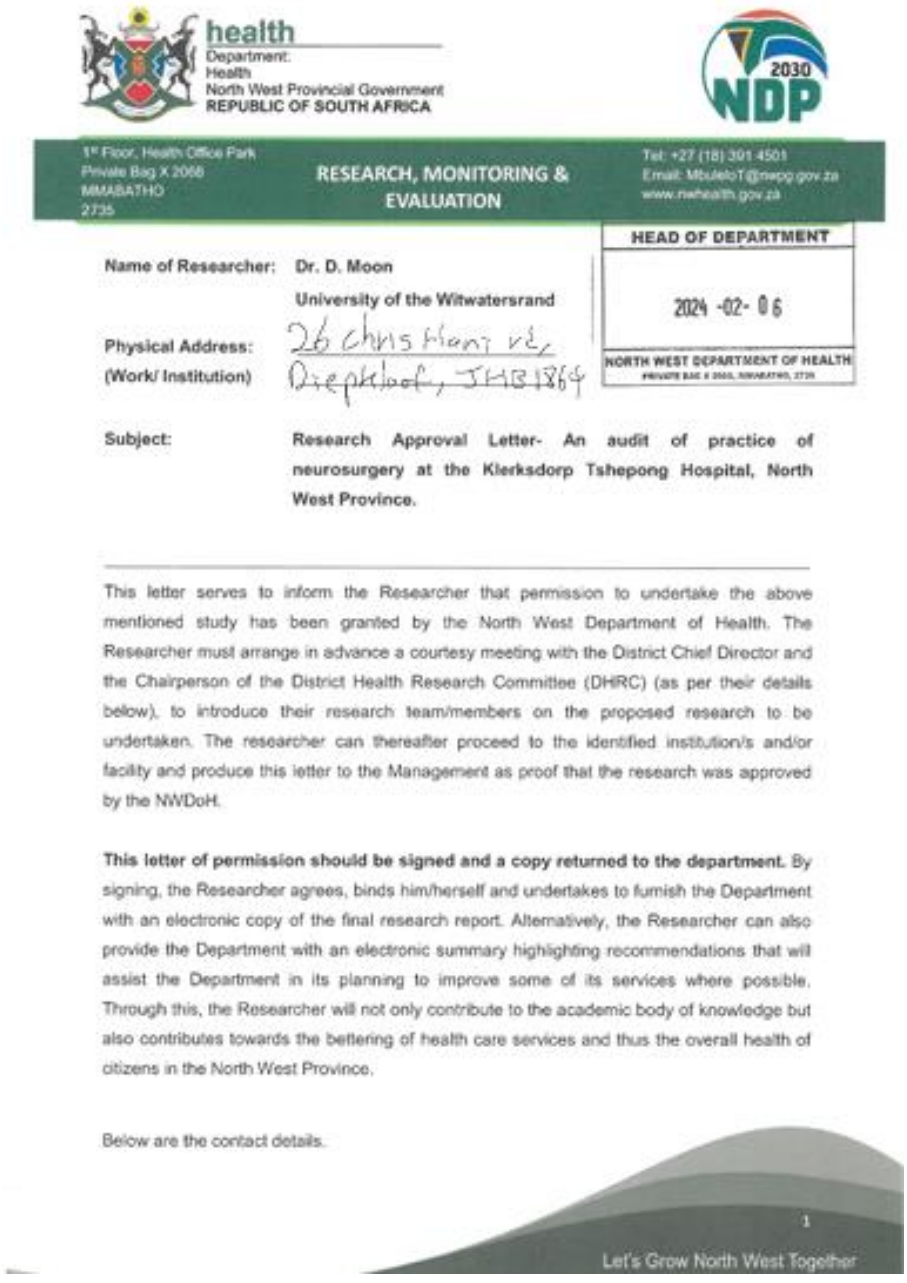
11 October 2023
Date:

HEAD OF DEPARTMENT
2023 -10- 11
NORTH WEST DEPARTMENT OF HEALTH

1

Let's Grow North West Together

APPENDIX E



health
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North West Provincial Government
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HEAD OF DEPARTMENT
2024 -02- 06
NORTH WEST DEPARTMENT OF HEALTH

Name of Researcher: Dr. D. Moon

University of the Witwatersrand

Physical Address: 26 Christiaan rd,
(Work/ Institution) Diepkloof, JHB 1864

Subject: **Research Approval Letter- An audit of practice of neurosurgery at the Klerksdorp Tshepong Hospital, North West Province.**

This letter serves to inform the Researcher that permission to undertake the above mentioned study has been granted by the North West Department of Health. The Researcher must arrange in advance a courtesy meeting with the District Chief Director and the Chairperson of the District Health Research Committee (DHRC) (as per their details below), to introduce their research team/members on the proposed research to be undertaken. The researcher can thereafter proceed to the identified institution/s and/or facility and produce this letter to the Management as proof that the research was approved by the NWDoH.

This letter of permission should be signed and a copy returned to the department. By signing, the Researcher agrees, binds him/herself and undertakes to furnish the Department with an electronic copy of the final research report. Alternatively, the Researcher can also provide the Department with an electronic summary highlighting recommendations that will assist the Department in its planning to improve some of its services where possible. Through this, the Researcher will not only contribute to the academic body of knowledge but also contributes towards the bettering of health care services and thus the overall health of citizens in the North West Province.

Below are the contact details.

1

Let's Grow North West Together

Office of the Chief Director: Dr. Kenneth Kaunda District	Chairperson of the DHRC
Ms. Dineo Moromane	Dr. L. Mahole
Contact person: Mr Calvin Mmisele 018 462 5744 CMmisele@nwpg.gov.za	Contact person: Thenjiwe Seitiso 018 462 5744 tseitiso@nwpg.gov.za

Kindest regards,

Dr. FRM Reichel
Director: RM&E
Date: 6/2/2024

Researcher
Date: 8/2/24

APPENDIX F

20 April 2023

Dear Dr Donjoon Moon

Re: Permission to conduct research at Klerksdorp/Tshepong Provincial Tertiary Hospital Neuro Surgery Unit

This letter serves to confirm that Klerksdorp/Tshepong Hospital Management gives you permission to conduct your research project namely 'An Audit of Practice of Neurosurgery at Klerksdorp/Tshepong Hospital, North West Province.

The permission is subject to you acquiring Approval of the University Ethics Committee and North West Provincial Government Research Committee.

In addition, you expected to give Klerksdorp/Tshepong Hospital feedback on your research findings.

Kind regards,

Dr N.D. Leburu
Clinical Manager
Klerksdorp/Tshepong Hospital Complex

APPENDIX G

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

NEUROLOGICAL SURGERY, Department of Neuroscience

School of Clinical Medicine, Faculty of Health Sciences, 7 York Road, Parktown, Johannesburg 2193, South Africa Tel: +27 11 717-2715 – Fax +27 11 717-2537

18 October 2023

To whom it may concern

Re: DR DONJOON MOON

This is to certify that Dr D. Moon MMed Topic: **AN AUDIT OF PRACTICE OF NEUROSURGERY AT THE KLERKSDORP TSHEPONG HOSPITAL, NORTH WEST PROVINCE** has been given permission to conduct the study in the department of Neurosurgery.

Yours sincerely,

Dr Muke Richard Mayoyo
Principal Specialist and Head
Department of Neurological Surgery
University of the Witwatersrand,
Johannesburg and
Chris Hani Baragwaneth Hospital

APPENDIX H

health
Department:
Health
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

2030 NDP

Department of Neurosurgery

19 October 2023

TO WHOM IT MAY CONCERN

RE: Dr D Moon

This letter serves to confirm that Dr D. Moon MMed Topic: **AN AUDIT OF PRACTICE OF NEUROSURGERY AT THE KLERKSDORP TSHEPONG HOSPITAL, NORTH WEST PROVINCE** has been given permission to conduct the study in the department of Neurosurgery at Tshepong- Klerksdorp Hospital Complex.

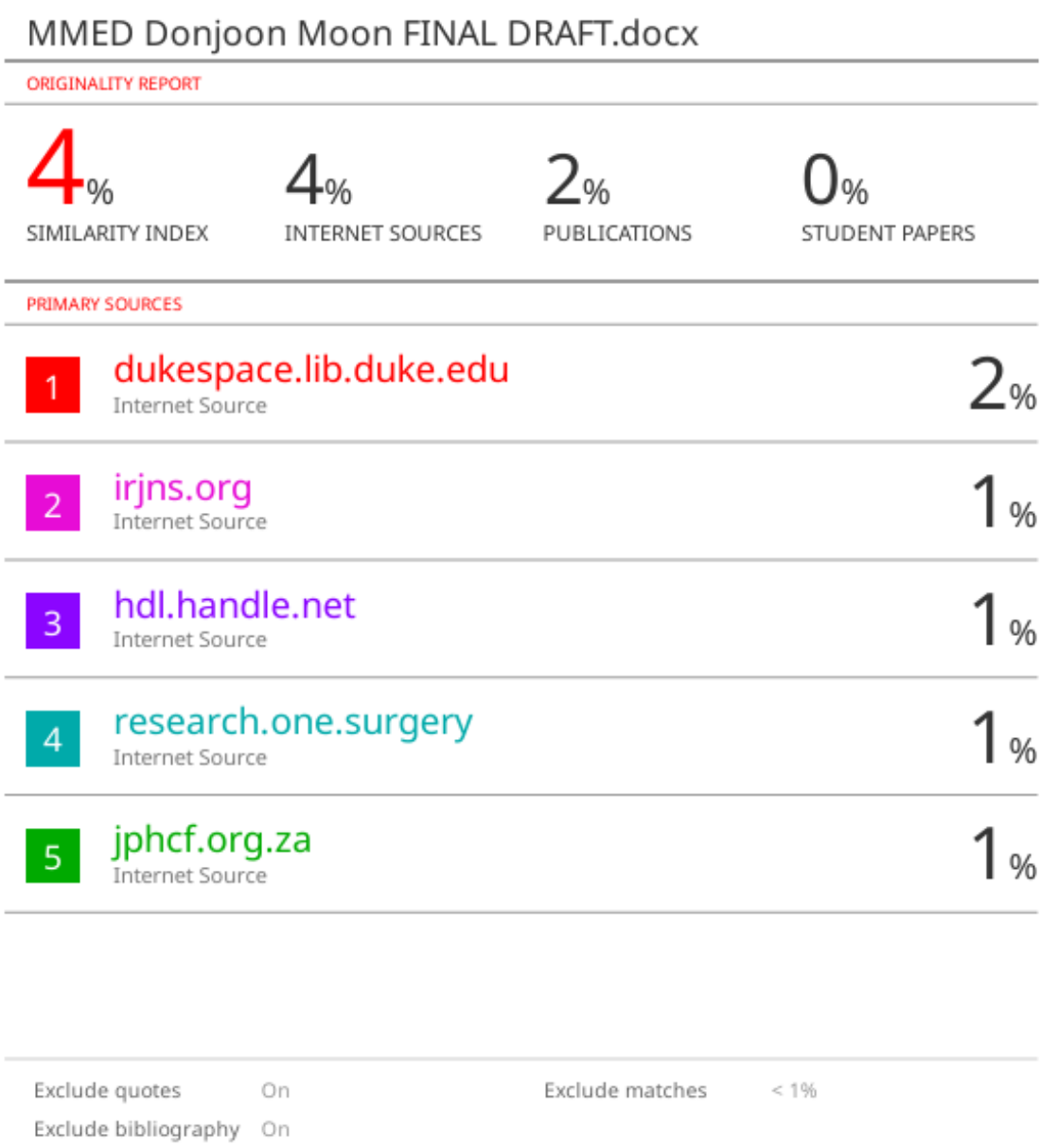
Kind regards,

Dr V Magumbeze

Head of department of Neurosurgery

Tshepong Klerksdorp Hospital Complex

APPENDIX I



MMED Donjoon Moon FINAL DRAFT.docx

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