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A Cost Comparison study of the electronic tick register with a paper-based tick register in clinics within the Ekurhuleni District.

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Candidate's Declaration

I, Dr. Courage Macduff Khoza, declare that this dissertation is my own, unaided work. It is being submitted for the degree of Public Health Medicine at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Courage M. Khoza

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Signature

On this 16th day of August 2023, at the University of Witwatersrand, Johannesburg

Dedication

This work is dedicated to:

Zethu Khoza, my wife and best friend who motivated me during times when I wanted to give up.

My parents, Glyden and Gloria Khoza, who instilled the value of academia and the pursuit of knowledge in our family.

My sisters, Gladness and Khensani Khoza. Thank you, Gladness, for providing administrative support during the early stages of my master's degree

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And I would like to thank God all mighty for: What if the Lord had not been with me, during my difficult times, I would have been swallowed up and engulfed by the difficulties of life. Praise the Lord…

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List of Abbreviations

DHIS	District Health Information System
DHMIS	District Health Management Information System
AGSA	Auditor General of South Africa
COVID-19	Coronavirus disease-2019
EMR	Electronic Medical Records
E-tick	Electronic Tick
GDOH	Gauteng Department of Health
HDSS	Health and Demographic Surveillance System
HITECH	HEALTH Information Technology for Economics and Clinical Health
HPRS	Health Patient Registration System
NHI	National Health Insurance
Information Technology	Information Technology
IQR	Interquartile Range
NDOH	National Department of Health
NGO	Non-Governmental Organization
PEPFAR	President's Emergency Plan for AIDS Relief
PHC	Primary Health Care
PRICELESS SA	Priority Cost-Effective Lessons for System Strengthening in South Africa
USA	United States of America
USD	United States Dollar
ZAR	South African Rand

1. Introduction

1.1. Overview

The World Health Organization subdivides a healthcare system into six essential components, however, the cornerstone of decision-making in all these components is an accurate and trustworthy Health Information system. Its purpose is to collect, analyse and translate data into useful information for decision-makers.[1] Due to this significance, the South African government adopted multiple policies at a national and provincial health system level to govern and facilitate the implementation of a reliable health information system which is mandated by the National Health Act 61 of 2003.[2] Furthermore, strengthening of the Health Information System was listed under the strategic outputs of the Negotiated Service Delivery Agreement by the National Department of Health (NDOH) in 2010 which is derived from the country's National Development Plan.[3] This was implemented through the District Health Management Information System (DHMIS) policy which was adopted in 2011 to create uniformity and outline the responsibilities of the various levels of the health system in the country.[4]

The DHMIS policy gave rise to the District Health Information System (DHIS) which is used by Primary Healthcare (PHC) clinics across the country to report health service activity information. Clinical details, such as presenting clinical problems, diagnosis, and services rendered, are initially recorded manually on a patient file during a consultation, then collated onto a paper-based tick register where the clinician ticks the relevant data points according to the indicators being monitored during a particular period. These registers are then submitted daily to data capturers for capturing onto the DHIS.[4] However, the DHIS data in districts have been found to be unreliable and inaccurate as evidenced by the Auditor General of South Africa's (AGSA) audit reports for the Gauteng Department of Health (GDOH) for the year 2019/20, which described substantial negative findings on DHIS data and poor compliance to regulations. The paper-based system was found to be error-prone and there was no evidence of data verification.[5] This unreliable data from the routine health information system used, results in a lack of accurate information for proper decision-making, which leads to inefficient budgeting and inappropriate resource distribution at the health district level around the country.[1,6]

1.2. Background

To address the aforementioned problem, the Ekurhuleni Health District, one of five health districts in the Gauteng province, South Africa, developed a unique electronic PHC tick register and piloted the use of this electronic version of the PHC tick register (E-tick) in three public health sector PHC facilities in the district. The Ekurhuleni district has 93 PHC facilities serving a population of 3.8 million inhabitants, most of whom rely on the public health sector.[7] The E-tick register pilot project was implemented from November 2017 to June 2019 within Ekurhuleni. Using this electronic system, clinicians record the clinical details and services rendered electronically, using a computer or tablet, instead of writing and ticking manually on a paper file and register, respectively. This data recording is done on a software system that can transfer the electronic data directly to the DHIS without the need for data capturers. This is assumed to eliminate the errors and delays associated with paper-based registers and allows managers to monitor performance indicators more frequently and in real time. It can also improve the accuracy and reliability of data reported to higher levels within the district health system.[8–10] The E-tick register pilot project was funded by one of the Ekurhuleni district support partners at the time, the Aurum Institute, which is a non-governmental organisation (NGO) based in Johannesburg, funded by the United States of America's President's Emergency Plan for AIDS Relief (PEPFAR). Aurum Institute supports the Gauteng Health Department to provide health services in poor communities.[11]

The funding for any type of health information system would include fixed costs such as the development of paper-based or electronic tools, equipment, the software system, data storage, and training of staff. Variable costs would include employee costs, stationery, Information Technology (IT) support and internet (data) costs. The outputs would be health service information captured on the DHIS system. The cost of the E-tick system was not included in the budget of the Ekurhuleni Health District, nor at the Gauteng Department of Health. Therefore, upon completing the pilot in 2019, the implementation of this system was halted as there was inadequate information on its costs. The Ekurhuleni health district needed to determine how much it would cost to implement an E-tick PHC register compared to the existing

paper-based system, and to motivate for budget allocations to scale up and sustain the E-tick register system going forward.

1.3. Literature review

A traditional narrative review of the literature was performed to understand the current body of knowledge comparing paper-based recording systems and electronic recording systems. Articles were searched from PubMed and Google Scholar. The keywords used were “cost-comparison study”, “paper-based records vs electronic records”, “Africa” and “cost-comparison South Africa.’” The number of articles found during the search was initially 93 and was reduced to those reviewed below using the aforementioned criteria. Articles written in English that compared paper-based recording systems with electronic recording systems using a cost comparison method were chosen with no timeline limits. The words “Africa” and “South Africa” were then added to find articles relevant to the African and South African context. Since there were no South African studies using a cost comparison to compare the two data collection systems, studies comparing them using other methods and those using cost comparison approaches to compare other digital health interventions were used for the South African context. The literature review found the following:

History of Electronic Medical Records

A 2022 review article from the United States of America (USA) which studied 158 articles, found that only 10% of health facilities had electronic recording systems before 2009 and most facilities used paper-based systems. Around this period, the use of electronic records was then recommended by the Health Information Technology for Economic and Clinical Health (HITECH), and by 2011, almost half of all doctors in the USA had started using electronic systems, as there were more advanced software systems and decreased costs. By 2022, about 80% of hospitals and medical practices used electronic systems to store data related to clinical details and costs and many of the systems used artificial intelligence to develop new databases which could assist with diagnosis and treatment, forecasting of outbreaks and reduction of medical errors. Regardless of the evident advantages, some clinicians argued that electronic systems were costly and difficult to use. The study also found that electronic recording systems were also being used in Europe with

many countries using them in combination with paper-based systems. However, Estonia was given the example of a country using a completely electronic system. The system in Estonia contains all the required demographic and clinical information which is accessed through inserting an identification card into a computer. The system is decentralized, and files are accessible to multiple users. However, it must be noted that Estonia as a country, is generally a paperless society, with only marriage, divorce, and inheritance being the only processes that use a paper-based system. By 2019, an electronic health record system similar to Estonia was used in the Netherlands and Scandinavian countries. The study found that a national system of electronic health records was most cost-effective and offered more advantages, which include enhanced management of patients, easy communication between healthcare facilities, efficient usage of limited resources and reduced cost of healthcare.[12]

Cost comparison study of electronic and paper-based data recording globally.

The use of an electronic data recording system is generally perceived to carry high costs; this perception is a challenge in resource-constrained settings. This can be addressed through a cost comparison study which quantifies the costs of the resources utilized in each intervention. These can be expressed in terms of fixed, variable, total and average costs. This method has been used within the health sector to compare various interventions.[8]

It was used to compare paper-based and electronic data collection systems in a 2009 simulated Slovenian study using a modelling technique that is based on the perspective of the staff members using the data collection systems. The sample included 10 facilities with 100 patients each using a form containing 10 sections and had five scenarios based on different estimated error rates and patient numbers. The only cost parameter measured was human resource (HR) costs. These were measured through three components, namely, time taken to complete tasks, salary per staff category per hour and error rate. It was found that the electronic system decreased data collection costs by 55%, however, the error rates of the different data collection systems were not measured but obtained from literature and staff interviews. This greatly affected the findings of the study as the higher error rate for the electronic system resulted in lower differences in costs between the two systems.

The small sample size also affected the cost as it resulted in a lesser difference in absolute costs.[8]

These findings were further supported by a 2005 American study that compared the two data collection systems by reviewing 20 reports of Alzheimer's patients, which were evenly distributed between the two data collection systems (i.e., 10 each). Three parameters were compared: time taken to record, error rate and costs. The error rate of the electronic system was directly measured by the researchers and found to be 8.5%. Costs were classified into fixed, variable, total and total average costs. The total cost was calculated by adding the fixed and variable costs, while the total average cost was obtained by dividing the total cost by the number of patients. The electronic system showed a higher fixed cost, while the paper-based system had a higher variable cost. Therefore, the average cost of the electronic system was initially higher than the paper-based but decreased as the number of patients increased and became lower than the paper-based system after 32 patients. However, this change at 32 patients was derived through extrapolated calculations and not directly observed, as the study only observed 10 patients per data collection and did not amortise the equipment costs over the expected lifetime of the equipment.[9]

This trend of an electronic system having lower costs with an increased number of patients was also observed in a 2009 study performed in six Canadian Health districts with population sizes ranging from 100 000 to 1 000 000, where the costs of electronic and paper-based systems for collecting Influenza immunization data were compared over five years using a computer model. Equipment and HR costs were calculated in two scenarios; Scenario 1: Influenza occurs in the first year while the remaining four years only experienced seasonal influenza, and Scenario 2: no Influenza pandemic and every year experienced seasonal Influenza. It was assumed that the purchasing of equipment would occur only once in five years (in the first year), while the remaining four years only required support and maintenance. The staff and managers from the districts supplied the required information through questionnaires and telephonic interviews. The equipment was expected to last five years which was also the time period used for projection in the study. All the costs incurred over the five years were combined and reported as an average cost per

patient. These were reported in 2009 Canadian dollars, with the other four years discounted at 5%. The electronic system showed a lower average cost per patient for both scenarios in all the districts, with the difference in cost being directly proportional to the population size.[10]

Cost comparison studies of electronic and paper-based recording in Africa

In the African context, a cost comparison study was used in a 2011 Kenyan study to compare 880 influenza surveillance questionnaires recorded on a smartphone platform with another 880 questionnaires recorded on paper. The records were randomly selected from four influenza sentinel surveillance sites and compared on cost, quality, and timeliness. The costs were classified into initiation and operating costs using data from the Kenya Medical Research Institute. The initiation and operating were combined to calculate the total costs using the average number of cases from 2010 and 2011. The electronic system's total costs were 14% lower than the paper-based system, although its initiation costs were 9.4% higher compared to the paper-based system. Additionally, the paper-based system had 10 times more incomplete records and it took, on average, 14 days longer to upload data.[13]

Another African study that compared the two systems was a 2016 Tanzanian study that used records from 961 households under a Health and Demographic Surveillance System (HDSS) to compare the cost and quality. The cost-related data were collected from the 2007/8 financial reports of the HDSS, and expenses were documented during the study. The costs were expressed per 1000 households and classified into total and recurrent costs. It was found that the total and recurrent costs for electronic system were 11% and 17% lower than the paper-based system, respectively. When only the error-free records were analysed, the total and recurrent costs of the electronic system were 19% and 38% lower than the paper-based system, respectively. The number of errors was used to assess the quality and it was found that the paper-based system's errors were nine times higher than the electronic system.[14]

Comparing electronic and paper-based data collection systems in South Africa

In South Africa, a 2014 study compared the two systems using a cost-effectiveness analysis, which reported the cost per correctly entered question. The costs were

classified into HR costs and start-up costs. 200 records from participants of a Diabetes study in Durban, were randomly allocated to either the electronic or paper-based system.[15] The HR costs were calculated using formulae developed by Walther et al,[16] from another study which compared the two systems in Sub-Saharan African countries. It was found that the paper-based system had four times more errors than the electronic system, while the human resource cost per correctly entered question was about two times higher for the paper-based system. The start-up costs were about two and a half times higher for the electronic system, however, this amount would be regained within six months of implementing the electronic system. This study was only conducted in a research setting, and not a real-world setting, hence, there is a gap in the literature from South Africa comparing the two systems in a real-world setting within the health sector.[15]

Cost-comparison studies of other health interventions

Although there is a scarcity of cost-comparison studies on electronic and paper-based records in the health sector, the cost comparison method has been tested in the South African health context in comparing medical interventions. A 2011 study in Pietermaritzburg compared two clinical procedures for managing burns. Information from an audit of the burns unit was used to develop a costing model. The cost items compared were dressings, medication, surgical operation, and length of stay. These were combined to calculate the average total cost per patient for each intervention.[17] Another study compared the cost of inpatient care for HIV-Infected patients with the cost of inpatient care for HIV-Uninfected patients in a hospital located in Soweto, South Africa. This study used hospital expenditure, patient utilization, patient records and government price lists to derive individual cost items which were used to calculate and compare the average total inpatient costs. These cost items included average length of stay, medication and intravenous fluids.[18] Both studies used the methods of a cost-comparison study similar to the studies above.

Comparing paper-based and electronic systems through non-cost related study designs

Furthermore, there have been other study designs comparing electronic and paper-based records in the health sector, such as a 2014 mixed methods comparative analysis from the North-West province comparing data accuracy of a paper-based

monitoring and evaluation system to an electronic system within the Ward-Based Primary Health Care Outreach Team (WBPHCOT) programme. The study used one WBPHCOT team which consisted of ten Community Health Workers, who used both paper-based and electronic systems to record information about services provided during home visits, over a six-month period. The study compared the two systems by assessing the accuracy of transferring data from the weekly report to the monthly summary. And a focus group discussion with the participants was used to record their experiences in using both recording systems. The study found that the paper-based system had poor data transfer accuracy, this improved through the utilisation of the electronic recording system.[19]

A 2007 mixed methods feasibility study, from Limpopo and Western Cape, compared the implementation of a paper-based surveillance system with an electronic cell-phone-based system to measure the impact of the WBPHCOT programmes. The quantitative data used a sample of 3 600 (1 800 for each system) home visits, which was aimed at achieving a 5% significance level (p-value of 0.05) and an 85% power. The qualitative data used focus group discussions with all CHW fieldworkers to establish their views and experiences with using the two systems. The study found that the electronic system required electricity to charge devices, network reception, internet access, information technology (IT) support and a security system to ensure the safety of the devices. While the paper-based system required stationery, photocopying facilities and storage facilities to ensure safety of completed forms and administrative staff. When the two systems were compared in terms taken to complete a form for a sick patient, it was found that the recording time for the paper-based system was 8 minutes, while the electronic system was 3.5 minutes, which means that the recording time for the electronic system was 56% lower than the paper.[20]

Additionally, a 2015 study in Limpopo, Mpumalanga, and Kwazulu-Natal, compared the completeness of data and user acceptability between cell-phone-based and paper-based malaria notifications systems. This was a cross-sectional quantitative which used interviewer-administered questionnaires and analysis of secondary data to evaluate and compare the two data collection systems. The study assessed completeness (events reported and accurately completed), and timeliness (time from

diagnosis to capturing into the Heath Information System). Simplicity – (time taken to complete and experience of users) and acceptability (users' willingness to use the reporting system).[21] However, these three studies only compared effectiveness or quality, instead of costs.

The study under review hopes to address the gaps noted above, which is the lack of a South African cost-comparison study comparing a general PHC-level paper-based recording system with an electronic recording system in a real-world setting within the health sector.

1.4. Problem Statement:

District Health Information System (DHIS) data in districts within the Gauteng Department of Health (GDOH) have been reported as unreliable and inaccurate, with the use of the paper-based system being found to be more error-prone.[5] This leads to a lack of accurate information for proper decision-making in the department which may lead to inefficient budgeting and inappropriate resource distribution.[1,6]

To address this matter, the GDOH, through external funding from the Aurum Institute, piloted the E-tick register in three clinics situated in the Ekurhuleni Health District. However, after the completion of the pilot, the implementation of the E-tick register was halted and could not be incorporated into the GDOH budget at the time, in part, due to inadequate information on costs of the innovation compared to the existing paper-based system.

1.5. Justification

The E-tick register can play an essential role in providing timeous, reliable and accurate data to facilitate informed decision-making. It is therefore essential to ascertain the costs and advantages of the E-tick register pilot in the Ekurhuleni Health district to assist the provincial health department with budgeting to motivate for the implementation of the system in health facilities across the province. The findings from this study will provide information about the costs of the E-tick and the paper-based tick registers during the pilot phase and therefore will help to determine whether implementing the E-tick register is a better financial investment for the Department of Health than the current paper-based PHC tick register system.

1.6. Research question:

What are the benefits and the costs of the E-tick register system compared with the paper-based tick register system in Ekurhuleni PHC clinics from a provider's perspective?

1.7. Aim:

This study aims to cost and compare the expenditure of the electronic tick register and the paper-based tick register systems and determine provider views on their use in the Ekurhuleni Health District.

1.8. Study Objectives:

1.8.1. To determine the cost of the existing paper-based tick register system between November 2017 to June 2019

1.8.2. To determine the cost of implementing the E-tick register in the Ekurhuleni District during the pilot phase of November 2017 to June 2019

1.8.3. To compare the costs of implementing a paper-based tick register and the E-tick register in Ekurhuleni District

1.8.4. To describe and compare the advantages and disadvantages of a paper-based tick register system and the E-tick register system in Ekurhuleni District clinics from a health worker/public provider's perspective.

2. Methods:

Definition of terms

For the purpose of this study, the following are the definitions of the terms used:

- Fixed Costs: costs that remain constant regardless of the number of outputs.
- Variable costs: costs that change depending on the number of outputs.
- Initiation costs: costs that are only incurred at the start of a project.
- Operating costs: costs that occur regularly throughout the duration of a project, excluding initiation costs.
- Financial year: a 12-month period starting in April and ending in March which is used for reporting financial accounts in the public service of South Africa.
- Amortisation: an accounting practice for spreading out the costs of a long-term asset over the expected lifetime of the asset.
- Nurse recording time: time which a nurse takes to complete patient data on a recording system.
    - For a paper based system, this includes recording on the file, head count register and PHC tick register.
    - For the E-tick system, this only includes recording on the E-tick system, as all the data is recorded at the same time

Examples of these costs are indicated in Table 1.

Table 1. Different types of costs and their examples

Fixed Costs:	**Variable Costs:**	**Initiation Costs:**	**Operating Costs**	**Cost Formulae**
Software system	Employees cost	Equipment	Employee costs	Total cost: Fixed cost + Variable cost
Equipment: Computers, Tablets and accessories	Stationery: Files, PHC tick registers, Headcount registers	Software system	Stationery	Average Cost per patient: Total cost/ number of patients
Maintenance		Installation costs	Maintenance	Operating Cost: Total cost - Initiation cost
Data Storage			Data Storage	

2.1. Study design

The study used the following two methods:

- For the first three study objectives (1.8.1, 1.8.2 & 1.8.3), a descriptive cost-comparison study is used. Cost data is obtained from the Ekurhuleni health district (GDOH) regarding expenditure on the paper-based tick registers and from its support partner (Aurum Institute) regarding expenditure on the E-tick register.
- For the last study objective (1.8.4), a descriptive cross-sectional study used interviewer-administered questionnaires asking health workers about their experiences using both systems.

2.2. Study site and setting

The Ekurhuleni health district where this study is set has a population of about 3.8 million people serviced by 84 Primary Health Care clinics, nine Community Health Centres, one district hospital, four regional hospitals and one tertiary hospital.[7]

The study was conducted in three public health sector PHC facilities where the E-tick register was piloted in the Ekurhuleni Health District which lies on the eastern side of Gauteng Province, South Africa. The three study facilities utilised both registers concurrently during the pilot period.

2.3. Study population

For study objective 1.8.4, healthcare workers who used both the E-tick and paper-based tick registers during the pilot period in the three PHC facilities in Ekurhuleni district where the E-tick register was piloted were included. These facilities employ about 112 staff members, who were responsible for clinical care recording and capturing health information.

Sampling: There was no sampling, all the healthcare workers who met the eligibility criteria in the three clinics were invited for the study.

Inclusion criteria: All Healthcare workers (HCWs) who used both the E-tick and Paper-based registers in the three PHC Clinics in Ekurhuleni District during the pilot period, and who were available at the time of the study. These were mainly nurses and data capturers. Nurse categories included in the study were enrolled nurses, registered nurses and specialist nurses, these have different training requirements

and scopes of practice which are covered in the discussion section. Data capturers did not use the E-tick register but since their role in capturing data was critical, to meet the objectives of the study, they were included in the study and only the responses relevant to the paper-based registers were used for them. Administration clerks sometimes performed the roles of data capturers, so they were asked questions regarding their data-capturer roles but were not included in the costing component for data capturers.

Exclusion criteria: Healthcare workers who were no longer working at the facilities when the study was conducted.

Study Period: Each register was costed using data from November 2017 to June 2019, while the comparison used data from 2018/19 and health worker interviews were conducted between January 2023 and March 2023.

2.4. Data collection

Early in 2023, data required for costing both registers were extracted from purchase orders obtained from the Ekurhuleni Health District for the study period November 2017 to December 2019. The data for the costing of the E-tick register was made available through the district by the district support partner. Interviews were conducted with 25 staff members and the rest either dis not consent or were unavailable due to shift-work, leave and others did not consent Interviewer-administered questionnaires (Appendix 4) were conducted over five days, between 20 January 2023 and 25 January 2023, in English by the researcher asking HCWs about their experiences with using the different systems. These were initially conducted telephonically to minimize physical contact in anticipation of a Coronavirus disease-2019 (COVID-19) wave but as the pandemic situation had changed, the interviews were conducted physically. Poor internet connectivity as a result of load-shedding at the time of the study also supported in-person interviews. Time to conduct the interviews was requested from the facility manager and the staff members beforehand as they took place during working hours. The interviews were recorded and transcribed by the researcher. Parts of the questionnaire relating to the E-tick register were omitted for the data-capturers as they did not capture data in this system since the data is captured directly by the clinician, without the need for a data

capturer. Data such as age and the number of years in position were not collected, as they may lead to the identification of the participants, particularly in facilities with only a few staff members occupying a particular position and positions with only one staff member.

2.5. Data Management

Microsoft Excel 2016 and STATA SE 17 were used for data capturing, tabulating, sorting, merging and manipulation. The costs of each item were expressed in terms of the South African Rand value. Data cleaning was performed manually, and data is stored in a safe place with restricted access and will be kept for an additional two years after publication or six years if it is not published.

2.6. Data analysis:

An economist from the University of Witwatersrand's Centre for Health Economics and decision science (RICELESS SA) was consulted for advice on the cost data analysis and no additional statistical expertise was sought. Descriptive statistics such as absolute counts, proportions and percentages are used for categorical variables. Mean (standard deviation) or median (interquartile range) are used for continuous variables. Analytical statistics such as the average cost per data collection system are calculated according to the three financial years covered in the study period. Even though the study period for the cost data was from Nov 2017 to Dec 2019, the year 2018/19 is used for the cost comparison, as it is the only complete financial year during the study period.

For open-ended questions, answers with a similar theme are grouped under one sub-heading. The advantages and disadvantages are classified into categories such as time and quality and are analysed together with the recommendations suggested by participants. The two systems will be compared based on these categories.

Calculation of costs:

2.6.1. Variable costs

To determine the variable costs of both the paper-based and E-tick PHC registers, it was important to determine the employee costs portion per register. This involved determining the total working time available for the staff, their salaries and the

amount of time spent by staff using the registers. Employee costs portion in the context of this study refers to the portion of an employee's salary which is attributable to the time spent recording information on either of the two types of PHC tick registers or capturing data onto the DHIS. This was calculated as follows:

a) Available working time in minutes

Table 2. Number of working minutes available per month per staff member

Item	**Days**
Days per Year (D)	365
Non-workdays (weekends and leave) (ND)	150
Workdays per year (WD= D – ND)	215
Workdays per month (WDM = WD/12)	17.9
Work hours per. Month (WHM =WDM x 8 hours per day)	143.3
Work minutes per employee per month (Wm = WHM x 60 minutes per hour)	8600
Total nurse work minutes per month (TWm_n = Wm x n_n)	8600 x no. of nurses
Total Data-capturers work minutes per month (TWM_d=Wm x n_d)	8600 x no. of Data-Capturers

The table above shows the average number of working minutes available per month per staff cadre (either nurse or data capturer). This amounts to 8600 working minutes per month for each staff member. This equates to the available working time, which is important for calculating the employee cost per minute.

Table 3. Available working time in minutes for the total number of nurses and data capturers per facility

Study Facility	**No of nurses**	**Total nurse working minutes**	**No. of data capturers**	**Total data capturer working minutes**
Facility A	13	111800	2	17200
Facility B	68	584800	3	25800
Facility C	23	197800	2	17200
Total	104	894400	7	60200

The above table shows the available working time for each staff category in all facilities. This amounts to 894 400- and 60 200-minutes available working per month for nurses and data capturers, respectively. These will be used to calculate the employee portion costs per register.

b) Salaries

Table 4. Monthly salaries per staff category from the years 2017/18 to 2019/20 for all three facilities (unit- ZAR)

Staff Category	**No. (n)**	**2017/18**		**2018/19**		**2019/20**	
		Monthly salary per category (s)	**Total monthly Salaries (n X s)**	**Monthly salary per category (s)**	**Total monthly salaries (n X s)**	**Monthly salary per category (s)**	**Total monthly salaries (n X s)**
Enrolled Nurse	8	13 334	106 670	14 267	114 136	15 152	121 212
Registered Nurse	45	20 288	912 938	21 708	976 849	23 054	1 037 415
Specialist Nurse	51	30 550	1 558 025	32 535	1659298	34 390	1 753 877
Nurse Total	104	64 171	2 577 632	68 510	2750283	72 595	2 912 504
Data capturer	7	13 722	96 056	14 793	103 554	15 711	109 974
Total	111		2 673 688		2 853 836		3 022 478

The table above indicates the numbers and salaries for each staff category from the financial years 2017/18 to 2019, starting from November 2017 to December 2019. The median grade one salary for each staff category according to the Department of Public Service and Administration (DPSA) salary scale for each year was used for the calculation. This amounted to a total monthly salary of R 2 673 688 for 2017/18, R2 853 836 for 2018/19, and R3 022 476 for the financial year 2019/20 for the 111 staff in the study. Other staff categories such as medical and allied health practitioners were excluded from the costing as they did not participate consistently

in the pilot project or were no longer available in the facilities as they were mainly staff members serving one year of community service. The financial year 2018/19 was used for comparing the two different recording systems as this was the only complete financial year during the study period.

c) Recording time per patient

To report on the costs per register, we had to first determine the time taken to record and capture data, per patient for each type of register system.

Table 5. Nurse recording time per visit type in minutes

Item	**Short Visit (SV) in minutes**	**Long Visit (LV) in minutes**
Paper-based register time (T)	10 (10-16.5)	20 (16.25 – 40)
E-tick register time (T)	5.8 (3 – 10)	15 (8 – 20)
Visit proportion (P)	70% (62.5 – 80)	30% (20 - 37.5)

The table above indicates the median (IQR) recording time per patient visit type. Nurses were asked to indicate recording times for a single patient for a short consultation visit and a long consultation visit. The majority (70%) of the consultations were short visits.

Table 6. Nurse recording time per patient

Register	**Calculation**	**Recording time**
Paper-based	10x70% + 20x30%	13 (Min)
E-tick	5.8x70% + 15x30%	8.5 (Min)

The table above indicates the calculation used to determine the recording time per patient for each register. The following formula was used:

- Recording time per patient = $(T_{SV} \text{ X } P_{SV)} + (T_{LV} \text{ X } P_{LV})$

Table 7. Capturing time per patient in minutes

Item	Per data capturer (dc)	Total (t)	Per patient (pp)
Capturing time in minutes (TC)	175 (90 - 210)	225	1.2

The table above depicts the capturing time per patient. This was calculated using the median number of capturing time per data capturer per day which was obtained from interviewing the data capturers. The calculation is different from nurse recording time, as it is not directly related to the length of a patient visit. The average number of patients per day (n_{pd}) was 1 042 and the number of data capturers (n_d) in all facilities was 7. The capturing time per patient was calculated using the following formulae:

- $TC_t = dc \times n_d$
- $TC_{pp} = TC_t/n$

Table 8. Formulae for calculating Nurse employee costs for the paper-based register

Item	**Formula**
Total paper recording time for nurses in minutes	Patient Headcount x recording time per patient (13 min)
Nurse Paper recording time %	(Total Nurse's paper recording time/ Total nurse work minutes) x100
Nurse Employee costs (paper)	Nurse Paper recording time % x Nursing Salary

The table above depicts the formulae used to calculate the Nurse Employee cost portion for the paper-based register. This refers to the portion of the Nurse's salary that is attributable to recording on the paper-based system. This is dependent on the amount of time spent recording patient-related activities and the headcount which is the number of patients seen by nurses at the facilities during a particular period. The recording time per patient was obtained from interviewing the nursing staff and was determined to be 13 minutes for all cadres of nurses in the study. These costs are important for calculating the overall employee costs for the paper-based system.

Table 9. Formulae for calculating Data capturer employee costs for the paper-based register.

Item	**Formulae**
Capturing time (in minutes)	Headcount x 1.2 min
Capturing time%	(Capturing time/ working time) x 100
Data capturer Employee cost (paper)	Capturing time% x Data Capturer salary

The table above depicts the formulae used to calculate the Data Capturer Employee cost portion for the paper-based register. This refers to the portion of the Data capturers' salary that is attributable to capturing data from the paper-based system. This is dependent on the amount of time spent capturing data and the patient headcount during a particular period, from interviewing the data capturers, it was determined that, on average, the capturing time was about 1.2 minutes per patient. This is another component of the overall employee costs for the paper-based system. Therefore, the total employee cost portion for the paper-based system was obtained by adding all the employee costs attributed above:

- Paper system employee cost portion = Nurse Employee costs (paper) + Data capturer paper employee cost (paper)

d) E-tick: employee cost portion

Table 10. Formulae for calculating Nurse employee costs for the E-tick register.

Item	**Formulae**
Total Nurses E-tick recording time (min)	Patient Headcount x recording time per patient (8.5 min)
Nursing E-tick time%	(Total Nurse's E-tick recording time/ Total nurse work minutes) x 100
Nursing Employee costs (E-tick)	Nursing E-tick time% x Nursing Salary

The table above depicts the formulae used to calculate the Nurse Employee cost portion for the E-tick register. The method of calculation is the same as that of the paper-based register above, with the difference being the recording time, which was determined to be an average of 8.5 minutes per patient. There are no data capturers involved in this system, therefore, the E-tick employee cost portion only consists of the E-tick Nurse Employee portion costs attributed.

e) Paper-based: Stationery costs

Table 11. Formulae for calculation of Stationery costs

Item	Formula
Headcount	Headcount/6000
Tick registers cost	No. tick registers x tick register unit price
No. of Headcount registers	Headcount/4800
Headcount register cost	No. of headcount registers x unit price
No. of files	Headcount/10
Files costs	No. of files x unit price

Another variable cost for the paper-based system was stationery. The calculation formulae depicted in the table above depict the types of stationery which consists of Tick registers, Headcount registers and files. Each Tick register can record 6 000 patients, while the headcount register records 4 800 patients and one file can record 10 patient visits.

Table 12. Quantity and unit prices of stationery items per financial year (All prices in ZAR)

Item	2017/18	2018/19	2019/20
No. of Tick registers	16	37	28
Tick registers unit price (ZAR)	148.99	110.74	227
No. of Headcount registers	19	47	35.
Headcount register unit price (ZAR)	75.66	69.9	72.77
No. of files	9294	22351	16893
File unit price (ZAR)	4.17	4.96	4.96

The table above depicts the quantity and unit price per stationery item for each financial year. The amount of stationery per item is multiplied by the unit of each item to calculate the stationery costs, which contribute to the variable costs of the paper-based register. The calculated results for each item are indicated in Appendix 2 (Table A).

2.6.2. Fixed Cost

a) Paper-based fixed costs

There were no fixed costs available for the paper-based register.

b) E-tick fixed costs

Table 13. List of fixed costs for the E-tick register

Category	Item
IT and Maintenance	Maintenance
	Monthly IT charges
Initiation costs	Equipment and accessories
	ICT installation
	Software development

The table above depicts the fixed costs for the E-tick register, detailed prices for each item are indicated in Appendix 2 (Tables B and C). The initiation costs were equally spread out over five years, which is the expected lifespan of the equipment.[22]

2.7. Advantages and disadvantages of both registers

For the fourth study objective (1.8.4), the views of staff members, regarding their experience with using the two different types of registers, were obtained through an open-ended questionnaire. The responses for each open-ended question were grouped and organised systematically into themes according to the six-step framework for thematic analysis developed by Braun and Clark.[23] This process was performed by the principal researcher, under the guidance of the supervisor. The steps are as follows:

Step 1: The responses were read multiple times to get a general familiarity with the topics covered regarding the advantages and disadvantages of each register.
Step 2: Codes were created and allocated to responses based on the topic covered by the response. The codes were created and modified as process unfolded, as the were no pre-set codes. Since the data set was small, this process was performed manually on Microsoft word without the use of any analytical software.
Step 3: Codes that addressed a similar issue were then grouped together into one theme.
Step 4: The themes were then reviewed in line with objective 1.8.4 and the themes from studies included in the literature review to ensure that they are coherent and not overlapping.

Step 5: The analysis was finalised by arranging the data into 10 themes of advantages per register, as indicated in the table below. Each register was then scored in terms of the 10 themes, the score was either Yes or No, depending on whether a particular theme was present per register system. A score of one was allocated for each “Yes” and zero for each “No”, without any ranking of the themes in any particular order.

Table 14. Final set of themes for advantages and disadvantages of each register

No.	Theme
A	Convenience
B	Independence from electricity supply
C	Easy access
D	Sufficient writing space
E	Quick recording time
F	Safe storage of information
G	Immediate capturing
H	Ability to add more elements
I	Fewer errors
J	Good font size and legibility

Step 6: The results are reported in section 3.5 of the following chapter, according to the above themes.

3. Results

The following results show the findings according to the study objectives.

3.1. Recording time for both types of the PHC tick registers

To report on the costs per register, we had to first determine the time taken to record and capture data, per patient for each register system.

Table 15. Recording and capturing time per patient per register by nurses and data capturers

Register	**Time (median) Per patient in minutes**		
	Recording (nurse)	**Capturing (Data capturer)**	**Capturing Interval**
Paper Register	13 (Min)	1.2 (Min)	1 day(s)
E-tick Register	8.5 (Min)	0 (Min)	0 day(s)
Difference	4.5 (Min)	1.2 (Min)	1 day(s)
% Difference	34%	100%	100%

The table above shows the median number of minutes taken to record information by the nurse for each type of PHC tick register and the amount of time taken to capture information from the paper-based register to the DHIS system as stated by participants during interviews. Recording time includes recording patient information on the patient file and ticking the activities completed on the register. The Paper-based register had a median recording time of 13 minutes per nurse per patient, compared to the E-tick register for which the nurses took 8.5 minutes to record patient information. Data from the paper-based tick register are usually captured on to the DHIS one day after recording with the data capturers spending about 1.2 minutes per patient on this. However, with the e-tick register, recorded data is immediately transferred onto the DHIS system, resulting in zero data capturing minutes and capturing interval. The study found that the nurse recording time for the E-tick register was 4.5 minutes shorter compared to the 13 minutes per patient for the paper based tick register.

3.2. Costs of the paper-based register

For the first study objective 1.8.1, we determined the costs of the paper-based register according to the different financial years covered in the study. The results for each financial year or portion thereof are depicted in the tables below.

Table 16. Costs of the paper-based register from November 2017 to March 2018 (All costs in ZAR)*

Type	Item	Total	Monthly average	Per patient cost	% of Total
Variable costs	Paper employee cost portion	3 649 964	729 993	39,3	99%
	Stationery costs	42 529	8506	0,4	1%
Fixed costs	None	0	0	0	0
Total	Total Costs	3 692 493	738 499	39,7	100%

*NB: period only consisted of five months

The table above depicts the costs of the paper-based register from November 2017 to March 2018. This period was not a complete financial year. The employee portion of the paper-based register was R39.3 per patient, while the stationery costs were R0.4. It is seen that the employee costs were responsible for 99% of the total costs of the paper register costs. There were no fixed costs listed for the paper-based register. Expenditure on the number of registers was dependent on the patient headcount.

Table 17. Costs of the paper-based register from April 2018 to March 2019 (All costs in ZAR)

Type	Item	Total cost for 2018-19	Monthly average cost in 2018-19	Per patient	% of Total
Variable costs	Paper employee cost portion	9 355 224	779 602	41.9	98.8
	Stationery costs	118 242	9 854	0.5	1.2%
Fixed costs	None	0	0	0	0
Total	Total Costs	9 473 466	789456	42.4	100%

The table above depicts the costs of the paper-based register from April 2018 to March 2019, this period was a complete financial year. The employee costs portion of the paper based-register was about R9.3 million during this financial year, with an average of about R779 600 per month. This amounted to R41.9 per patient. The total cost of stationery was about R118 200 per and about R9 800 per month, amounting to R0.5 per patient, meaning that employee costs accounted for 98.8% of the paper-based register costs.

Table 18. Costs of the paper-based register from April 2019 to December 2019 (All costs in ZAR)

Type	Item	Total	Monthly average	Per patient	% of Total
Variable costs	Paper employee cost portion	7 505 744	833 972	44.4	98.8%
	Stationery costs	92 734	10 304	0.6	1.2%
Fixed costs	None	0	0	0	0
Total	Total Costs	7 598 478	844 275	45	100%

The table above depicts the costs of the paper-based register from April 2019 to December 2019, this period was not a complete financial year. The employee portion of the paper-based register was R44.4 per patient, while the stationery costs were R0.6. The employee costs were responsible for 98.8% of the total costs of the paper register costs.

3.3. Costs of the E-tick register

In the second study objective, we determined the costs of the E-tick register according to the different financial years covered in the study. The results for each financial year or portions thereof are depicted in the tables below.

Table 19. Cost of E-tick register from November 2017 to March 2018 (All costs in ZAR)*

Cost Type	Item	Total	Monthly average	Per patient	% of Total
Variable costs	E-tick employee cost portion	2 276 835	455 367	24.5	85.8%
Fixed costs	Combined fixed costs	377 017	75403	4.1	14.2%
	- IT and Maintenance	236 257	47251	2.5	
	- Initiation costs	140 760	28152	1.5	
Total	Total E-tick Cost	2 653 853	530 771	28.6	100%

*NB: period only consisted of five months

The table above depicts the costs of the E-tick register from November 2017 to March 2018, this period was not a complete financial year. During this period, the employee portion of the E-tick register was R24.5 per patient. The combined fixed costs included the monthly IT costs (data storage, software), maintenance and initiation costs (equipment and installation) amounted to R4.1 per patient. The employee costs contributed to 85.8% of the total costs of the E-tick register costs, while the fixed costs accounted for 14.2%, with a total cost per patient of R28.6.

Table 20. Cost of E-tick register from April 2018 to March 2019 (All costs in ZAR)

Cost Type	Item	Total	Monthly average	Per patient	% of Total
Variable costs	E-tick employee cost portion	5 832 315	486 026	26.1	87.5%
Fixed costs	Combined fixed costs	836 360	69 697	3.7	12.5%
	- IT and Maintenance	671 258	55 938	3	
	- Initiation costs	165 102	13 758	0.7	
Total	Total E-tick Cost	6 668 675	555 723	29.8	100%

The table above depicts the costs of the E-tick register from April 2018 to March 2019, this period was for a complete financial year. The employee cost portion of this register was about R5.8 million during this period, with an average of about R486 000 per month. This amounted to R26.1 per patient, which is 87.5% of the total E-

tick costs. The combined fixed costs amounted to about R836 400 during the financial year, with a monthly average of about R69 700 per month.

Table 21. Cost of E-tick register from April 2019 to December 2019 (All costs in ZAR)*

Cost Type	Item	Total	Monthly average	Per patient	% of Total
Variable costs	E-tick employee cost portion	4 679 187	519 910	27.7	88%
Fixed costs	Combined fixed costs	637 413	70 824	3.8	12%
	- IT and Maintenance	513 586	57 065	3	
	- Initiation costs	123 826	13 758	0.7	
Total	Total E-tick Cost	5 316 600	590 733	31.5	100%

*NB: period only consisted of nine months

The table above depicts the costs of the E-tick register from April 2019 to December 2019, this period depicts only a portion of this financial year. During this period, the employee portion of the E-tick register was R27.7 per patient, while the fixed costs were R3.8. The employee costs were 88% of the total costs, while the fixed costs accounted for 12%. The total cost per patient was R31.5.

3.4. Cost differences between the paper-based and E-tick registers

The third objective compared the cost differences between the two registers during the 2018/19 financial year, as this was the only complete financial during the study period. The results are depicted below.

3.4.1. Total costs per register

Table 22.Total costs of paper-based register vs E-tick register from April 2018 to March 2019 (ZAR)

Item	Paper	E-tick	Difference
Employee cost portion per patient	41.9	26.1	15.8 (37.7%)
Total Cost per patient	42.4	29.9	12.5 (29.5%)
Employee cost portion % of Total	98.8%	87.3%	11.5%
Total costs	9 473 466	6 682 199	2 791 268 (29.5%)
Monthly average costs	789 456	555 826	232 606 (29.5%)

The table above depicts the total costs per register and the difference in costs between the two registers. The Employee cost portion of the paper-based register was R41.9 per patient, which was 37.7% more than the E-tick register at R26.1 per patient. The total paper-based register cost per patient was R42.4 which is R12.5 (29.5%) higher than the E-tick at R29.9. Employee portion costs account for a higher portion (98.9%) of the paper-based register costs compared to the E-tick register costs (87.3%).

3.4.2. Monthly operating costs

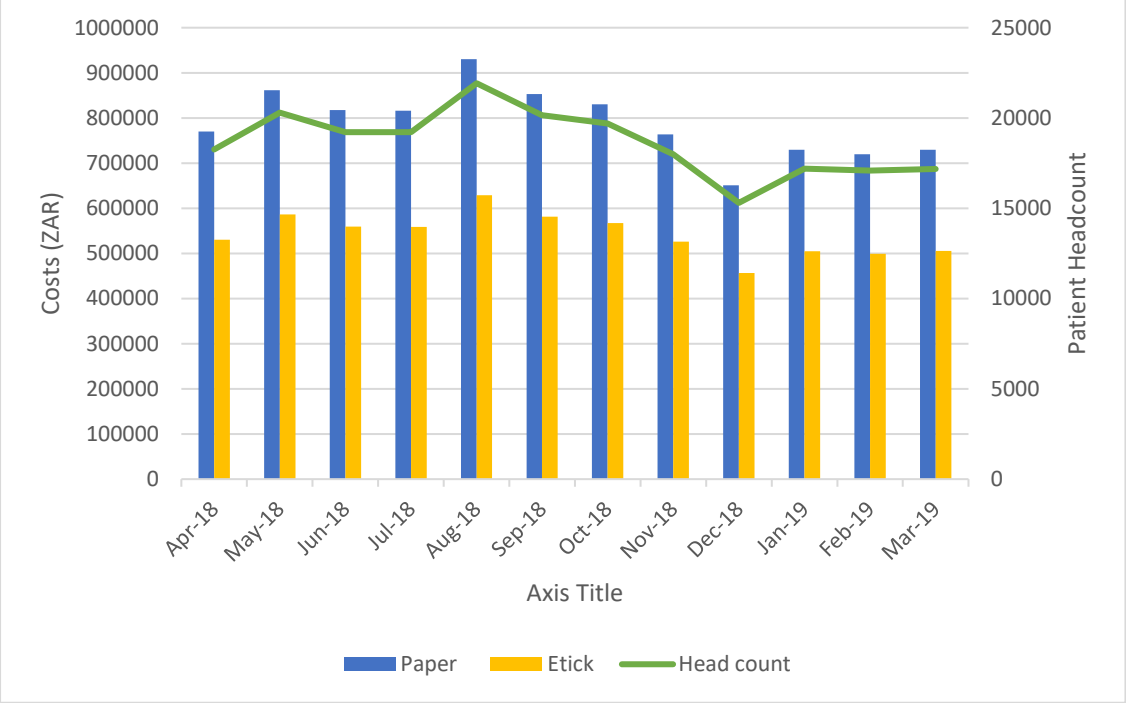

Figure 1. Monthly operating costs of the E-tick register vs Paper-based register according to patient headcount from April 2018 to March 2019

Since the initiation costs of the paper-based register were not available, it is important to compare the operating costs of the two systems. This included the total monthly costs of the paper-based system but excluded the initiation costs of the E-tick register. The year 2018-19 again as the full financial year is used here. The graph above compares the monthly operating costs of the E-tick register with the paper-based register according to the patient headcount for all three study clinics, from April 2018 to March 2019. December 2018 had the lowest number of patients at 15 299 and the lowest cost for both registers, with the paper-based at R651 125 and

the E-tick at R456 909. August 2018 had the highest headcount at 21 924 and the highest cost for both registers with the paper-based register at R930 145 and the E-tick register at R628 616. Overall, the E-tick register had lower operational costs per month compared to the paper-based register.

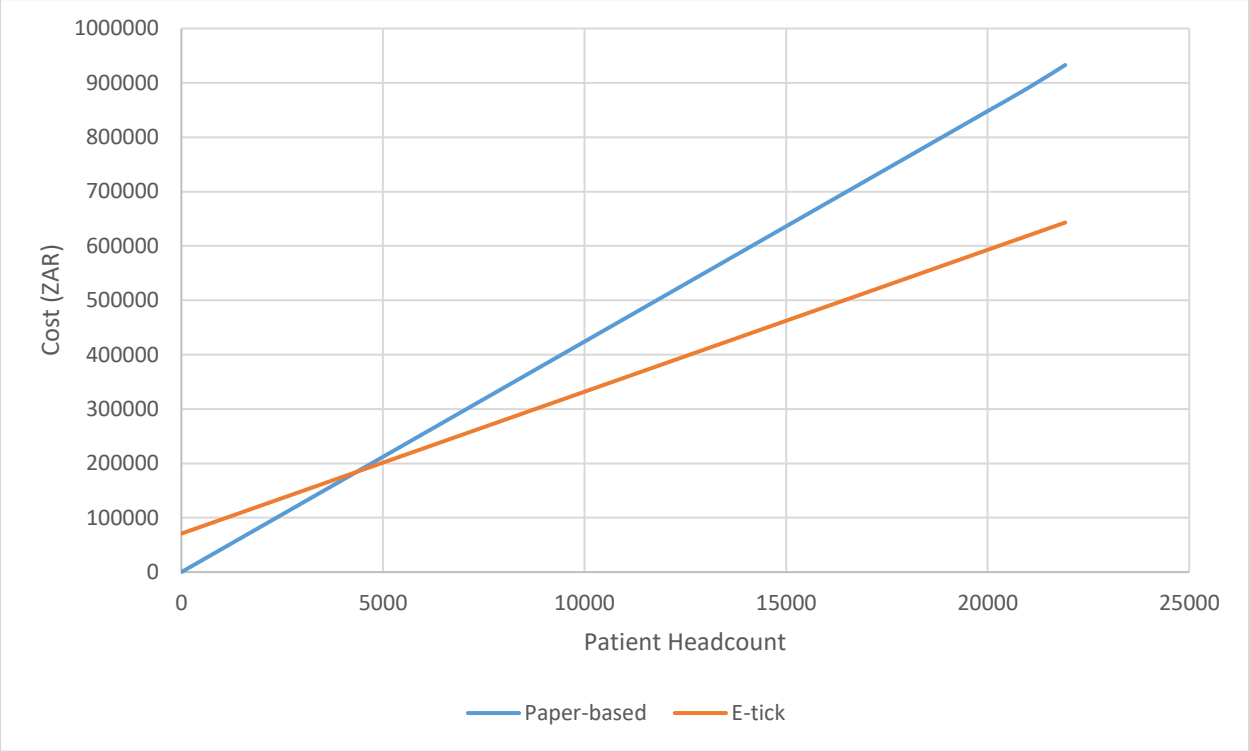

Figure 2. Average Total Monthly costs of the Paper-based register vs E-tick register according to patient headcount for 2018/19

Using the data obtained in Tables 7 and 8, the above graph was plotted to depict the average monthly costs of the paper-based register and the E-tick register according to the headcount. Using the standard formula of a line graph (y=mx + c), y represents the average costs, x represents the headcount, m represents the cost per patient and c represents the fixed costs. The equation for the paper-based *is* $y_p=42.4x_p$, as the variable cost per patient is R42.4, while there were zero fixed costs. And the equation for the E-tick register is $y_e=26.1x_e + 70\ 824$, as the variable cost per patient is R26.1, while the fixed costs were R70 824. The two graphs intersect where the headcount reached 4 345. It was found that the paper-based register was cheaper below this cut-off of 4 345, while E-tick register was less costly after his point.

3.5. Health Providers' Views

For the fourth study objective (1.8.4), staff members gave their views regarding their experience with using the two different types of registers, and the results are presented below.

Table 23. Number of participants by staff category and facility interviewed (n)

Staff category	Facility A (n)	Facility B (n)	Facility C (n)	Total
Nurse	4	4	9	17
Data capturer	1	2	2	5
Other admin staff	1	1	1	3
Total	6	7	12	25

The table above shows the number of participants interviewed by staff category and facility. The table above shows the number of participants interviewed by staff category and facility. Nursing categories included Specialist Registered Nurse, Registered Nurse and Enrolled Nurse. The administrative staff were mainly data capturers and other administrative staff members who performed the duties of data capturers, these included administration clerks and administration officers. Various categories of nurses and other administrative staff were not indicated as certain categories only included one individual and that may result in the participants being identifiable. The total number of participants was 25, with the majority (68%) being nursing staff, while 32% were administrative staff. In terms of distribution between facilities, 48% were from Facility C, 28% from Facility B and 24% from Facility A.

3.5.1. Advantages and disadvantages of the paper-based register system

The table below shows the advantages and disadvantages of the paper-based register system according to the responses received. These were grouped into 10 themes and indicated as "Yes" where the register was favourable and "No" where it was not favourable. The paper-based register was only favourable in 40% of the themes.

Table 24. Advantages and disadvantages of the paper-based PHC tick register system

No.	Theme	Paper
A	Convenience	Yes
B	Independence from of electricity supply	Yes
C	Easy access	Yes
D	Sufficient writing space	Yes
E	Quick recording time	No
F	Safe storage of information	No
G	Immediate capturing	No
H	Ability to add more elements	No
I	Fewer errors	No
J	Good font size and legibility	No
Score		4/10

Advantages of paper-based register

Many of the staff members reported that the paper-based system was easy to use as they were familiar with it, as one said: *"It is user-friendly when you are used to it."* Some added that it was easy to correct errors, as one said: *"I can erase whenever there was a mistake..."* Another reported advantage of the paper-based system was that it can be used when there is no electricity, as one staff member reported*: "Even if there is load-shedding it is not disturbed."* Staff members also reported that it is easily accessible to all staff members without the requirements of log-in details, as one staff member said: *"Everybody has access to it even if they don't have user details."* Other staff members reported that the paper-based system keeps records in the form of hard copies which can be kept for at least five years, as one said: *"It can always have a copy to file them."* Additionally, it was highlighted that on a paper-based patient record system, the files have more space to write comprehensive clinical notes, as one said: *"You can write comprehensively and explain what you want."* Other staff members reported that with this system they can easily check the patient notes, as one reported, *"We are able to check patient information and compare the file."*

Disadvantages of Paper-based

A commonly reported disadvantage of the paper-based system was loss of documents, as one staff member said: *"Documents can be lost and not available during audit time."* Another commonly reported disadvantage was that it takes more time to complete, as one staff member said: *"It is time-consuming and impacts on patient waiting time,"* and others said that they sometimes pack the files to record information on the register at a later time. Some staff members reported that the paper-based register had a small font size and even the spaces were small, as one said: *"The font is small and there is not enough space."*

Another reported disadvantage was that clinicians would make many errors and have overlapping ticks on the register, as one said: *"There can be ticks that cover 2 boxes so it is not clear"* and another said: *"It needs more verification."* Some staff members reported that the paper-based tick register did not have some of the elements, as sometimes there were new elements required, as one said: "*Many of the services that are done in the clinic are not there on the tick register, so sometimes clinicians put elements that are not there on the tick register*" and another said: "*The information keeps changing*…."

Another disadvantage of the paper-based system was that clinicians had to fill many registers and there was duplication of information, as one said: "*There is duplication of information*." Some staff members reported that there was insufficient space to store the registers, as one said: "*There is no space to store them*." Another reported disadvantage of the paper-based system was Illegible handwriting, as one staff member said: *"Another person might not be able to read my handwriting."* Another reported issue was that with the paper-based system, there is a possibility of tempering with the record, as one staff membered said: *"It can be tempered with."* Another staff member reported that there is an occasional lack of stationery: "*Sometimes there is no stationery*." There was also a sizable number of staff members who felt that this system had no advantages, as one said: "There is nothing good about it."

3.5.2. Advantages and disadvantages of the E-tick register system.

The table below shows the advantages and disadvantages of the E-tick register system according to the responses received. These were grouped into 10 themes and indicated as “Yes” where the register was favourable and “No” where it was not favourable. The E-tick was favourable in 80% of the themes, which is much higher than the paper-based at 40%.

Table 25. Advantages and disadvantages of the E-tick register system.

No.	Theme	E-tick
A	Convenience	Yes
B	Independence from electricity supply	No
C	Easy access	Yes
D	Sufficient writing space	No
E	Quick recording time	Yes
F	Safe storage of information	Yes
G	Immediate capturing	Yes
H	Ability to add more elements	Yes
I	Fewer errors	Yes
J	Good font size and legibility	Yes
Score		8/10

Advantages of the E-tick

The most reported advantage of the E-tick register system is that it was quicker and enabled clinicians to see more patients and meet the required waiting time standards. *“It saves time, so we were able to service more patients and match core standards waiting time.”* Another reported advantage was that it is convenient as the clinical record was linked to the patient registration information, as the staff members said: *“Once the patient is entered at reception, I just click.”* Staff members also reported that the E-tick register system provided safe storage of information as it eliminates the problem of documents getting lost, as one staff member said: *“Records won’t be missing, it will stay there, even if you want to retrieve information from 2 years ago, you can get it on the E-tick.”* Participants reported that the E-tick system had more features such as enabling clinicians to track the patient waiting

time and disease options for clinicians to choose from, as they said: *"It shows the current waiting time of the patient" and "It has different conditions already specified."*

Easy patient tracking of patients in the facility and other facilities was another reported advantage, as one participant said: *"It can easily trace patients who go around many clinics."* Staff members also mentioned that the E-tick register enables easy transfer of clinical information from one clinician to another, as one said: *"If the next clinician takes over, they can see that the patient was seen."* Another reported benefit was that the E-tick system can capture recorded data directly onto the health information system without delay, as one staff member said: *"It records the same time as you see the patient."* The E-tick system was also reported to enable the recording of more elements, as the staff member said: *"It can record all elements."* Participants also reported that the E-tick register had fewer errors as it guides clinicians on where to tick: "There are less chances of mistakes" and "It guides on where to tick."

Disadvantage of E-tick register

Staff members reported that the use of the E-tick register system was disrupted by electricity outages and network challenges - If there is a network problem, as they said: *"The disadvantage is if the electricity is off and there is no petrol for the Generator" and "when the system is down or there is no network we couldn't operate."* Another commonly reported challenge was the theft of equipment such as tablets and chargers, and fixing the tablet in a particular area made it difficult to record data when the patient moved to another room: as they said: *"The tablets were stolen and the charger was stolen"* and *"it is fixed to one area so it cannot be taken to another room if the patient is attended in another room."*

Participants highlighted that the E-tick system did not have enough space to write clinical information and was guiding the ticking, as they said: *"It is very brief, so you can't go into details, and you just click on the elements"* and *"It was channelling us to say what it wanted."* Some staff members cited that the E-tick system was difficult for them to use as they were technologically challenged, as one said: "*I don't know much about technology, so it was a problem to start using it, I don't know computer, it was too difficult to even complete one patient without asking for help*."

Having to complete both registers concurrently was cited as a challenge which could have resulted in staff members spending less time on the E-tick register, as one said: "*We had to do both the manual and E-tick registers at the same time, we were spending less time on the E-tick because the manual was the one that was used for verification*." There was also a concern about the loss of electronic information after the maintenance of equipment and also a concern about computer viruses, as participants said: "*Information disappears if the computer goes for repairs*" and "*I don't know if it comes to computer viruses*." Another staff member felt that there were no challenges, as they reported: "*There were no real disadvantages."*

3.5.3. Suggestions for improvements according to participants

Table 26. Suggestions of participants regarding both registers

No.	Paper-based register	E-tick register
1	Increase font size and writing space	Improved connectivity and equipment
2	Amending the elements	Improved security measures
3	Eliminate it	Implement it
4	Improved filing	More training
5	Allocation of registers	Amend the clinical details section
6	None	Consistent access

Suggestions to improve the paper-based register.

To improve the paper-based recording system, staff members gave multiple recommendations such as increasing the font size and writing space, as the participants said: *"They should increase the space to write and the fine print."* Another recommendation was to amend the elements and consult clinicians when changes are made, as they said: *"They should add more elements"* and *"They should remove some of the indicators, they are too much…."* Another recommendation was to improve the filing system by increasing space, appointing filing clerks, decreasing the number of registers and enhancing filing procedures, as they said: *"We need more filing space"*, *"We need clerks that are responsible for filling only"* and *"there should be neater and proper filing."* There was also a suggestion that each nurse should be allocated a register, as one said: *"Every nurse*

should have their own register." There were many suggestions that the paper-based system should be eliminated, as one said: *"Do away with paper and find a way to put it on e-tick."* However, some participants felt that the paper-based system was fine and had no recommendations to improve, as one said: "*None, it is user friendly*."

Suggestion to improve the E-tick register.

To improve the E-tick register system, participants made multiple recommendations such as improved connectivity and equipment as they said: *"We should be provided with quality computers which are regularly serviced to avoid the problems"* and *"If they can improve the connections."* Another suggestion was improved security measures, as they said: *"They should ensure chargers are mounted because they get stolen"* and *"If a tablet can be allocated per nurse and be labelled."* Many staff members were recommending for the E-tick register to be implemented and didn't want to change anything, as they said*: "It should be brought back"* and *"It is perfect, there is nothing to modify."* Others recommended more training, as they said: *"There should be more training if it is implemented."* Another recommendation was to amend the clinical details section, as they said: *"add some of the elements, especially for acute patients"* and *"try to incorporate everything from the paper system into the E-tick."* There was also a recommendation for consistent access, as they said: *"If we can use it consistently and have access to it all the time regardless of load shedding"* and *"all the rooms must have it."*

3.5.4. Preferred register by nurses

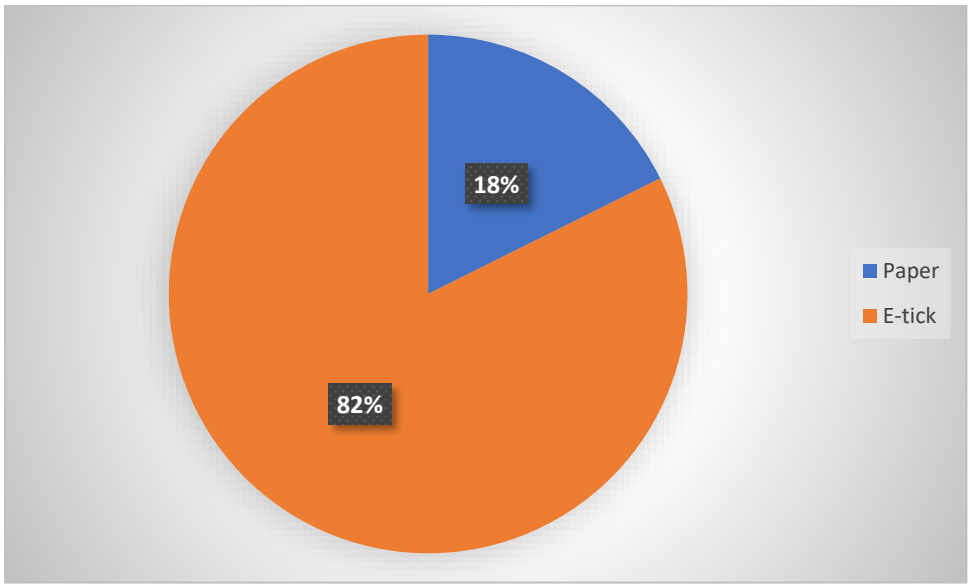

Figure 3. Preferred register by nurses

During the interviews, nurses were asked which of the two registers would they prefer to be implemented in their facilities. The above graph shows the preferred choices of the staff members, with 82% (n=3) of participants choosing the E-tick register compared to only 18% (n=14) who chose the paper-based register.

4. Discussions

This section will discuss important findings from the four study objectives to further demonstrate the differences between the paper-based register and the E-tick register in terms of costs and healthcare workers' perceptions, based on the result reported above.

Cadre of staff members in PHC

Almost 70% of participants in this study were nurses, as Primary Health Care (PHC) in South Africa is mainly nurse-driven, the number of public sector professional nurses per 100 000 uninsured populations was 145.4 in the year 2020, which is four times the number of doctors per 100 000 uninsured populations (33.6) in the same year, as reported by the District Health Barometer of 2019/20.[24] Therefore, since nurses make up the bulk of the health workforce in the PHC setting, the amount of time they spent on various activities during their working time is important to ensure efficient service delivery at the PHC level.

The various categories of nurses in PHC facilities encountered in this study are described by the Nursing Act (no. 33 of 2005) and South African Nursing Council as follows: Specialist registered nurses, are mainly specialists in PHC competent to independently perform physical examination, diagnoses medical conditions and provide PHC level treatment and care.[25] Registered nurses (Professional nurses) are qualified nursing practitioners who can independently provide comprehensive nursing services and have received basic training in areas such as community nursing, psychiatry and midwifery.[26] Enrolled nurse (Staff nurse) is qualified to provide basic nursing services under the supervision of a registered nurse.[27] All nurses were given the same questionnaires and the recording time used in the calculations was a combined average for all categories, as certain categories of nurses, such as Enrolled Nurses were very few, making up just 7.7% of nurses in the facilities included in this study.

Recording time

This study showed that nursing staff members spent less time recording information on the E-tick register compared to the paper-based register. A 2016 Western Cape

study on activities performed by Registered Nurses in 15 clinics, showed that nurses only spent 15% of the consultation time (2/13 minutes) on patient examination, therefore using a system that decreases the amount of time spent on data recording can provide more time for essential activities including clinical examination.[28] Furthermore, shorter recording times could result in shorter patient waiting times; a 2021 study in Kwazulu-Natal and Western Cape demonstrated that patients spent about 2 hours and 30 minutes in health facilities. Shorter times can contribute to the reduction of overcrowding in facilities, which is important to prevent the spread of respiratory infections such as Tuberculosis and Covid-19.[29]

Employee costs

The longer recording time plus the requirement of data capturers to enter the data onto DHIS, results in a higher employee cost component for the paper-based register compared to the E-tick register. This is quite significant as the employee cost is the largest expenditure item on the South African national government budget accounting for 42% of the expenditure in the year 2018/19. Furthermore, when the government employee cost was analysed over 14 years from 2004/05 to 2018/19, it was reported to have increased at an average yearly rate of 10.5%, which was about twice the average yearly consumer price index of 5.8%, during the same period.[30] Therefore, if the healthcare workers spend less time recording on tick registers, the employee cost component for this administrative work is less. This allows more time and a higher component of their salary to go into clinical work, which would be more cost-effective for the government.

Difference in fixed and variable costs and effects of head count on costs

Furthermore, there were no fixed costs for the paper-based system, hence its costs were more sensitive to an increasing patient headcount, while the E-tick system involved several fixed costs which were not dependent on the headcount. This was evidenced by the operating cost for August 2018 (with the highest monthly headcount) which increased by 17.6% from the monthly average of R791 194, while the E-tick register's operating costs only increased by 15.8% from the monthly average of R543 047 (see in Figure 1). With the paper-based register costs being directly proportional to the patient headcount, the costs of this system would continue to rise as the population increases and facility headcounts increase.

The provincial population increases at a much higher rate than the number of health professionals, as the number of Registered Nurses per 100 000 uninsured population only increased from 109.5 in 2008/9 to 124.1 in 2019/20, which is just a 13% increase in 11 years. And the number of doctors per 100 000 uninsured population increased from 27.6 in 2008/9 to 33.9 in 2019/20, which is 23% over the same period. However, the provincial population increased by 45% over the same period. This means having a recording system that is directly proportional to the patient headcount would not be financially sustainable in the long term as the population has increased at a rate that is 3.5 times higher than the increase in the number of nurses.[31,32]

This is further illustrated by the line graph in Figure 2. where, initially, the paper-based register had lower costs than the E-tick register. The two graphs intersect where the monthly headcount reaches 4 345, from this point, the costs of the paper-based register are higher than the E-tick, with the difference increasing up to R 292 268 when the headcount is highest at 22 089 per month. Therefore, the difference between the costs of the two systems changes significantly as the headcount increases, this is consistent with other studies, such as the 2009 Slovenian study using a simulated modelling technique to cost data collection systems, and the 2005 American study that compared the two data collection systems by reviewing reports of Alzheimer's patients and the 2009 Canadian study on Influenza immunization data collection systems.[8–10] If the monthly headcount was more than 4 345 then the E-tick register would be the less costly option, while the paper-based system becomes more expensive above this cut-off. This means that the average monthly headcount per facility should be considered when prioritising the implementation of the E-tick register. The average monthly headcount for the three facilities studied was 6 209, which is above the cut-off of 4 345, meaning that for these facilities, it would be less costly and more efficient to use the E-tick register system. Further, information from the district management (Appendix 3) showed that the average headcount per PHC facility in the Ekurhuleni Health District was higher than 4 345 indicating that using the E-tick register would be less costly for the district if all the clinics the entire district were using the E-tick system.

E-tick costs considering government prices

An important issue to note is that the fixed costs for the E-tick system during the study period were incurred by a non-government organisation (NGO), therefore the prices may be different if the Department of Health takes over the project as government procurement processes may involve higher prices for the fixed costs. Since the monthly average headcount per clinic is 6 209, this then becomes the maximum cut-off for the E-tick system to remain cheaper. For the graph lines to intersect at this point, the fixed cost would need to be R101 207, which is 43% more than the current fixed costs for 2018/19, this would change the equation of the graph, as shown in Figure 4 below for the E-tick system monthly average costs to y=26.1X + 101 207. If the graph lines intersect at 6 209, the E-tick system costs would be lower above this cut-off, meaning that it would remain viable even if the government prices resulted in the fixed cost increasing by 43%.

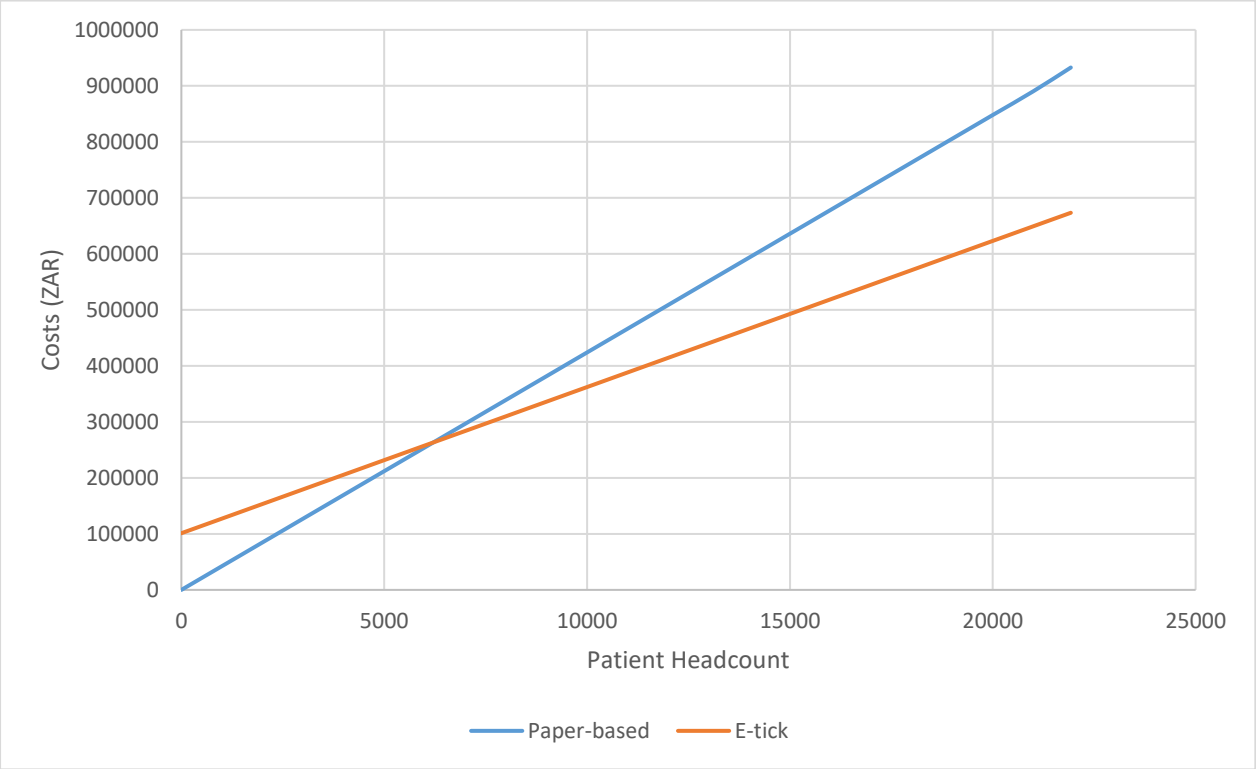

Figure 4. Average Monthly costs of the Paper-based register vs E-tick register according to headcount if fully funded by government

Independence from electricity supply

A big advantage of the paper-based register system was that it was not affected by electricity challenges, while the E-tick system was greatly affected by this issue. This poses a great challenge for the implementation of the E-tick system as South Africa faces an electricity shortage crisis characterised by planned power cuts for a particular period in a day, termed as load-shedding. This is expected to be a problem for at least the next four years, as a medium-term adequacy report from the country's electricity producer (Eskom) indicated that the availability of electricity is projected to range between 58% and 67% by the end of 2027.[33] This implies that implementation of the E-tick register should be accompanied by other measures to ensure uninterrupted power supply to all health facilities.

Safe storage of information

Another disadvantage of the E-tick system was the theft of devices, as crime is a major challenge in the country, with about 1.5 million cases of property crimes reported by the community from 2017/18 to 2019/20 according to the South African Police Services' (SAPS) crime statistics report of 2022.[34] This implies that additional security measures may need to be implemented together with scale up of the E-tick register system.

Another major disadvantage of the paper-based system is the challenge of records getting lost, this has legal consequences as the Department of Health is mandated to keep records and patient information safe in accordance with the National Archives and Records Service of South Africa Act, 1996 (Act 43 of 1996) and Protection of Personal Information Act, 2013 (Act 4 of 2013).[35,36] Furthermore, the records should be available in line with the Promotion of Access to Information Act, 2000 (Act 2 of 2000), and the inability to produce records is the worst form of noncompliance with the Public Audit Act (Act no. 25 of 2004)[37,38]. As a result, the NDOH has adopted the National Guideline for Filing, Archiving & Disposal of Patient Records in Primary Health Care Facilities, which requires all patient records to be kept in archives for a minimum of six years, which increases to 21 years for obstetrics and child care records and for a lifetime for mental healthcare records.[39]

Therefore, the E-tick register's ability to keep records safe not only positively influences the continuity of patient care but also addresses legal requirements. However, electronic records may pose other safety challenges, as a 2021 study in a

South African hospital demonstrated that the hospital's electronic information was vulnerable to computer viruses, old computers, and software systems. The study recommended the implementation of password protection, encryption, antivirus software and security audits, as security measures to ensure the safety of electronic information. This means that the E-tick register system may require additional costs to protect against potential cyber security challenges.[40]

Fewer errors

Health information reported by the department of health is audited annually by the AGSA, as a way to ensure the validity of items which the government budget is spent on, in accordance with the Public Audit act (Act no. 25 of 2004).[38] As multiple audits have found major problems with the reliability of the paper-based system used by the DOH, a recording system with less errors, such as the E-tick register, can help the department improve compliance with this act.

Ability to add more elements

According to the DHIMS, the indicators used to measure performance for health services in the department of health, should be revised every two years. This process is led by the NDOH to ensure that the national indicator set (NIDS), contains data elements that are always aligned to national strategic goals and objectives for healthcare. Therefore, a change in indicators means that more financial investment maybe required to develop new paper-based tick registers, rendering previous copies as useless. However, this problem can be minimised by the using an electronic register, such as the E-tick, which allows new elements to be easily added on to the system. [4]

Illegible handwritings

Furthermore, multiple studies on medication errors have found that illegible handwritings can also cause these errors and result in adverse events. Therefore, an electronic system such as the E-tick, can help to improve patient safety through preventing medication errors. [41–43]

Important contextual issues to consider

This study took place during a period when the South African government was planning to implement the National Health Insurance (NHI), which is a funding mechanism aimed at ensuring that all people in the country receive the required healthcare services based on their needs, instead of socio-economic status. [44] This system requires demographic and clinical information of patients for a service provider to be paid, hence, the NDOH implemented the Health Patient Registration System (HPRS). This is an electronic system for capturing demographic data of patients in health facilities, however, this system is not able to record clinical information as indicated in NDOH's National Digital Strategy For South Africa 2019-2024.[45] This further exacerbates the need for transitioning into a more reliable health information system, such as the E-tick register system developed in and by the Ekurhuleni Health District as a local digital innovation.

The NDOH's National Digital Strategy for South Africa 2019-2024 noted that a major obstacle against the implementation of digital health solutions has been poor value for money.[45] This is supported by a 2010 systematic review on the barriers to the acceptability of electronic medical records (EMRs) which found the following barriers: high costs and uncertainty over return on investment, lack of computer skills and lack of belief that EMRs would improve patient care.[46] However, our study has provided important evidence that an electronic recording system can be a less costly option even if government procurement prices are taken into consideration. Furthermore, the E-tick register system was preferred by the majority of the study participants, which means that the lack of support would not be barriers to implementation in the district where this study was conducted. There was a minority of staff members who still preferred the paper-based register due to stated technological challenges; these would require more training to develop sufficient competence with using the E-tick register system.

5. Limitations

The time taken to record data on the registers was not observed but was obtained through questionnaires, this has a potential for recall bias; hence the recording time is asked using multiple questions. Furthermore, the E-tick register system had less writing space than the files used in the paper-based register system, this can affect

the recording time for both systems. Recording time did not include time spent by patient administration clerks to register patients and to retrieve files, as they already use an electronic system to register patient information, which would make it difficult to separate registration time between the two systems. Time to retrieve files may also affect the benefits of the paper-based system, however, this would not affect the E-tick system nor its advantages which were documented in this study.

The increased load-shedding during the period of data collection can cause a negative perception towards the E-tick register, however, participants still preferred the E-tick register despite this challenge.[33]

The South African Rand (ZAR) was used to indicate all costs in the study; however, different years were separated such that the costs could be converted to the USD value according to the exchange rate of the relevant year. This will make the results more generalizable to other countries.
The study only looked at the costs, advantages, and disadvantages from the provider's perspective and not from a patient perspective and further research may be required to look at the patient perspective.

The Department of Health receives a budget on an annual basis according to the Division of Revenue Act (no. 3 of 2017), the budget is allocated and spent during a particular financial year and monitored monthly.[47] As the number of patients fluctuates from month to month, it is important to analyse and compare expenditures throughout a completed financial year, however, only one financial year was complete during the pilot period, therefore cost data for the one complete financial year of 2018-19 was used use to compare the two registers.

6. Ethical considerations

Ethics clearance from the University of Witwatersrand Human Research Ethics Committee was received before the beginning of the study. Approval was also requested from the Department of Health through the Ekurhuleni Health District Research committee for permission to perform the study in the district and to request the information that is required for the study. Consent was obtained from all

participants that were involved in the study. The participants received an information sheet and were informed that the study is voluntary and that they have a right to withdraw consent at any part of the study. No personal identifiers were obtained from the participants on the questionnaire, to protect their identity.

7. Conclusion

This study has provided evidence that the E-tick register was more favourable than the paper-based register as it was 4.5 minutes (34%) quicker, R12.5 (29.5%) cheaper, and preferred by 82% of staff members. Of ten study theme areas, the E-tick was reported as advantageous in eight, these were: Convenience, easy accesses, quick recording time, safe information storage, immediate data capturing, ability to add more elements, fewer errors and good font size and legibility. The paper-based register was found to be advantageous in just four study themes which were: Convenience, easy accesses independence from electricity supply and sufficient writing space. Furthermore, the study provided evidence against the common barriers that usually hinder the implementation of digital health solutions such as financial concerns and lack of acceptability. Therefore, these barriers should not hinder the implementation of the E-tick register system in the Ekurhuleni District. The implementation of the E-tick register across other district clinics, would not only improve recording times but can also assist the Department of Health to improve compliance with legislation that governs record management in the public sector.

8. Recommendations

Based on the findings from this study, we recommend the following at different government levels:

- The NDOH to adopt an electronic tick register recording system, such as the E-tick register, with accompanying cyber security systems. Implementing the programme at a national level will spread some of the fixed costs across many facilities, making it cheaper per patient. The average monthly headcount per facility should be considered when prioritising the implementation of the system.

- The Provincial DOH should budget for local technological innovations such as the E-tick register for scale-up across all five districts in the Gauteng province.
- The Provincial DOH should invest in alternative electricity sources such as solar power and electricity generators to ensure that electronic systems can function without interrupted electricity supply.
- Another important issue at the provincial and district level is enhanced physical security at facilities to prevent theft of equipment.
- The District Health Management in Ekurhuleni to organise training on the use of electronic recording systems, with a greater focus on technologically challenged staff members.
- End-users should indicate whether they have technological challenges to receive enhanced training.

9. References

1. World Health Organization. Monitoring the building blocks of health systems: a handbook of indicators and their measurement strategies [Internet]. Geneva: World Health Organization; 2010 [cited 2023 May 5]. Available from: https://apps.who.int/iris/handle/10665/258734

2. South African Government. National Health Act 61 of 2003 | South African Government [Internet]. [cited 2022 Jan 10]. Available from: https://www.gov.za/documents/national-health-act

3. National Department of Health. Delivery agreement for outcome 2: A long and healthy life for all South Africans. 2010.

4. National Department of Health. District Health Management Information System (DHMIS) Policy | Department of Health Knowledge Hub [Internet]. [cited 2022 Jan 10]. Available from: https://www.knowledgehub.org.za/elibrary/district-health-management-information-system-dhmis-policy

5. Auditor General of South Africa. Financial Management Report: Gauteng Department of Health 2020. Unpublished; 2020.

6. Khan A, Zaman S. Costs of vaginal delivery and Caesarean section at a tertiary level public hospital in Islamabad, Pakistan. BMC Pregnancy Childbirth. 2010 Dec;10(1):2.

7. Ekurhuleni Health District. Ekurhuleni District Health Plan 2021/22. Unpublished; 2021.

8. Pavlović I, Kern T, Miklavčič D. Comparison of paper-based and electronic data collection process in clinical trials: Costs simulation study. Contemporary Clinical Trials. 2009 Jul 1;30(4):300–16.

9. Weber BA, Yarandi H, Rowe MA, Weber JP. A comparison study: paper-based versus web-based data collection and management. Applied Nursing Research. 2005 Aug 1;18(3):182–5.

10. Pereira JA, Foisy J, Kwong JC, Heidebrecht CL, Quach S, Quan SD, et al. A cost comparison of electronic and hybrid data collection systems in Ontario during pandemic and seasonal influenza vaccination campaigns. BMC Health Services Research. 2011 Sep 1;11(1):210.

11. The Aurum Institute. Who we are [Internet]. The Aurum Institute. [cited 2022 May 3]. Available from: https://www.auruminstitute.org/about-us/profile/who-we-are

12. Lorkowski J, Pokorski M. Medical records: A historical narrative. Biomedicines. 2022 Oct;10(10):2594.

13. Njuguna HN, Caselton DL, Arunga GO, Emukule GO, Kinyanjui DK, Kalani RM, et al. A comparison of smartphones to paper-based questionnaires for routine

influenza sentinel surveillance, Kenya, 2011-2012. BMC Med Inform Decis Mak. 2014 Dec 24;14:107.

14. Mukasa O, Mushi HP, Maire N, Ross A, de Savigny D. Do surveys with paper and electronic devices differ in quality and cost? Experience from the Rufiji Health and demographic surveillance system in Tanzania. Global Health Action. 2017 Jan 1;10(1):1387984.

15. Dillon DG, Pirie F, Rice S, Pomilla C, Sandhu MS, Motala AA, et al. Open-source electronic data capture system offered increased accuracy and cost-effectiveness compared with paper methods in Africa. Journal of Clinical Epidemiology. 2014 Dec 1;67(12):1358–63.

16. Walther B, Hossin S, Townend J, Abernethy N, Parker D, Jeffries D. Comparison of Electronic Data Capture (EDC) with the Standard Data Capture Method for Clinical Trial Data. PLOS ONE. 2011 Sep 23;6(9):e25348.

17. Allorto NL, Clarke DL, Thomson SR. A cost model case comparison of current versus modern management of burns at a regional hospital in South Africa. Burns. 2011 Sep 1;37(6):1033–7.

18. Thomas LS, Manning A, Holmes CB, Naidoo S, van der Linde F, Gray GE, et al. Comparative Costs of Inpatient Care for HIV-Infected and Uninfected Children and Adults in Soweto, South Africa. JAIDS Journal of Acquired Immune Deficiency Syndromes. 2007 Dec 1;46(4):410.

19. Neupane S, Odendaal W, Friedman I, Jassat W, Schneider H, Doherty T. Comparing a paper based monitoring and evaluation system to a mHealth system to support the national community health worker programme, South Africa: an evaluation. BMC Med Inform Decis Mak. 2014 Dec;14(1):69.

20. Clarke M, Schoeman H, Friedman I. Towards a generic surveillance system to measure the impact of Community Health Worker programmes in South Africa: Comparison of paper-based and mobile/cell phone methods. HST. 2007;136.

21. Baloyi RE, Shandukani MB, Graffy R, Misiani E, Mayet N, Mabunda E, et al. Evaluating a 24-h mobile reporting system for malaria notifications in comparison with a paper-based system in South Africa, 2015. Malar J. 2018 Aug 23;17(1):308.

22. HP Online Store. What is the average lifespan of a computer? [Internet]. 2022 [cited 2023 Jul 26]. Available from: https://www.hp.com/in-en/shop/tech-takes/post/average-computer-lifespan

23. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006 Jan 1;3(2):77–101.

24. Health Systems Trust. District Health Barometer 2019-20 [Internet]. Health Systems Trusts; 2020 [cited 2023 Apr 25]. Available from: https://www.hst.org.za/publications/District%20Health%20Barometers/DHB%202019-20%20Complete%20Book.pdf

25. South African Nursing Council. Competencies for primary care nurse specialist. South African Nursing Council; 2014.

26. Distinguishing Devices – SANC [Internet]. [cited 2023 May 9]. Available from: https://www.sanc.co.za/distinguishing-devices/

27. South African Government. South African Nursing Act (no. 33 of 2005) [Internet]. 2005 [cited 2023 Jul 26]. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/a33-050.pdf

28. Igumbor J, Davids A, Nieuwoudt C, Lee J, Roomaney R. Assessment of activities performed by clinical nurse practitioners and implications for staffing and patient care at primary health care level in South Africa. Curationis. 2016 Mar 11;39(1):1479.

29. Karat AS, McCreesh N, Baisley K, Govender I, Kallon II, Kielmann K, et al. Waiting times, patient flow, and occupancy density in South African primary health care clinics: implications for infection prevention and control [Internet]. medRxiv; 2021 [cited 2023 Apr 8]. p. 2021.07.21.21260806. Available from: https://www.medrxiv.org/content/10.1101/2021.07.21.21260806v1

30. Statistics South Africa. What does government spend money on? | Statistics South Africa [Internet]. 2020 [cited 2023 Apr 7]. Available from: https://www.statssa.gov.za/?p=13805

31. Statistics South Africa. Mid-year population estimates 2008 [Internet]. Statistics South Africa; 2008 [cited 2023 May 8]. Available from: http://www.statssa.gov.za/publications/P0302/P03022008.pdf

32. Statistic South Africa. Mid-year population estimates 2019 [Internet]. Statistics South Africa; 2019 [cited 2023 May 8]. Available from: https://www.statssa.gov.za/publications/P0302/P03022019.pdf

33. Mdhluli S. Medium-Term System Adequacy Outlook [Internet]. Eskom; 2022. Available from: https://www.eskom.co.za/wp-content/uploads/2022/10/Medium-Term-System-Adequacy-Outlook-2023-2027.pdf

34. South African Police Services. Annual crime statistics 2021/22 [Internet]. 2022 [cited 2023 Apr 8]. Available from: https://www.saps.gov.za/services/crimestats.php

35. South African Government. National Archives and Records Service of South Africa Act, 1996 (Act 43 of 1996) [Internet]. Republic of South Africa; 1996 [cited 2023 Apr 8]. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/act43of1996.pdf

36. South African Government. Protection of Personal Information Act (No. 4 of 2013). Republic of South Africa; 2013.

37. South African Government. Promotion of Access to Information Act (No. 2 of 2000) [Internet]. Republic of South Africa; 2000 [cited 2023 Apr 8]. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/a2-000.pdf

38. South African Government. Public Audit Act, 2004 (No. 25 of 2004) [Internet]. Republic of South Africa; 2004 [cited 2023 Apr 8]. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/a25-04.pdf

39. Matsotso MP. National Guideline for Filing Archiving and Disposal of Patient Records in PHC Web design.pdf [Internet]. National Department of Health; 2017 [cited 2023 Apr 8]. Available from: https://knowledgehub.health.gov.za/system/files/elibdownloads/2020-07/National%20Guideline%20for%20Filing%20Archiving%20and%20Disposal%20of%20Patient%20Records%20in%20PHC%20Web%20design.pdf

40. Chuma KG, Ngoepe M. Security of electronic personal health information in a public hospital in South Africa. Information Security Journal: A Global Perspective. 2022 Mar 4;31(2):179–95.

41. Ebrahimpour F, Shahrokhi A, Ghodousi A. Patients' safety and nurses' medication administration errors. Iranian Journal of Forensic Medicine. 2014 Apr 10;20(4):401–8.

42. A B, Ml K. Handwriting errors: harmful, wasteful and preventable. The Journal of the Kentucky Medical Association [Internet]. 2001 May [cited 2023 Jul 25];99(5). Available from: https://pubmed.ncbi.nlm.nih.gov/11391897/

43. Edwards M, Moczygemba J. Reducing medical errors through better documentation. Health Care Manag (Frederick). 2004;23(4):329–33.

44. National Department of Health. National Health Insurance Bill 2019 [Internet]. 2019 [cited 2023 Apr 25]. Available from: https://www.health.gov.za/wp-content/uploads/2020/11/bill-national-health-insurance-2019_compressed.pdf

45. National Department of Health. National Digital Strategy For South Africa 2019-2024 [Internet]. 2019 [cited 2023 Apr 25]. Available from: https://www.health.gov.za/wp-content/uploads/2020/11/national-digital-strategy-for-south-africa-2019-2024-b.pdf

46. Boonstra A, Broekhuis M. Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions. BMC Health Services Research. 2010 Aug 6;10(1):231.

47. South African Government. Division of Revenue Act no. 3 of 2017 [Internet]. South African Government; 2017 [cited 2023 May 9]. Available from: https://www.gov.za/sites/default/files/gcis_document/201705/40871gon475divisionofrevenueact3of2017.pdf

10. Appendices:

Appendix 1: 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 Courage Macduff Khoza (Student number: 0702936y) am a student registered for the degree of Masters of Medicine in the academic year 4th.

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: 12/05/2023

Appendix 2: Prices

Table A. calculated stationery cost per financial year (All costs in ZAR)

Item	2017/18	2018/19	2019/20
Headcount	92941	223512	168932
No. of Tick registers	15.5	37.3	28.2
Tick registers cost	2308	4125.3	6382.8
No. Of Headcount register	19.4	46.6	35.2
Headcount register cost	1465	3254.9	2561.1
No. of files	9294	22351.2	16893.2
Files costs	38756	110862	83790
Total Stationery cost	42529	118242	92734

Table B27. Stationery Unit Prices according to financial years

Item	2017/18 price	2018/19 Price	2019/20 Price
Tick register	148.99	110.74	226.7
Headcount register	75.66	69.9	72.7659
File	4.17	4.96	4.96

Table C. E-tick Initiation costs prices

Item	Facility A	Facility C	Facility B	Total
Computers and accessories	100 933,30	59 408,91	157 018,90	317 361,11
Tablets and accessories	42 809,66	24 893,66	186 137,70	253 841,02
Printer	7118,5	7118,5	7118,5	21 355,50
network points	18450,9	20200,8	29489	68 140,70

ICT installation	4104	4104	29489,52	37 697,52
Sub-Total	173 416,36	115 725,87	409 253,62	698 395,85
Additional software development (All clinics) Phase 1				81 654,35
Additional software development (All clinics) Phase 2				45 458,41
Total				825 508,61

Appendix 3: Ekurhuleni Head District Patient Headcount

Month	2017/18	2018/19	2019/20
April		441563	442323
May		475593	488958
June		435373	429103
July		464233	485102
August		489344	459007
September		443908	430735
October		484126	496336
November	472630	448795	453882
December	335682	310983	320792
January	449481	457476	
February	439209	434012	
March	451393	430323	
District Average	429679	442977	445138
Average per Facility	**4 620**	**4 763**	**4 786**

Appendix 4 A: Questionnaire: Nurses

Date: ___/___/_____

Participant number_____

1. What was your employment category during the period of the E-tick register pilot? _____
2. Which Clinic do you work in? _____
3. Are you a shift worker? Yes___ No___
4. please indicate the type of work schedule per week
   8 hours X 5 days __ 12 hours X 7 days 12 hours X 4 days Other _____
5. Did you record data on any of the following registers?
   Paper-based tick register Yes:__ No: __, E-tick Register Yes___ No___
6. Did you receive training on any of the above registers?
   Paper-based tick register: Yes:__ No: __,
   E-tick Register Yes___ No___
7. On overage, how much of your total working time is spent on recording data per day?
   Paper-based tick register:____ minutes, E-tick Register____ minutes
8. On average how long did it take you to record data on the register for a single patient for a short visit? (patient with = <3 fields)
   Paper-based tick register:____ minutes, E-tick Register____ minutes
9. On average how long did it take you to record data for a single patient for a long visit? (patient with = <3 fields)
   Paper-based tick register:____ minutes, E-tick Register____ minutes
10. On average what proportion of the recording time is spent on short visit patients seen per month? ____ %
11. On average what proportion of the recording time is spent on long visit patients seen per month? ____ %
    NB: answers to 10. And 11 must add up to 100%

12. According to your experience, what are the Advantages of the Paper-based system?
    _____
    _____
    _____
    _____
    _____
    _____
13. According to your experience, what are the Disadvantages of the Paper-based system?
    _____
    _____

_____
_____

14. According to your experience, what are the Advantages of the E-tick system?
_____
_____
_____
_____
_____

15. According to your experience, what are the Disadvantages of the E-tick system?
_____
_____
_____
_____
_____

16. Please mention any recommendations or anything that you think should be changed with regards to the Paper-based register.
_____
_____
_____
_____

17. Please mention any recommendations or anything that you think should be changed with regards to the E-tick register.
_____
_____
_____
_____

18. Between the two registers, which one would you recommend?
Paper-based tick register __, E-tick Register ___

Appendix 4 B: Questionnaire: Data Capturer

Date: ___/___/_____

Participant number_____

1. What was your employment category during the period of the E-tick register pilot ? _____
2. Which Clinic do you work in?_____
3. please indicate the type of work schedule per week
   8 hours X 5 days __ 12 hours X 7 days 12 hours X 4 days Other _____
4. Did you capture data from any of the following registers?
   Paper-based tick register Yes:__ No: __, E-tick Register Yes___ No___
5. Did you receive training on any of the above registers?
   Paper-based tick register: Yes:__ No: __,
   E-tick Register Yes___ No___
6. On overage, how much of your total working time is spent on capturing data the following registers per day?
   Paper-based tick register:____ minutes, E-tick Register____ minutes
7. On average how long did it take you to capture data on the register for a single patient for a short visit per day? (patient with = <3 fields)
   Paper-based tick register:____ minutes, E-tick Register____ minutes
8. On average how long did it take you to capture data for a single patient for a long visit? (patient with = <3 fields)
   Paper-based tick register:____ minutes, E-tick Register____ minutes
9. On average how would you allocate the proportion in terms of long vs short visit patients captured per month?
   9.1. ____ % Short visit, 7.2.____% long visit (i.e. 7.1. +7.2. = 100%
10. On average, how many days (from date of recording on the register to date of capturing) does it take to capture data from the paper-based register? ___ days
11. On overage, how much of your total working time is spent on verifying data the following registers per day?
    Paper-based tick register:____ minutes, E-tick Register____ minutes
12. On average how long did it take you to verify data on the register for a single patient for a short visit per day? (patient with = <3 fields)
    Paper-based tick register:____ minutes, E-tick Register____ minutes
13. On average how long did it take you to verify data for a single patient for a long visit? (patient with = <3 fields)
    Paper-based tick register:____ minutes, E-tick Register____ minutes

14. According to your experience, what are the Advantages of the Paper-based system?
    _____
    _____
    _____

_____
_____
_____

15. According to your experience, what are the Disadvantages of the Paper-based system?

_____
_____
_____
_____

16. According to your experience, what are the Advantages of the E-tick system?

_____
_____
_____
_____
_____

17. According to your experience, what are the Disadvantages of the E-tick system?

_____
_____
_____
_____
_____

18. Please mention any recommendations or anything that you think should be changed with regards to the two registers.

_____
_____
_____
_____

19. Between the two registers, which one would you recommend?
Paper-based tick register __, E-tick Register ___

Appendix 5: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Dr CM Khoza

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M220802

NAME: (Principal Investigator)	Dr CM Khoza
DEPARTMENT:	School of Public Health Department of Community Health Medical School University
PROJECT TITLE:	*A cost comparison study of the electronic tick register with a paper-based tick register in clinics within the Ekurhuleni District*
DATE CONSIDERED:	2022/08/26
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Dr LS Thomas
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/09/28

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

DECLARATION OF INVESTIGATORS

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

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

Signature of Principal Investigator

29/09/2022
Date

Appendix 6: Signed Turn-it-in report

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Word count:	16,926
Character count:	94,204
Submission date:	12-May-2023 02:00AM (UTC+0200)
Submission ID:	2090836975


UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

A Cost Comparison study of the electronic tick register with a paper-based tick register in clinics within the Ekurhuleni District.

I, Leena S. Thomas, hereby confirm that I have checked and approved the originality report for this MMED research report submission (report is on the next page).

Leena Thomas

Leena S. Thomas

12/05/2023

Date

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