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THE IMPACT OF THE COVID-19 PANDEMIC ON ESSENTIAL PUBLIC HEALTHCARE SERVICES IN GAUTENG PROVINCE, SOUTH AFRICA.

BY

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DECLARATION

I, Cyril Bernsah Fonka, declare that this research is my original work. It has not been submitted for any award at any university. No organisation or institution influenced this study.

Signature:_____

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13th June 2023

DEDICATION

I dedicate this study to my parents Mr Denis Fonka and Mrs Shulika Silveria Fonka.

ABSTRACT

Background: The Covid-19 pandemic like previous outbreaks has the potential to adversely impact essential healthcare services. Even though the Gauteng province was considered the epicentre of the Covid-19 outbreak in South Africa, there is no comprehensive assessment of the effect of Covid-19 on the service utilisation, delivery and health outcomes of routine healthcare services in Gauteng province.

A**im:** To assess the impact of the Covid-19 pandemic on the utilisation, delivery and health outcomes of essential maternal, neonatal and child health (MNCH) services in Gauteng province, South Africa.

Methods: This was a mixed methods study. A longitudinal study design was used to analyse data from the District Health Information Software (DHIS). We compared key MNCH indicators in the pre-Covid-19 period (March 2019-February 2020) to corresponding periods during the Covid-19 outbreak (March 2020-February 2021). The differences were analysed using time plots, linear regression, and Interrupted Time Series Analysis (ITSA) in Stata 17.0, at a 5% level of alpha for statistical significance. In-depth interviews were conducted with senior managers in the Gauteng Department of Health (GDoH) using MS Teams, to explore their perspectives on the impact of Covid-19 on routine healthcare services in the province and their recommendations for dealing with future pandemics. The interviews were recorded, transcribed, coded and analysed thematically using MS word 2016.

Results: The Covid-19 pandemic disrupted the utilisation of essential MNCH services in the Gauteng province. The disruption was observed in the time trend plots, and then quantified by comparing the indicator means for the 12-month periods before and during Covid-19. The impact was a statistically significant decline in the mean of three indicators: PHC headcount <5 years declined by 77 103.9 visits ($p<0.001$), ANC 1st visits before 20 weeks decreased by 3.0% ($p=0.002$) and PNC visits within 6 days decreased by 10.2% ($p<0.001$) (Table 2). The ITS regression provided a more nuanced analysis. The decrease in PHC headcount <5 years and PNC visits within 6 days were due to the immediate effect of the March 2020 Covid-19 lockdown which led to a drop in utilisation services. However, the effect on ANC 1st visits before 20 weeks was a continuous decline in utilisation throughout the Covid-19 period (Table 4). Service delivery and outcome indicators were negatively affected though not significantly. There were no significant recoveries and some indicators rather became worse post-lockdown.

The nature of the adverse impact of Covid-19 on MNCH indicators was similar across all five districts, although the degree of disruption varied among the districts and services. The decline in service utilisation for PHC headcount <5 years, ANC 1st visits before 20 weeks and PNC visits within 6 days was statistically significant in all districts, except for ANC 1st visits in Johannesburg (Table 4). The decline in PHC headcount <5 years was significantly larger in the three metropolitan districts (Johannesburg, Ekurhuleni and Tshwane) compared to the two non-metropolitan districts (Sedibeng

and West Rand) (Table 5). ANC 1st visits before 20 weeks significantly declined in the Ekurhuleni, Sedibeng and West Rand districts compared to Johannesburg. While the decrease in PNC visits within 6 days significantly deteriorated in Johannesburg compared to the other four districts (Figure 4). Pneumonia fatality <5 years significantly declined in the pooled analysis, in the Tshwane district alone.

The majority of the respondents agreed that the Covid-19 pandemic disrupted essential healthcare services but a few disagreed. Several reasons were advanced for the disruption. On the supply side, they included: (i) the reallocation of resources to fighting Covid-19; (ii) healthcare worker shortages due to Covid-19 illness; (iii) healthcare facilities turning away non-Covid-19 patients; and (iv) Covid-19 screening that increased waiting times. On the demand side are; (i) restrictions on movement and limited public transport during the lockdown; (ii) fears of being infected by Covid-19 at health facilities; and (iii) misinterpretation of health information about the availability of non-Covid services. According to the respondents, the disruption of essential healthcare services had significant consequences, particularly for chronic patients, including treatment interruption, loss of follow-up, and death. The 'catch-up' plan and technology were used to improve service delivery during Covid-19.

Conclusion: The Covid-19 pandemic disrupted the utilisation of essential healthcare services for MNCH. Although service delivery and health outcomes were less impacted, some outcome indicators at district levels went worst. While there were recovery attempts for service delivery like immunisation, some services rather deteriorated post-Covid-19 lockdown. However, there were mixed findings, fewer routine services were not affected by Covid-19. It is important to continuously assess and redress the unintended impacts of outbreaks even while they are occurring. This requires an understanding of the reasons and mechanisms of service disruption from demand and supply perspectives. Critical policies like lockdowns should be a collective decision, implemented without undermining routine services. High-level policymakers must consider addressing geographical variations of an outbreak's impact on essential healthcare services. Covid-19 may have more complex long-term effects, especially for individuals with adverse social determinants. And it may take longer for some healthcare services to fully recover hence, the need for health systems interventions to prioritise the affected services.

Keywords: Covid-19, essential healthcare services, lockdown, utilisation, pandemic, disrupted.

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ABBREVIATIONS AND ACRONYMS

AIDS - Acquired Immunodeficiency Syndrome

ANC - Antenatal care

COVID-19 – Coronavirus disease 2019.

DHIS - District health information software

GDoH - Gauteng department of health

HIV - Human Immunodeficiency Virus

HREC - Wits Human Research Ethics Committee

ITSA - Interrupted time series analysis

MNCH – Maternal and newborn and child health

NDoH - National department of health

NICD - National institute for communicable diseases

PNC – Postnatal care

PPE - Personal protective equipment

TB – Tuberculosis

WHO - World Health Organization

Wits – University of the Witwatersrand-Johannesburg

CHAPTER 1: INTRODUCTION

1.1 Background

The Covid-19 pandemic is one of the most significant healthcare challenges of the 21st century, that has exposed the unpreparedness of health systems in high, middle, and low-income countries to adequately prevent, detect and manage a pandemic (1,2). Covid-19 is a highly contagious severe viral respiratory infectious disease that has contributed to a significant increase in global mortality (3,4). South Africa is one of many countries that implemented multiple mitigation responses, including lockdowns, to limit the spread of the infection. However, these measures also disrupted the access to and delivery of routine healthcare services (1,2).

According to the National Institute for Communicable Diseases (NICD) (5), the first Covid-19 case in South Africa was reported on 5th March 2020. By 27 March 2020, the South African government like many other countries, declared a nationwide lockdown under Section 3 of the Disaster Management Act of 57 of 2000 (6). The lockdown was intended to limit infections, minimise the severity of cases, reduce the number of patients requiring hospitalisation and assist the country to prepare and respond effectively to the Covid-19 pandemic. Lockdowns though necessary, also affected the utilisation of routine healthcare services, producing poorer health outcomes in non-Covid-19 patients that could not access healthcare facilities for treatments (7). For example, the World Health Organization (WHO) highlighted that due to Covid-19, 24 counties postponed measles immunisation which could make 117 million children more susceptible to measles (8).

Inadequate human resources in the national health system were partly responsible for the disruption in the supply of routine healthcare services during Covid-19 (10–12). For example, health workers in South Africa suspended household visits for HIV and TB patients' follow-ups, and the healthcare workers were redirected to fight Covid-19. Even though these clients were classified as high-risk patients of contracting Covid-19 and needed essential healthcare. The suspension further stigmatised HIV and TB patients and limited the demand for essential healthcare services needed (12).

Gauteng is a highly urbanised and the most populated province in South Africa with a population of over 16 million people (13). And has had the highest number of Covid-19 infections in South Africa but the third-highest incidence rate (14). This study investigated the impact of the Covid-19 pandemic on essential public maternal, neonatal and child health (MNCH) services in the Gauteng province by comparing routine health service indicators before and during the Covid-19 outbreak. And explored the perspectives of senior managers at the Gauteng department of health (GDoH) about the impact of the Covid-19 pandemic on essential public healthcare services in Gauteng province. It is expected that the evidence will inform health policymakers, stakeholders and institutions on services to be supported and the strategies to maintain essential healthcare services in future Covid-19 waves and other outbreaks.

1.2 Literature Review

In this section, we will review the available literature on the impact of Covid-19 on essential public healthcare services from other settings, and present South African data on the impact of Covid-19 on services for MNCH, HIV/AIDS and TB. We also summarise research on the challenges experienced by patients in accessing essential public healthcare services during the Covid-19 pandemic.

1.2.1 Essential service disruptions due to Covid-19 in other settings.

Covid-19 has disrupted the provision of essential health services and generated additional demand for personal protective equipment (PPE), medical consumables and hospital intensive care. The fear of being infected by Covid-19 caused a high demand for PPE for frontline workers worldwide, and this has been shown in some studies to be responsible for disruptions in service delivery. For example, obstetricians in Haiti refrained from work due to shortages in PPE (15) and this led to patients' needs not being met. In the USA cardiac surgery declined due to service disruption to fight Covid-19 (9).

In sub-Saharan Africa, some Zimbabwean health facilities were unable to provide care during Covid-19 as health workers did not report on duty and went on strike whenever shortages in PPE arose (16). Likewise, significant declines in maternal health service utilization in Ethiopia, for antenatal care (ANC) visits, institutional delivery and postnatal care (PNC) were attributed to Covid-19 restrictions (17). In Liberia, the Covid-19 pandemic hindered the demand and supply of essential healthcare (18).

Contact tracing is one strategy to curb Covid-19 infection. But, this is an additional burden or cost to the health system because more staff and other resources are needed to perform Covid-19 contact tracing. There is evidence that part of the disruption in essential public healthcare services was due to a shift of resources to Covid-19 contact tracing (16).

A model developed by Roberton (19) estimated that reductions in healthcare access as a direct effect of the Covid-19 pandemic could result in a 9-45% increase in under-five mortality and an 8-39% increase in maternal mortality in low and middle-income countries. This corresponds with the WHO and UNAIDS 2020 model which suggested that the lack of effective interventions in sub-Saharan Africa during the Covid-19 outbreak could cause 500 000 AIDS-related deaths as a result of a six-month disruption in antiretroviral treatments (ARTs) (20).

1.2.2 Maternal and child health services in South Africa during Covid-19.

Several South African studies have investigated changes in essential healthcare services provision and access/utilization during the Covid-19 pandemic (7,21,22). Overall, in an observational cohort study that used an interrupted time series analysis in rural South Africa, clinic attendance and hospital admission dropped drastically when compared to the baseline monthly average before the Covid-19 outbreak (22). A retrospective review in Kwazulu-Natal (7) revealed that MNCH experienced low rates

of both service delivery and utilisation due to Covid-19 restrictions. The analysis indicated a 42% and 30% reduction in facility headcounts and immunization coverage respectively for children under 5 years, in April 2020 against the base year average from 2019-2020. Another South African study in Gauteng province that was descriptive and used administrative data from the District Health Information System (DHIS), showed a decrease of 30% in client visits for primary healthcare between March-April 2020, a 45% reduction in clients seeking contraceptives each month, and a 5% decline in abortion services (21). The observations in April 2020 when further compared to April 2019, the year before Covid-19, indicate a negative impact of Covid-19 on family planning uptake. Although these studies indicated that Covid-19 disrupted access to and service delivery of healthcare, they did not assess the consequent impact on maternal and child health outcomes.

1.2.3 HIV/AIDS and TB services in South Africa during Covid-19.

South Africa is the epicentre of the HIV/AIDS epidemic with the highest prevalence and incidence globally, hosting 7.7 million people living with HIV (23). South Africa also has very high HIV/AIDS and TB rates, including significant multidrug resistance (23). Neglecting HIV/AIDS and TB to address Covid-19 implies destabilising the progress made to achieving the 90-90-90 objectives. 11,000 HIV/AIDS patients in Gauteng at the start of the lockdown failed to collect their medications with a decreased headcount between 30% -70% at Johannesburg clinics (24). TB testing and diagnosis dropped by 50% and 37% respectively (25) as TB wards were converted to Covid-19 patients' admission rooms. Lockdown restrictions in general patient movements were implicated in these declines (5).

1.2.4 Geographical variations of Covid-19's impact on essential services

Fewer studies have highlighted some evidence that the impact of the Covid-19 pandemic on essential public healthcare services was different in different places over time (9,26–28). In a study conducted in Northern America and Canada, the impact of Covid-19 on the disruption of cardiac surgery services was different among all the provinces (9). Another study in the United Kingdom (UK) also found that the Covid-19 pandemic affected the training for surgery speciality in the regions disproportionately (29). In addition, another study also found evidence that there was an increase in the number of people seeking healthcare during the Covid-19 pandemic in rural areas compared to urban areas (30).

On the other hand, reasons have to be tabled to explain the geographical variations in Covid-19's impact on essential healthcare services. For example, the UK study pinpointed regional inequalities in resources that existed pre-Covid19 such as infrastructure and healthcare personnel that made Covid-19 impact the less resourced settings more (29). Many studies have rather investigated the reasons for the geographical variations in the burden of the Covid-19 pandemic, qualitatively, and stated that high population density eased the spread of the Covid-19 pandemic hence more populated areas were affected more than the less populated areas as seen in Turkey, Poland, Malaysia and the USA (31–34).

1.2.5 Healthcare access challenges in South Africa during Covid-19.

Researchers in South Africa have reported several challenges regarding access to essential healthcare services during the Covid-19 pandemic (5,6,12,17). These challenges are categorized as (a) physical access barriers because of transportation and curfew; (b) services not available due to supply-side constraints; (c) financial unaffordability due to lack of income; and (d) fears of being infected by Covid-19 at facilities. The challenges are explained below.

Limited public transportation during the lockdown and curfew periods made it difficult to get to healthcare services (12). The movement of vehicles and particularly public transportation like most other sectors were forbidden during the lockdown. Roadblocks and patrols were instituted to restrict movement. The situation was worse during lockdown and curfew hours because movement without a travel permit was considered a criminal offence. Hence, under the general restriction of movement, people were unable to access healthcare in different localities due to Covid-19 restrictions (12).

In addition, the fear of harassment from law enforcement officers for not having the required traveller's permit reduced healthcare-seeking behaviour (12). This has been reported as a major challenge that hindered the movement of clients from their place of residence to access healthcare facilities for consultation and treatment (12).

The redeployment of essential resources and personnel to respond to the Covid-19 crisis led to reduced healthcare service delivery including preventive and curative childcare services (5). Another study reported that due to Covid-19, TB testing was not prioritised (12). The workforce and other resources were diverted to tackle Covid-19. Consequently, the redeployment of resources to Covid-19 limited the availability of primary healthcare services. This undermined the progress made in previous years, particularly on TB programmes (12), and affected the health outcomes of clients. Moreover, the absenteeism of healthcare workers, because they were in quarantine or afraid of being infected, reduced the available workforce, put more pressure on the working nurses and doctors, and increased waiting times at facilities (5,6,17).

Furthermore, the public opinion that Covid-19 was concentrated at healthcare facilities dissuaded patients from seeking healthcare services (12,35). People believed that the risk of being infected with Covid-19 at healthcare facilities was higher than the risk of being infected if they remained at home. Hence, they avoided visiting and seeking healthcare at facilities for fear of Covid-19 infections.

Another obstacle to accessing healthcare during the Covid-19 pandemic in South Africa is increased unemployment during the lockdowns. This meant that many patients became economically vulnerable and were unable to pay for transportation to facilities. The National Income Dynamics Study

Coronavirus Rapid Mobile Survey found that 23% of those who needed to access healthcare did not do so because of financial constraints (36).

1.3 Statement of the problem

The Covid-19 pandemic has the potential to adversely influence the delivery of essential healthcare services (3,4,37). The quantitative impact of Covid-19 on MNCH services in Gauteng has not been thoroughly assessed to inform decision-makers on the most affected services to be prioritised for support. Health services in different districts may have not been equally affected by Covid-19, but the geographical variation has also not been investigated to assist in directing resources to the most impacted districts. It is important to understand the perceptions of GDoH senior managers on the impact of the Covid-19 pandemic on essential healthcare services, the reasons and mechanisms of services disruption during the Covid-19 pandemic, the consequences and their recommended strategies for maintaining essential healthcare services during a Covid-19 resurgence and future outbreaks.

1.4 Justification for the study

A few South African studies have investigated the effects of Covid-19 on essential health services in other provinces (7,38,39). This study adds to that emerging literature. It extends those analyses to the Gauteng province, which had the highest number of Covid-19 infections and the third-highest incidence rate in the country (14). None of the other national studies has provided a comprehensive analysis of the impact of the Covid-19 pandemic on a range of essential healthcare services including MNCH.

The intention of this research was also to undertake a more extended analysis than earlier South African studies made only five weeks (21) and three months (7) into the Covid-19 epidemic, which could only report a short-term observation of Covid-19's impact without a better control of seasonality and experimental analysis to capture the real effect of Covid-19 on essential healthcare services. In addition, this study investigates the impact of Covid-19 on health outcomes by including some health outcome indicators, as recommended by the other studies (7,21,22)

The study also explores geographical variation in the impact of Covid-19 at the district level, which was not evaluated in the previous studies. Lastly, this research elicits the opinions of senior public healthcare managers in the Gauteng Department of Health (GDoH) about the impact of Covid-19 on essential service delivery, and their policy recommendations for managing future outbreaks. Overall, this study should inform local stakeholders, facility managers, district authorities, the GDoH, the South African government and public health experts on the importance and methods of ensuring the continuation of essential public healthcare services while managing Covid-19 or future outbreaks, in a more balanced manner.

1.5 Research question, study aim and objectives.

1.5.1 Research Question

What has been the impact of the Covid-19 pandemic on access to, service delivery and health outcomes of essential MNCH healthcare services in Gauteng province, South Africa?

1.5.2 Aim of the study

This research is aimed to assess the impact of the Covid-19 pandemic on access to, service delivery and health outcomes for maternal and child health services in Gauteng, South Africa.

1.5.3 Specific objectives of the study

1. To describe the time trends in service utilisation, delivery and health outcome indicators for maternal and child health services in Gauteng from March 2019-February 2021.

2. To evaluate the change in access, service delivery and health outcomes indicators for maternal and child health services in Gauteng between March 2019-Feb 2020 (pre-Covid-19) and March 2020–February 2021 (during Covid-19).

3. To investigate the geographical variations in the impact of Covid-19 on maternal and child health, services in Gauteng from March 2019-February 2021.

4. To explore GDoH senior managers' perspectives on the impact of Covid-19 on essential public healthcare services in Gauteng and the implications policies of this for managing future epidemics.

CHAPTER 2: METHODOLOGY

This is a mixed-method study. This chapter describes the quantitative and qualitative methods used in this study.

2.1 Study design

The quantitative part of the study covers Objectives 1, 2 and 3. This is a longitudinal study design, aimed at investigating the impact of Covid-19 on essential public healthcare services in Gauteng, through a secondary data analysis comparing indicators of maternal and child health services before and during the Covid-19 pandemic. The primary data for this analysis is the longitudinal routine health information from the DHIS of the GDoH over two years from March 2019-February 2021, aggregated monthly.

For objective 4, an exploratory qualitative study design was used (40). This facilitated the exploration of GDoH senior managers' experiences, insights and explanations of the impact of Covid-19 on essential public healthcare services, and their policy recommendations for the future.

2.2 Study setting

The primary data was collected at all public healthcare facilities in the five districts of the Gauteng province namely: Johannesburg, Pretoria, Ekurhuleni, Sedibeng, and West Rand Districts. These districts are predominantly urban although a few healthcare facilities are located in areas that could be characterised as semi-urban and rural. DHIS data is reported daily from 426 public healthcare facilities, (public hospitals and clinics) comprising both fixed and mobile facilities, serving a population of more than 16 million people (13). Again, Gauteng is the leading province in South Africa with the highest number of Covid-19 positive cases and has the third-highest incidence rate (14).

2.3 Study population

The primary study population are patients who attended maternal and child healthcare, services in Gauteng public healthcare facilities from March 2019-February 2021. The analyses were focused on the routine data collection from those patients to produce key health service delivery indicators.

The target population interviewed for the qualitative objective were senior healthcare managers at the GDoH. The senior managers differ in their portfolios and included: These study participants came from diverse backgrounds, including:

- Nurses and physicians
- MNCH, HIV/AIDS, TB, and immunisation program coordinators
- Infectious/communicable, and non-communicable disease experts,

- Monitoring and evaluation experts,
- Forensic investigators,
- Communication officers, among others.

They had different levels of education from bachelor, master and PhD degrees to professorship. Some managers had over 30 years of professional experience. They were made up of both males and females.

2.4 Sampling

The primary study utilised the data of patients attending public healthcare facilities in Gauteng for the quantitative study. The focus was on clients who visited the facilities for maternal and child health services from March 2019-February 2021.

The senior managers at GDoH were sampled for the qualitative component using a purposive sampling technique (41). The list of key programme managers above was obtained from GDoH and they were invited to participate in in-depth interviews based on their role as senior managers who were directly involved in the fight against the Covid-19 pandemic in Gauteng province. The total number of senior managers sampled was 22 but we attained saturation at 13 and the interviews were stopped.

2.5 Data collection:

Secondary data: DHIS indicators

DHIS data was used for objectives 1, 2 and 3. In the DHIS, data is collected manually at each healthcare facility in registers and then entered into an electronic data system which is aggregated at the district level and forwarded to the GDoH for provincial aggregation (7,12). The system is used for the monitoring and reporting, of priority healthcare programmes and diseases from clinics, and hospitals. The data set has data elements and indicators for 37 different domains which are reviewed every three years for improvement by the National Department of Health (NDoH) (7). Examples of domains include child health, HIV/AIDS, TB etc. DHIS was established in 1996/97 (42).

The primary data was obtained from the GDoH through an application. We received district and provincial-level data that was aggregated per indicator per month, extracted and exported into a Microsoft Excel file from Gauteng's DHIS, for the period before Covid-19 (March 2019-February 2020) and the period during Covid-19 (March 2020-Feb 2021), for the selected indicators for this study. Missing data was verified with the District Information Officers and the GDoH statistician.

Primary data: in-depth interviews with GDoH senior managers.

The qualitative primary data was collected by the principal researcher (student), from in-depth interviews with senior managers from the GDoH and the five health districts within the province. The interviews were conducted in English using open-ended questions. The questions covered a range of

issues regarding the impact of Covid-19 on essential healthcare services in Gauteng province. That is, we sought to understand how the Covid-19 pandemic affected services utilisation, delivery and health outcomes of routine healthcare services, the reasons and mechanisms of service disruption and the consequences, and finally, the recommended strategies to maintain essential services during Covid-19 new waves and future outbreaks. Details of the interview guide are seen in Appendix D.

The interviews supplemented the secondary data and gave managers perspectives on Covid-19's impact on routine services. The focus was on senior managers at GDoH central office. To gain first-hand insights into the differences between districts, the list was extended to include at least one senior manager from each district. Participants were briefed and their consent was obtained for notetaking and audio recordings. The average duration of the in-depth interviews was 35 minutes. To respect social distancing, all the interviews were conducted online through MS Teams. Content saturation was achieved after 13 interviews.

2.6 Study variables and measurements

For objectives 1, 2 and 3, this study evaluated services utilisation, delivery and health outcome of performance indicators for MNCH services before and during the Covid-19 pandemic. Table 1 shows the description and definition of the key indicators used. All the dependent variables are numerical and continuous and were computed as counts, percentages, and ratios. The independent variables of interest are the two time periods before Covid-19 (March 2019-February 2020) and during Covid-19 (March 2020-February 2021) and the five districts in Gauteng. We deliberately avoided the term "after or post-Covid-19" because this study was conducted during the pandemic hence the term "during-Covid-19".

Table 1: Essential healthcare service indicators by category

Category	Types of essential healthcare services	Variables	Definition of indicators	Unit
Utilisation	Child Health	Clinic headcounts under 5 years.	Total number of children seen at the facility who are less than 5 years old	count
	Maternal & Neonatal	ANC 1st visits before 20 weeks.	(Number of antenatal 1st visit before 20 weeks/Total number of neonates less than 20 weeks)x100	rate
		PNC 1st visit within 6 days	(Number of postnatal visits within 6 months/total number of expected postnatal visits within 6 months)x1000	rate
Service delivery	Child Health	Measles 2nd dose coverage.	(Number of Measles 2nd dose vaccinated <2 years/total population for Measles 2nd does)x100	rate
	Maternal & Neonatal	Fully immunised < 1-year coverage.	(Fully immunised under 1 year /population under 1 year) x100	rate
Health outcomes	Child Health	Deaths in facility 0-6 days.	Total number of deaths in the facility 0-6days	count
		Pneumonia case fatality <5 years.	(Number of Pneumonia death under 5 years/number of Pneumonia separations under 5 years)x100	rate
	Maternal & Neonatal	Maternal mortality.	(Number of maternal death in facility/Live births known to the facility)x1000 live births	ratio

2.7 Data management

The quantitative data was obtained in an MS Excel sheet from the GDoH. The data was imported into Stata 17 software and cleaned. Missing data was checked with data gatekeepers of DHIS for GDoH and statisticians. Only variables of interest as seen in Table 1 were extracted. All data was stored electronically in Google Drive and on a computer with password encryption.

2.8 Data Analysis

2.8.1 Objective 1: Time trends of indicators

District and provincial level indicators were calculated for each month from March 2018-February 2021 from the facility data. Count indicators were summed while the mean was calculated for proportions and rates. Time series plots were drawn for each indicator, for each district and the entire province. To deal with seasonality variation in indicators, we restricted the comparison to the same months in the two periods of pre-Covid-19 (March 2019 to Feb 2020) and post-Covid-19 (March 2020 to Feb 2021) lockdown. We also evaluated a longer period of 48 months (two years before Covid-19 versus two years into Covid-19) and the was no difference in the results. This initial descriptive analysis informed the selection of the methods used in the subsequent analyses in objectives 2 and 3.

2.8.2 Objective 2: Evaluate change in indicators due to Covid-19

Statistical analyses were conducted to investigate significant changes in essential public healthcare services in Gauteng, before and during the Covid-19 pandemic. We calculated the means, standard deviation, median and interquartile range (IQR) for the two periods (before and during Covid-19) for each indicator. We used the Student's t-test to compare the means and determine the mean difference between the two periods. Some indicators followed a non-normal distribution so the non-parametric Mann-Whitney test was also used. The parametric and non-parametric tests produced the same results in determining the statistically significant differences.

Following the methods used in similar studies (7,43), objective 2 was further investigated using linear regression and interrupted time series (ITS) analysis.

2.8.2.1 Linear regression analysis

A linear regression model was constructed to compare the mean for each indicator for the period before and during Covid-19. The analysis was conducted using a basic linear regression framework. The equation for this model is:

$$\mathbf{Y = \beta_0 + \beta_1 X + \varepsilon} \qquad \text{(Equation 1)}$$

where:

Y is the district or provincial-level outcome indicator for each period,

X is a binary variable time indicating the period (before and after Covid-19),

β_0 is the intercept,

ε is the error term, and

β_1 is the coefficient on X and indicates the size of the change due to Covid-19.

2.8.2.2 Interrupted time series analysis (Itsa)

The impact of Covid-19 was more robustly evaluated through an interrupted time series analysis (44) for all of the indicators in Table 1. In the absence of a randomised control trial, the interrupted time series (ITS) analysis is a quasi-experimental alternative for analysing changes in trends and levels at a specific point (44). We used the date of the first lockdown (March 2020) as the interruption point for this analysis.

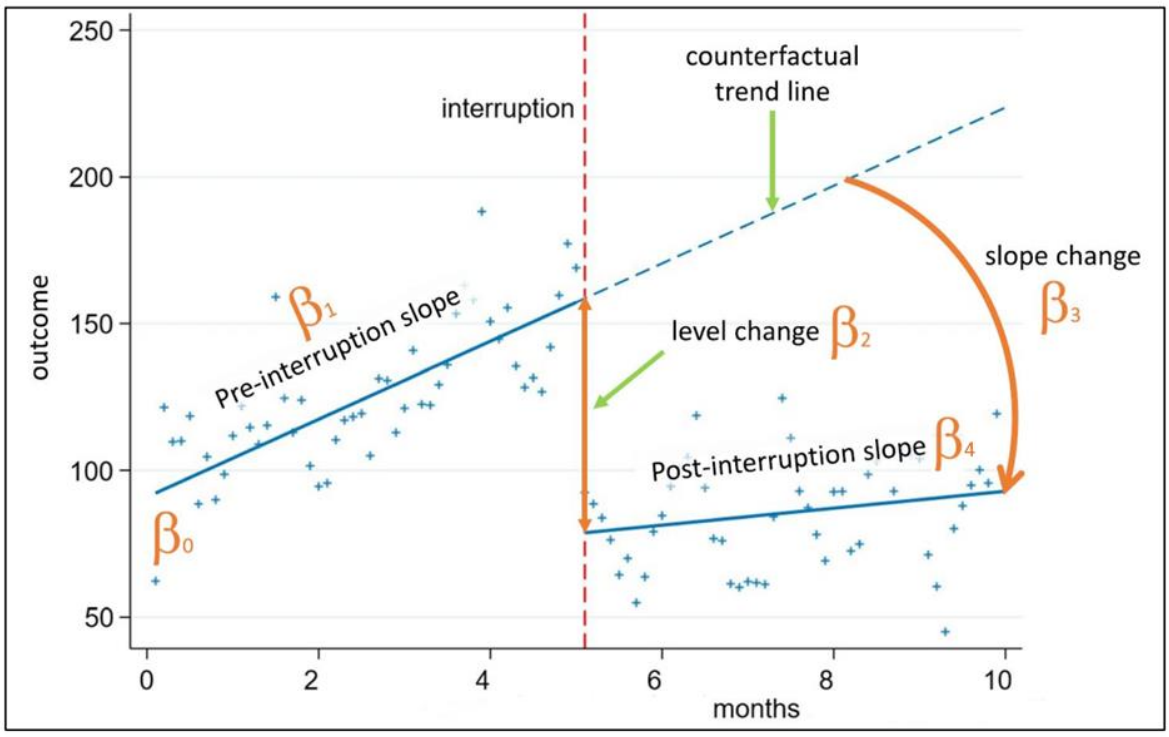

Figure 1: ITS analysis segmented regression

A segmented ITS regression model was formulated and used to determine changes in the level and slope (trend) of the indicators at the interruption point (Figure 1). To increase the power of this analysis, the number of data points before and after the interruption was equal. The analyses were performed using the Stata *itsa* ado command (45). The regression model tested the equation:

$$\mathbf{I_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 T X_t + \varepsilon_t} \qquad \text{(Equation 2)}$$

Where:

$\mathbf{I_t}$ is the indicator at time t,

T is the study time in months,

$\mathbf{X_t}$ is the dummy variable coded (0) and (1) before and during the Covid-19 lockdown respectively,

$\boldsymbol{\beta_0}$ is the baseline I at T=0, and

$\boldsymbol{\varepsilon_t}$ is the error term,

Therefore:

$\boldsymbol{\beta_1}$ is the trend in the pre-Covid-19 period,

$\boldsymbol{\beta_2}$ is the change in level due to the Covid-19 lockdown, and

$\boldsymbol{\beta_3}$ is the change in slope due to the Covid-19 lockdown.

$\boldsymbol{\beta_4}$ is the post-lockdown trend which is calculated as $\beta_4 = \beta_1 + \beta_3$.

Autocorrelation was tested with the Durbin-Watson statistic.

2.8.3 Objective 3: Geographical variations in the impact of Covid-19.

We analysed the change in each indicator by the district using a multiple linear regression framework, extending Equation 1 as follows:

$$\mathbf{Y = \beta_0 + \beta_1 X + \beta_{2i} D_i + \beta_{3i} D_i X + \varepsilon} \qquad \text{(Equation 3)}$$

Where:

$\boldsymbol{\beta_0}$ is the intercept, **X** is the period variable (before and during Covid), and $\boldsymbol{\beta_1}$ indicates the mean change in indicator due to Covid-19, as before,

$\mathbf{D_i}$ is a series of dummy variables for the different districts, and

$\mathbf{D_i X}$ is the interaction between the district dummies and the period variable.

So:

the $\boldsymbol{\beta_{2i}}$ coefficients indicate district differences compared to the reference district, and

the $\boldsymbol{\beta_{3i}}$ coefficients compare the change in each district to the change in the reference district.

2.8.4 Objective 4: GDoH senior managers' perspectives of Covid-19.

In-depth interviews were recorded, transcribed verbatim and supplemented with notebooks. The data were manually coded and analysed in MS Word 2016, by the researcher and a third academic who has experience in qualitative research. The thematic method of analysis was used to deduce codes and themes. The data was further explored inductively, to identify unanticipated codes and themes. That is, some themes such as service disruption, reason and mechanism of service disruption and codes were derived in advance while others were derived from the data. A codebook was developed and the codes and themes from the analyses were collapsed into 18 themes.

This study only reports on the 6 themes directly linked with the objectives of this study. The data was reviewed several times to ensure that no important insights were omitted. The application of the interpretative paradigm was used to understand senior managers' perspectives on Covid-19's impact on

essential healthcare services in Gauteng. The views of the participants were analysed independently but the commonalities that emanated across the data were grouped as themes. To ensure the trustworthiness of the data and eliminate the pitfall of transcription errors, the researcher played multiple roles of both the interviewer and the transcriber as suggested by one study (46). The write-up was checked against the Consolidated Criteria for Reporting Qualitative Research (COREQ) (47).

2.9 Ethical Considerations

The ethics approval for this study Ref: M220149 was granted by the Wits Human Research Ethics Committee (HREC) (see appendix H). In addition, this was viewed as multi-district research. As such, the five health districts in Gauteng province reviewed the protocol and granted approvals Ref No: NHRD-GP_202203-031 (see appendix I). Permission to access DHIS data was obtained from the GDoH. Written consent of the participants (Appendix F) and the audio recordings of the interviews (appendix G) were obtained from respondents before they were interviewed.

The confidentiality of participants was guaranteed. Only aggregated and anonymous data has been reported. All data has been kept in a secured passworded computer which is only accessible to the researcher and supervisors.

CHAPTER 3: RESULTS

3.1 Introduction

In this chapter first, we will present the quantitative results for the three study objectives that explored the DHIS data. Followed by the qualitative results from in-depth interviews conducted with senior managers at the GDoH, for objective four. The data ascertain the impact of the Covid-19 pandemic on healthcare service utilisation, delivery and health outcomes of essential public healthcare services in Gauteng province, South Africa.

3.2 Quantitative Results (objectives 1, 2 & 3)

3.2.1 Objective 1: Time Trends of Selected Indicators (Mar 2019-Feb 2021)

To describe Covid-19's impact on access to, service delivery and health outcomes of essential public healthcare services in Gauteng province, the time trends of routine indicators we were able to obtain are presented in Figure 2 below.

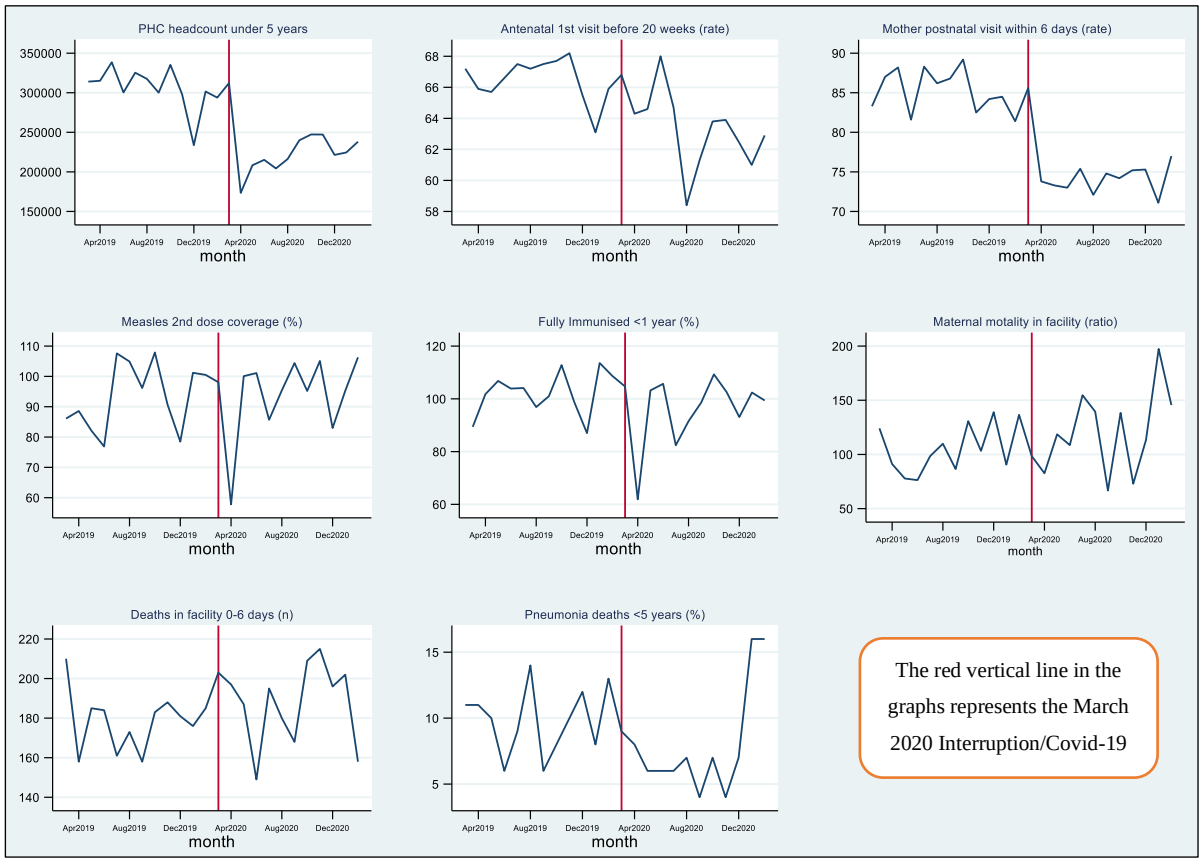

Figure 2: Time trends of Gauteng provincial indicators (March 2019- February 2021)

Figure 2 shows some important aspects. Firstly, there was a significant variation from month to month in many of the indicators, both before and after the Covid-19 lockdown, which makes the patterns difficult to evaluate. Secondly, most indicators indicate some disruption following the nationwide

Covid-19 lockdown Level-5 instituted in March 2020. Although the nature of the disruption varied among the indicators.

The immediate disruptive impact of the lockdown was most marked in five indicators: PHC headcount under 5 years, mother postnatal visits within 6 days, measles 2nd dose coverage, fully immunised <1 year and pneumonia deaths <5 years. Most of these indicators reached their minimum levels for the period of analysis in April 2020, a month after the start of the lockdown. For example, the PHC headcount under 5 years was 315,138 in April 2019 during the pre Covid-19 period but was reduced almost by half to 173,470 in April 2020 during the pandemic. PHC headcount <5 years, PNC, and pneumonia deaths <5 years declined immediately and then stayed fairly low for some time. However, the measles 2nd dose and fully immunised < 1-year indicators had a short immediate decline in April 2020 but then seem to recover in subsequent months to close to the pre-Covid-19 levels.

Other indicators did not show a drastic decline immediately after the March 2020 lockdown. They include the antenatal 1st visit before 20 weeks and maternal mortality ratio indicators. Antenatal 1st visit before 20 weeks seems on a downward trend before Covid, while maternal mortality possibly shows an upward trend, and these patterns more or less continue during Covid-19, although with persistent fluctuations from month to month. Lastly, there is no clear pattern for the impact of Covid-19 on deaths in facilities 0-6 days.

3.2.2 Objective 2: Quantification of changes in indicators due to Covid-19

The graphical time trend depiction is limited because it does not quantify changes in the indicators as an impact of the Covid-19 pandemic. Hence, no assertion can be made regarding the statistically significant difference between the two periods. Therefore, further quantitative analyses were conducted for objective 2. This was done using two different methods of analysis. Firstly, we examined the mean/median difference between the two periods before and during the Covid-19 pandemic. Secondly, we used an interrupted time series (ITS) analysis to quantify changes in the levels and trends over the two periods.

All statistically significant results (numerical figures and p-values) in this report have been bolded in tables. Also, the negative signs in the means coefficient indicate that the indicators performed less during the Covid-19 period compared to the pre-Covid-19 period.

3.2.2.1 The mean difference in indicators between the before and during Covid-19 periods

Table 2: Comparison of mean before and during Covid-19

Category	Type of service	Indicator	Measure	Before Covid-19 (March 2019-Feb 2021)	During Covid-19 (March 2020-Feb 2021)	Mean difference [95%CI]	p-value	
Utilisation	Child health	PHC headcounts < 5 years (n).	Mean ±SD	306158.5 ±27,110.7	229054.6 ±33,510.7	**-77103.9 [-102909.2; -51298.6]**	t-test	**<0.001**
			Median [IQR]	307827 [299130; 321467]	223002 [211835; 243586]		ranksum	**<0.001**
	Maternal and neonatal health	ANC 1st visits before 20 weeks rate	Mean ±SD	66.5 ±1.4	63.5 ±2.6	**-3.0 [-4.7; -1.2]**	t-test	**0.002**
			Median [IQR]	66.9 [65.8; 67.5]	63.9 [61.9; 64.7]		ranksum	**0.003**
		PNC visit within 6 days rate	Mean ±SD	85.3 ±2.7	75.1 ±3.7	**-10.2 [-12.9; -7.5]**	t-test	**<0.001**
			Median [IQR]	85.4 [82.9; 87.6]	74.5 [73.2; 75.4]		ranksum	**<0.001**
Service delivery	Child health	Measles 2nd dose coverage %	Mean ±SD	93.4 ±11.2	94. ±13.5	0.5 [-9.9; 11.0]	t-test	0.918
			Median [IQR]	93.5 [84.1; 103.1]	96.8 [90.5; 102.8]		ranksum	0.887
		Fully immunised < 1-year coverage %	Mean ±SD	102.1 ±8.3	96.2 ±13.1	-5.8 [-15.1; 3.4]	t-test	0.204
			Median [IQR]	102.9 [97.9; 107.8]	100.9 [92.3; 104]		ranksum	0.347
Health outcomes	Child health	Pneumonia case fatality <5 years rate	Mean ±SD	9.8 ±2.6	8.0 ±4.0	-1.8 [-4.7; 1.0]	t-test	0.194
			Median [IQR]	10.0 [8.0; 11.2]	7.0 [6.0; 8.5]		ranksum	0.069
	Maternal and neonatal health	Deaths in facility 0-6days	Mean ±SD	178.5 ±14.8	188.3 ±20.6	9.8 [-5.4; 24.9]	t-test	0.197
			Median [IQR]	182.0 [167.0; 185.0]	195.5 [174; 202.5]		ranksum	0.155
		Maternal mortality ratio	Mean ±SD	105.4 ±22.5	119.8 ±37.7	14.4 [-11.9; 40.7]	t-test	0.269
			Median [IQR]	100.9 [88.6; 127.4]	116 [90.6; 142.6]		ranksum	0.326

From Table 2, three out of eight indicators showed a statistically significant difference ($p<0.05$) in the means before and during Covid-19. These are PHC headcount <5 years, PNC within six days, and ANC1st visit before 20 weeks. Notably, all 3 indicators experienced a reduction in their mean values during the Covid-19 pandemic. Also, these are utilisation indicators, meaning that the Covid-19 pandemic negatively impacted on utilisation of essential public healthcare services in Gauteng province particularly from March 2020 to February 2021.

On the other hand, the mean differences before and after the lockdown were not significantly different for any of the other indicators (Table 2). This concurs with the graphical patterns in Figure 2 where, although indicators such as measles 2nd dose coverage and fully immunized <1 year experienced an immediate shock at the start of the lockdown, the impact was short-lived, with little impact on the mean for the period after the lockdown although measles is slightly higher. For the outcome indicators, Table 2 shows that deaths in facilities 0-6 days and maternal mortality increased in Gauteng province during the Covid-19 pandemic, but this increase was not statistically significant.

The p-values and statistical conclusions were similar between the Student's t-test and the Mann-Whitney (rank-sum) test suggesting that the distributions for these indicators were adequate for parametric analyses.

3.2.2.2 Interrupted Time Series Analysis

Although indicators seem to show a decrease/increase after the lockdown (Figure 2), there is lots of noise and variation in the monthly data so the patterns are difficult to see for most indicators. The noise arose from variations that could not be explained by the data, sample and measurement errors as well. In other words, the noise indicates that any observed difference is due to chance. Hence, we needed a more robust statistical analysis known as the Interrupted time series analysis (ITS) which uses regression techniques to summarise the data and identify changes in the trends and levels of the indicators before and during Covid-19. The ITS plots are presented in Figure 3 and the ITS segmented regression results are summarised in Table 3.

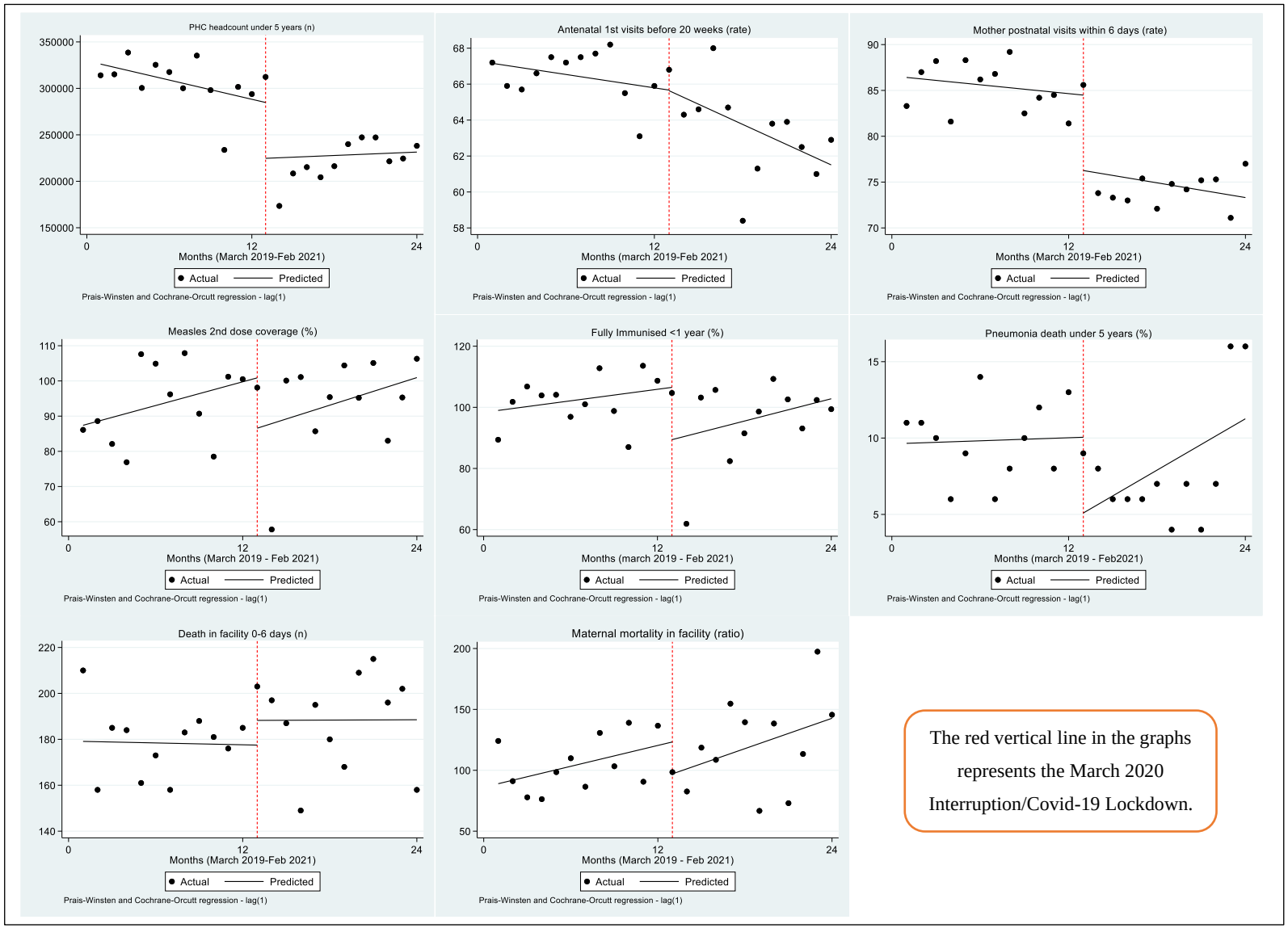

Figure 3: ITS plots of Gauteng provincial indicators (Mar 2019-Feb 2021) and the Mar 2020 Covid-19 lockdown effect

Table 3: Interrupted Time Series analysis of Gauteng provincial indicators (March 201-February 2021)

Category	Types of essential health services	Dependent variables	Pre-lockdown trend (March 2019-Feb 2020)		Immediate change at lockdown (Level 5)		Change in trend (gradient) between pre and post-lockdown		Post-lockdown trend (Mar 2019-Feb 2021)	
			β_1 95%CI	P value	β_2 95%CI	P value	β_3 95%CI	P value	β_4 95%CI	P value
Utilisation	Child Health	PHC headcounts < 5 years (n).	-3443.1 [-7004.3; 118.0]	0.057	**-60106.9 [-116710.4; -3503.3]**	**0.039**	611 [-6.1; 7334.7]	0.852	4054.2 [-4080.5;12188.9]	0.311
	Maternal and Neonatal	ANC 1st visits before 20 weeks rate.	-0.1 [-0.4; 0.2]	0.366	0.0 [-3.4; 3.3]	0.982	**-0.4 [-0.7; -0.1]**	**0.013**	-0.3 [-0.7; 0.2]	0.225
		PNC visit within 6 days rate.	-0.2 [-0.5; 0.2]	0.382	**-8.2 [-12.4; -4.1]**	**0.001**	-0.3 [-0.8; 0.3]	0.317	-0.1 [-0.8; 0.6]	0.761
Service delivery	Child Health	Measles 2nd dose coverage %.	1.1 [-0.2; 2.4]	0.086	-14.3 [-35.0; 6.4]	0.165	1.3 [-1.0; 3.6]	0.248	0.2 [-2.4; 2.8]	0.883
		Fully immunised < 1-year coverage %.	0.6 [-0.6; 1.8]	0.284	-17.1 [-35.7; 1.5]	0.069	1.2 [-0.7; 3.2]	0.210	0.6 [-1.7; 2.9]	0.596
Health outcomes	Child Health	Pneumonia case fatality <5 years rate.	0.0 [-0.5; 0.6]	0.895	-5.0 [-10.8; 0.9]	0.094	0.6 [-0.3; 1.4]	0.173	0.5 [-0.5; 1.5]	0.285
	Maternal and Neonatal	Deaths in facility 0-6 days.	-0.1 [-3.1; 2.8]	0.924	10.8 [-15.3; 36.8]	0.400	0.0 [-3.6; 3.6]	0.989	0.2 [-4.4; 4.8]	0.943
		Maternal mortality ratio.	2.9 [-0.4; 6.4]	0.085	-26.2 [-58.5; 6.0]	0.105	4.2 [-0.5; 8.8]	0.079	1.3 [-4.3; 6.9]	0.634

Figure 3 shows that only antenatal 1st visits before 20 weeks did not experience an immediate change in level at the imposition of the lockdown, although its post-lockdown trend is steeper. Except for deaths in facilities 0-6 days which saw an increase in the level of lockdown, all the other indicators witnessed a downward change. And still, the size of the change was different among the indicators. For example, the size of the decline at the imposition of the lockdown (level) is much bigger in ANC, PHC headcount, and pneumonia deaths compared to measles coverage.

As shown in Table 3, there were statistically significant impacts of the Covid-19 lockdown for only three of the eight indicators in this analysis**.** The immediate effect (β_2) of the lockdown was a significant decrease in the levels of two utilisation indicators, namely **PHC headcount <5 years (p=0.039) and PNC visits within 6 days (p<0.001).** In other words, there was a significant reduction in the number of children under the age of 5 years and the number of mothers who took their children within 6 days after birth to healthcare facilities as a consequence of the lever 5 lockdown of March 2020. Once more, these significant changes are well demonstrated in Figures 2 and 3.

The only indicator that witnessed a significant change in its gradient (the change between the post-lockdown and the pre-lockdown periods (β_3)) was **ANC 1st visits before 20 weeks (p=0.013).** This implies that the gradient of this indicator was less steep during the Covid-19 period compared to the gradient before the lockdown period. That is, there were fewer ANC visits during the Covid-19 period or lockdown compared to the period before Covid-19 and lockdown which had more ANC visits.

All other changes were not statistically significant at the 5% level of alpha. Some changes approached significance (p<0.5) but had wide standard errors due to the inherent noise in the data. For example, the maternal mortality indicator showed an increase in the post-lockdown trend compared to the pre-lockdown trend (β_3), which was almost significant (p=0.079). Similarly, the immediate decreases after lockdown (β_2)**,** were almost significant for fully immunized <1 year (p=0.069) and pneumonia case fatality <5 years (p=0.094).

Despite the changes in trends observed in Figure 3, there was no significant change in the post-lockdown trends (β_4) in all the indicators as depicted in Table 3. However, two indicators ANC and PNC had negative post-lockdown trends which suggests that these two indicators kept deteriorating during the post-lockdown period rather than recovering. Although this downward trend is similar to their pre-lockdown trends. The other six indicators seem to be recovering after the lockdown. But a recovery or an increase (even if not statistically significant) for certain indicators like deaths in facilities 0-6 days, pneumonia fatality <5 years and maternal mortality is bad and undesired. Hence, only immunisation (fully immunised and measles 2nd dose) and PCH headcount seem to have warranted recovery in the post-lockdown but still not significant. Moreover, deaths in facilities 0-6 days became worst in the post-lockdown period compared to the pre-lockdown period though not significant as well.

Table 4: Mean differences in district indicators before and during the Covid-19 periods

Category	Types of essential healthcare services	Indicators	Mean difference, [95% CI] and t-test p-value					
			Johannesburg	**Tshwane**	**Ekurhuleni**	**Sedibeng**	**West Rand**	**Mean variation across all districts**
Utilisation	Child Health	PHC headcounts < 5 years (n).	**-20954.5 [-29489.6; -12419.5] P<0.001**	**-15443.7 [-20293.8; -10593.6] P<0.001**	**-24934.3 [-33168.9; -16699.8] P<0.001**	**-6721.9 [-8846.8; -4597.1] P<0.001**	**-9049.5 [-12048.1; -6050.9] P<0.001**	**-77103.9 [-102909.2; -51298.6] P<0.001**
	Maternal and Neonatal	ANC 1st visits before 20 weeks rate.	-1.0 [-2.2; 0.2] P=0.108	**-2.5 [-4.9; -.2] P=0.035**	**-4.6 [-7.6; -1.6] P=0.005**	**-5.3 [-7.9; -2.7] P<0.001**	**-8.4 [-12; -4.9] P<0.001**	**-3.0 [-4.7; -1.2] P<0.002**
		PNC visit within 6 days rate.	**-24.9 [-32.1; -17.7] P<0.001**	**-6.1 [-9.7; -2.5] P=0.002**	**-7.9 [-12.7; -3] P=0.003**	**-7.5 [-12.2; -2.9] P=0.003**	**-4.8 [-7.8; -1.8] P=0.003**	**-10.2 [-12.9; -7.5] P<0.001**
Service delivery	Child Health	Measles 2nd dose coverage %.	-4.8 [-11.5; 1.9] P=0.155	-4.0 [-11; 3.1] P=0.253	-2.7 [-10; 4.6] P=0.451	-6.0 [-13.3; 1.2] P=0.098	-4.0 [-17.3; 9.3] P=0.542	0.5 [-9.9; 11.0] P=0.918
		Fully immunised < 1 year coverage %.	-7.7 [-15.8; 0.5] P=0.063	-4.9 [-12; 2.2] P=0.169	-1.3 [-8.3; 5.7] P=0.704	**-7.3 [-14.5; -0.1] P=0.047**	-3.7 [-16.7; 9.2] P=0.555	-5.8 [-15.1; 3.4] P=0.204
Health outcomes	Child Health	Pneumonia case fatality <5 years rate.	0.1 [-1.1; 1.3] P=0.883	**-1.8 [-3.5; -.0] P=0.048**	-0.4 [-1.6; 0.8] P=0.466	-0.2 [-.7; 0.3] P=0.482	0.4 [-.3; 1.1] P=0.223	-1.8 [-4.7; 1.0] P=0.194
	Maternal and Neonatal	Deaths in facility 0-6days.	2.8 [-6.6; 12.3] P=0.541	**9.3 [1.9; 16.6] P=0.016**	-1.4 [-9; 6.1] P=0.700	0.0 [-2.5; 2.5] P=1.000	-0.9 [-3.3; 1.5] P=0.432	9.8 [-5.4; 24.9] P=0.197
		Maternal mortality ratio.	18.9 [-22.2; 60] P=0.350	25.2 [-36.7; 87] P=0.407	-3.5 [-38.2; 31.1] P=0.834	42.4 [-27.9; 112.6] P=0.224	1.2 [-82; 84.3] P=0.977	14.4 [-11.9; 40.7] P=0.0.269

3.2.3 Objective 3: District variations in the impact of Covid-19

Table 4 presents the mean difference in district indicators and the average across all five districts, based on the multiple linear regression results from Equation 3. The column of the mean variation across all districts in Table 4 was explained earlier in Table 2.

From Table 4, only two indicators declined significantly in all five districts. **PHC headcount <5 years** statistically significant decline across all five districts during Covid-19. The largest decrease in PHC headcount <5 years was recorded in Ekurhuleni district, while the lowest decrease was in Sedibeng district. **PNC visits within 6 days** also statistically significant decline in every district. The highest decline came from the Johannesburg district, whereas the West Rand district had the lowest decline.

Other statistically significant changes at the district level were more sporadic. **ANC 1st visits before 20 weeks** reduced significantly in four districts, but not for Johannesburg. The largest change in mean values occurred in the West Rand while the lowest decrease was in Johannesburg. **Fully immunized <1 year** decreased significantly only in Sedibeng. **Pneumonia fatality <5 years** declined significantly in Tshwane but **deaths in facilities 0-6 days** increased in that district (9.3 [1.9; 16.6], p=0.016)

Overall, of the selected indicators for this study, the Tshwane district appeared to be the municipality most impacted by Covid-19, with significant changes in five indicators, four of the indicators were negatively affected whereas, the decrease in pneumonia fatality < 5 years was positively affected. This was followed by the Sedibeng district with four changes, all negative. Ekurhuleni and West Rand districts had three significant changes in the selected indicators while Johannesburg district only had two. These three districts were all negatively impacted by Covid-19. Importantly, the results confirm that the district-level disruption of essential public healthcare services by Covid-19 was mostly for the utilisation indicators. Service delivery indicators were only disrupted in the Sedibeng district while health outcomes were significantly affected only in the Tshwane district.

It is important to reconcile Table 2 and Table 4 to indicate the importance of the district analysis. Only three indicators namely PHC headcount, ANC and PNC were significantly affected at the provincial level. At the district level, fully immunised became significantly affected in the Sedibeng district. While pneumonia fatality significantly decline but deaths in facilities 0-6 days increased in the Tshwane district. Measle 2nd dose coverage and maternal mortality remained insignificantly affected both at the provincial and five district levels.

To evaluate whether these differences between districts were statistically significant, we used a pooled multiple linear regression model. This added the district effects to compare district indicator levels to Johannesburg and used the interaction between the district and period effects to test whether the changes in indicators caused by Covid-19 in each district were different to the changes caused by Covid-19 in

Johannesburg municipality as the reference district. The regression results are summarised in Table 5 while the margin plots from the regression analysis are shown in Figure 4. The margin plots compare the regression-predicted changes due to Covid-19 for the five districts, for each indicator.

From the reported adjusted R^2, most of the pooled models had an adequate fit. The least reliable model was that for maternal mortality (R^2=0.030). In the pooled model, the overall changes due to Covid-19 were significant for PHC headcount under 5 years and PNC within 0-6 days but not for antenatal 1st visits before 20 weeks (Table 5). Not surprisingly the model also showed some significant differences in indicator levels between districts. However, since the purpose of this analysis is to compare the impact of Covid-19 between the 5 districts we will focus mostly on the period-district interaction results.

For **PHC headcount under 5 years,** the change in mean headcounts due to Covid-19 was not significantly different in Tshwane and Ekurhuleni districts compared to the Johannesburg district (Table 5). However, the interaction terms were significantly different and positive for the Sedibeng and West Rand districts, indicating that the decline in headcounts due to Covid-19 for these two districts was lower than that of the Johannesburg district. These results can be checked in the margins plot in Figure 4, which shows a similar downward trend between the two periods for Johannesburg, Tshwane and Ekurhuleni, but a less steep decline in Sedibeng and the West Rand.

The decline in ANC 1st visits before 20 weeks due to Covid-19 was significantly larger in Ekurhuleni, Sedibeng and West Rand than in the Johannesburg district, with the largest decrease occurring in the West Rand district (Table 5). However, the impact of Covid-19 was not significantly different in Tshwane compared to Johannesburg for this indicator. Figure 4 shows steep decreases in ANC 1st visits before 20 weeks from before Covid to during Covid in Ekurhuleni, Sedibeng and West Rand, little change in Johannesburg district, and a decline in Tshwane somewhere between those.

For PNC visits within 0-6 days, the decrease in all four of the other districts was significantly lower than the decrease in the Johannesburg reference district (Table 5), which is also the pattern indicated in Figure 4. The only significant difference for pneumonia case fatality <5 years was that the indicator decreased more in the Tshwane district than in Johannesburg and other districts.

Lastly, the impact of Covid-19 on Measles 2nd dose coverage, Fully immunized < 1 year, deaths in facilities 0-6 days and maternal mortality were not significantly different in the districts compared to the Johannesburg district.

Table 5: Multiple regression-comparison of district indicators to Johannesburg reference district

	PHC headcount <5yr	Antenatal 1st visits before 20wks	Mother postnatal visits 6d	Measles 2nd dose	Fully immunised < 1 yr	Pneumonia case fatality <5ys	Deaths in facility 0-6d	Maternal mortality ratio
	Coef *p value*	*Coef* *p value*	*Coef* *p value*	*Coef* *p value*	*Coef* *p value*	*Coef* *p value*	*Coef* *p value*	*Coef* *p value*
Period								
Before lockdown	—	—	—	—	—	—	—	—
After lockdown	**-20954.5** **<0.001**	-1.0 0.447	**-24.9** **<0.001**	-4.8 0.258	-7.7 0.072	0.1 0.879	2.8 0.369	18.9 0.521
Districts								
COJ Metro	—	—	—	—	—	—	—	—
Tshwane Metro	**-47927.3** **<0.001**	-1.6 0.213	**-45.9** **<0.001**	-1.9 0.644	-0.6 0.886	**3.1** **<0.001**	**-16.8** **<0.001**	2.7 0.927
Ekurhuleni Metro	**-22727.8** **<0.001**	0.3 0.825	**-44.7** **<0.001**	-9.5 0.026	-4.5 0.295	**1.9** **<0.001**	**-15.4** **<0.001**	20.2 0.493
Sedibeng	**-87272.7** **<0.001**	2.7 0.039	**-44.4** **<0.001**	2.0 0.639	-1.6 0.700	-0.9 0.096	**-54.9** **<0.001**	12.3 0.676
West Rand	**-85477.1** **<0.001**	**7.1** **<0.001**	**-53.0** **<0.001**	6.0 0.155	**10.7** **0.013**	-0.9 0.096	**-57.7** **<0.001**	33.4 0.258
Period*District								
COJ*After	—	—	—	—	—	—	—	—
Tshwane*After	5510.8 0.178	-1.6 0.393	**18.8** **<0.001**	0.8 0.897	2.8 0.639	**-1.8** **0.019**	6.4 0.151	6.3 0.880
Ekurhuleni*After	-3979.8 0.330	**-3.6** **0.050**	**17.1** **<0.001**	2.1 0.730	6.4 0.288	-0.5 0.519	-4.3 0.340	-22.5 0.590
Sedibeng*After	**14232.6** **0.001**	**-4.4** **0.018**	**17.4** **<0.001**	-1.3 0.829	0.4 0.946	-0.3 0.747	-2.8 0.525	23.4 0.574
West Rand*After	**11905.0** **0.004**	**-7.5** **<0.001**	**20.1** **<0.001**	0.8 0.894	4.0 0.510	0.3 0.667	-3.8 0.400	-17.8 0.670
Constant	**109912.7** **<0.001**	**66.2** **<0.001**	**119.6** **<0.001**	**80.7** **<0.001**	**88.0** **<0.001**	**1.3** **0.001**	**64.7** **<0.001**	**95.4** **<0.001**
n	120	120	120	120	120	120	120	120
Adjusted R^2	0.955	0.496	0.893	0.162	0.206	0.489	0.908	0.030

Again, the bolded figures represent the statistically significant changes due to the Covid-19 pandemic.

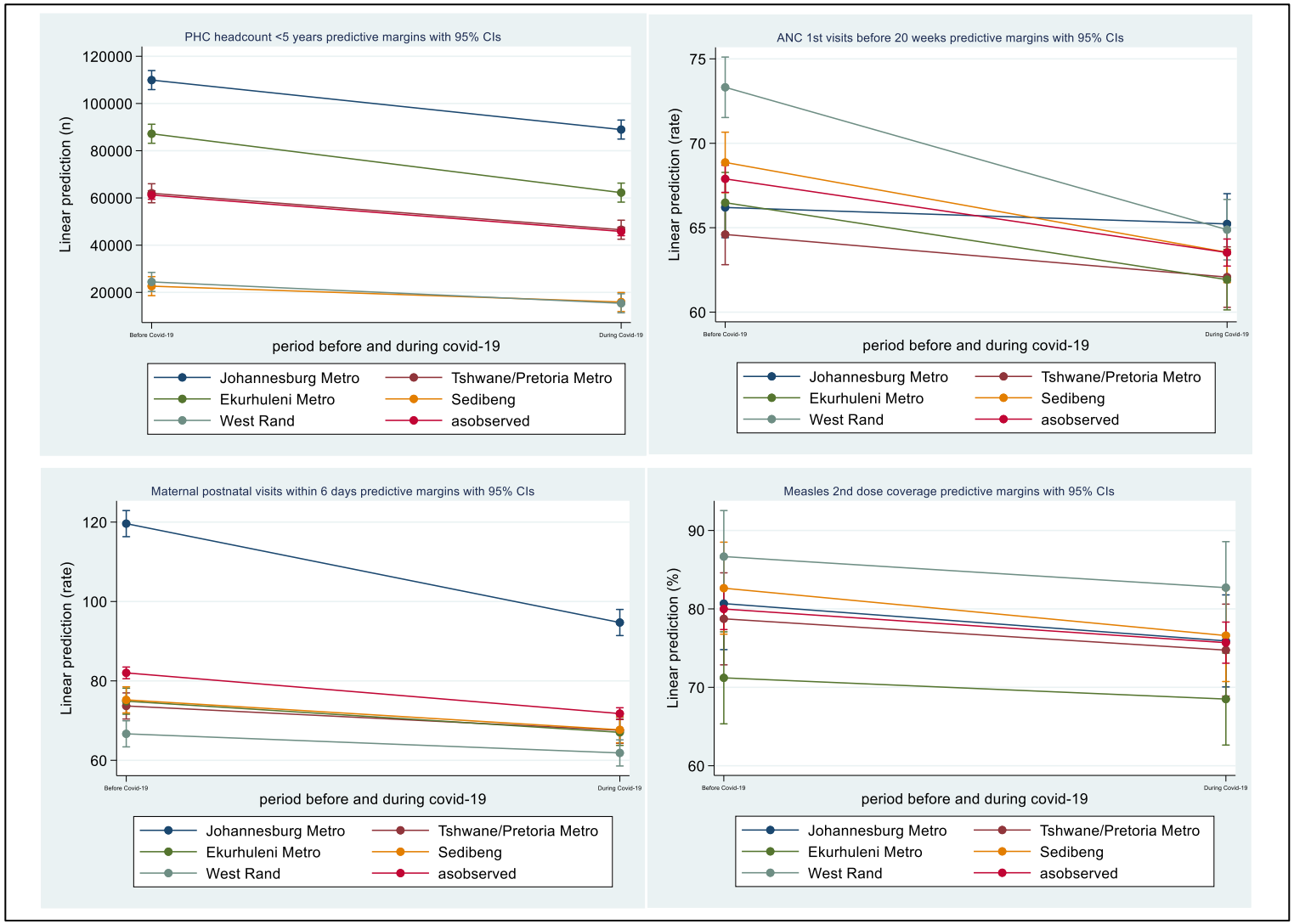

Figure 4: Margin plots of district indicators performance before and during Covid-19 (March 2019-Feb 2021)

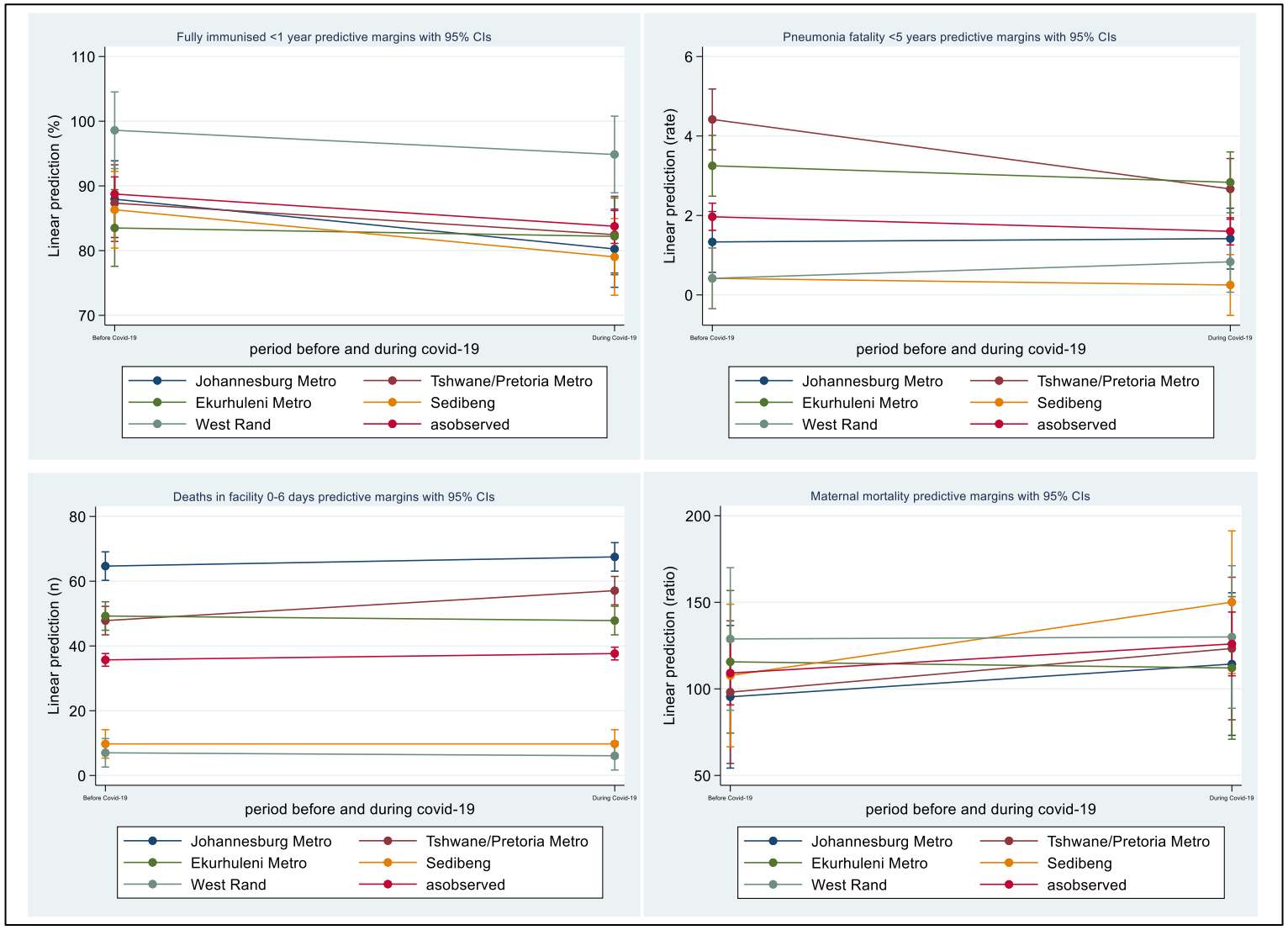

Figure 4: Margin plots of district indicators performance before and during Covid-19 (March 2019-Feb 2021)

3.3 Qualitative results (objective 4)

The qualitative objective was "To explore GDoH senior managers' perspectives on the impact of the Covid-19 pandemic on essential public healthcare services and the implications for managing future pandemics". The phrases beside the quotes indicate the provincial (GDoH) or district department in which the respondents were working at the time they participated in this study. These phrases are brief to avoid the disclosure of the participant's identity. The results of the in-depth interviews have been resolved into 4 themes as presented below.

3.3.1 Theme 1: Disruption of essential public healthcare services during Covid-19

The majority of the participants reported that essential public healthcare services were disrupted in Gauteng province during the Covid-19 pandemic. Some of the services highlighted to have been greatly disrupted include fully-immunisation under 5 years, measles, chronic disease services for HIV/AIDS and care for the elderly, among others. According to some of the participants:

"We've seen a drop in our indicators, where we monitor the immunization of children under five years, and those under one year for measles and other immunization. So, performance dropped, there's a high default rate". *Respondent 9-GDoH*

"There was a negative impact if you check our annual reports for 2020/2021 and 2021/2022, the Gauteng Department of Health is on record stating the extent of the impact that services were disrupted, not just for HIV/AIDS and TB but even for other services". *Respondent 4-GDoH*

Furthermore, some of the senior managers explained that services were disrupted at multiple levels.

Service delivery was affected especially in our hospitals and also in our primary healthcare facilities. *Respondent 8-GDoH*

However, not all respondents agreed that primary healthcare services were disrupted during Covid-19 in Gauteng province. A few of the senior managers argued that GDoH implemented strategies that filled the gaps in resource shortages and, therefore, essential public healthcare services continued without being disrupted in Gauteng. These respondents argued:

"It [Covid-19] didn't affect the delivery of health services in Gauteng because we established additional healthcare facilities purely to manage the pandemic so the rest of the services continued. So there was no effect on delivery or health outcomes in the province. Our services were open at all stages so the influx of patients continued throughout the period". *Respondent 3-GDoH*

3.3.2 Theme 2: Reasons and mechanisms of service disruption during Covid-19

The main reason for the disruption of essential public healthcare services was because of the need to focus attention on fighting the Covid-19 pandemic which meant mobilising resources and, for example, reallocating healthcare workers away from other services. This was a critical decision considering the inadequate resources for both routine services and the response to Covid-19. The participants used

different terminologies like disruption and deferment interchangeably, but they all seem to merely convey the message that essential healthcare services were compromised because resources were diverted to Covid-19. According to some senior managers:

"Several services were affected like lost-to-treatment for Tuberculosis and immunization because we had to focus on ensuring that people are vaccinated against Covid-19. Services continued but invariably we had to defer certain services". *Respondent 2-GDoH*

"The fight against Covid-19 was a clinical risk decision. It's not something you wake up in the morning and decide, lots of interactions, engagements, and clinical governance were made and to combat it effectively we needed to defer services. Whatever decision was made, it was a collective risk adjustment to save lives". *Respondent 7- Johannesburg district*

Other mechanisms were mentioned through which Covid-19 disrupted essential public healthcare services in Gauteng province. Firstly, access to routine healthcare services during Covid-19 was restricted by facilities or deferred by the clients or caretakers themselves according to some managers:

"There was a time when we were not allowing people to come to facilities because of the high levels or rates of infections. Indeed, a lot of facilities had to repel people and focus their attention on Covid-19". *Respondent 1-Ekurhuleni district*

"*Service delivery and access were affected. We gave people medication for six months of treatment so that they don't come more often into the facilities.* *Respondent 5-Johannesburg district*

While the above respondents seem to suggest that essential public healthcare services during Covid-19 were disrupted from the supply perspective, others on the other hand suggested that the disruption was from the demand side through healthcare deferment either by the clients themselves or caretakers.

"*It is a fact that were was a deferment of services. Remember during lockdown there was less movement and no routine transport. And a lot of fear and panic that you could catch COVID at the hospitals and clinics. So this pandemic in the early phase really affected services negatively".* *Respondent 12-Sedibeng*

"*On access, and coming to immunization, everyone was scared to take their children to the facilities".* *Respondent 5-Johannesburg district*

Another reason for the deferment of essential public healthcare during Covid-19 seems to be the effect of the conditions to which people were subjected at healthcare facilities such as longer waiting times and queues, exacerbated by environmental conditions like sunshine or rainfall. Hence, some people were reluctant to seek routine care.

"People who went into the facilities were subjected to screening whether it was raining or not. You would spend more than five hours in the facility just to be screened. So people didn't want to be subjected to such treatment and exposure to environmental factors like rain and sunny days. Yeah, most people decided not to access health care services because of those factors". *Respondent 13-Ekurhuleni district*

Also, the senior managers perceived that service delivery was affected due to high rates of Covid-19 infections and deaths among healthcare workers which exacerbated the shortage in the workforce hence, Covid-19 was prioritized at the expense of essential healthcare services.

"*Indeed, services were severely affected because our nurses were getting sick, quarantined and some died. So there was a very close shortage of nurses or clinicians, which include doctors and others to offer these [essential] services. So, that had a very negative impact on service delivery". Respondent 6-Tshwane district*

Finally, misinterpretation or misunderstanding of health information by clients/patients is one of the reasons that disrupted the utilisation of essential public healthcare services during Covid-19 in Gauteng.

"We said to people; if your illness is not such that you come to the hospital then you don't necessarily have to come there and so those that were on treatment decided not to come. Our message was actually that those taking treatments should come but you know people being people, some will hear the message otherwise and interpret it whatever way. But whichever way, there was an impact because we saw a decline in the numbers of people that were receiving treatment". Respondent 10-Ekurhuleni district

3.3.3 Theme 3: Consequences of essential healthcare disruption during Covid-19

The senior managers recounted that the impact of Covid-19 on essential public healthcare services was far-reaching. That Covid-19 impacted health outcomes like loss-to-follow-up, particularly for chronic clients. This resulted in some clients becoming vulnerable or immunocompromised, some of whom died. Some of the senior managers shared their perspectives as follows:

"Chronic diseases were told not to come to facilities. Electives were cancelled and now we are struggling, at Barag they have lots of waiting cases. Chronic patients suffered a lot. Imagine living with OA [osteoarthritis] awaiting joint replacement which was supposed to be scheduled for next month but due to Covid-19, it has been cancelled. How will you survive that type of pain?" Respondent 2-GDoH

Moreover, because the chronic patients did not go to the facilities for their chronic care, their chronic condition got worst. Chronic patients were also more at risk of Covid-19.

"Yes, most of those who were demised were those who had chronic diseases like hypertension, kidney failure, diabetes, and people with HIV/AIDS. It was easy for them to get Covid-19. Also, those aged over 60 years got affected and most of them died. So, it affects the aged and the chronic, those are the most vulnerable groups in Gauteng". Respondent 11- Tshwane district

3.3.4 Theme 4: Strategies to maintain essential services during Covid-19

The senior managers explained that to address the effects of Covid-19 and the possible resurgence of the pandemic to ensure the continuation of essential healthcare services, the GDoH adopted a strategic plan which included services integration, a catch-up plan and the use of technology. The integration of

essential services into the Covid-19 response package was coordinated by each district and reported to the provincial Department of Health.

"… they don't only do COVID-19 testing and screening but they were integrating the services into the battle plans or the hotspots. They were also testing and screening for TB simultaneously. They distributed condoms and screened for HIV, and BP [blood pressure] and tested for diabetes as well. It also renders the chronic medication for those who were not able to go to the hospitals". *Respondent 10-Ekurhuleni district*

In addition, some of the participants reported that the GDoH adopted a recovery (catch-up) plan to immediately address the healthcare services and vulnerable groups, cases lost-to-follow-up cases, and others affected by the Covid-19 pandemic.

"We came up with an intervention plan to ensure that we catch up. It is called the catch-up plan, to ensure that all the services that were affected go back to normal and we support them. So we came up with a plan as the department and we're implementing that plan". *Respondent 1, Ekurhuleni district.*

"I think those with HIV and TB became vulnerable hence, the catch-up programs. We were able to say if you are immunocompromised, come for your treatment and don't default because the stronger your immune system the more chances you have to fight Covid-19. I think that also assisted". *Respondent 9-GDoH.*

Finally, all the senior managers expressed satisfaction that despite the challenges of the Covid-19 pandemic on essential healthcare services, technology played a significant role to bridge physical distance during movement restrictions. Such healthcare technology involvement was recounted as:

"Covid-19 highlighted the importance of investing in healthcare technology. We introduced telerehabilitation for fragile and rehabilitation cases. Because they did not come to the facilities for fear of being infected, we used the new technology and rehabilitate them via the introduction of telerehabilitation to get better health outcomes for those patients". *Respondent 5- Johannesburg district.*

Telehealth or telemedicine not only in Gauteng but internationally has been tested to be effective. A lot of research has been done on telemedicine and telerehabilitation and people are advocating for it. We have a strategy for e-health but Covid-19 fastened it and we can see some benefits. *Respondent 6-Tshwane district.*

CHAPTER 4: DISCUSSION

4.1 Introduction

This study investigated the impact of the Covid-19 pandemic on service utilisation, delivery and health outcomes of essential public healthcare services in Gauteng province-South Africa, from March 2020 to February 2021. Specifically, we examined indicators of maternal, neonatal and child healthcare (MNCH). In addition, the GDoH senior managers were interviewed to understand their perspectives on the effect of Covid-19 on routine healthcare. This chapter will discuss the findings and their implications.

4.2 Summary of study findings.

Quantitatively, the Covid-19 pandemic disrupted the utilisation of essential MNCH services in the Gauteng province. The disruption was observed in the time trend plots, and then quantified by comparing the indicator means for the 12-month periods before and during Covid-19. The impact was a statistically significant decline in the mean of three indicators: PHC headcount <5 years declined on average by 77 103.9 visits ($p<0.001$), ANC 1st visits before 20 weeks decreased by 3.0% ($p=0.002$) and PNC visits within 6 days decreased by 10.2% ($p<0.001$) (Table 2). The ITS regression provided a more nuanced analysis. The decrease in PHC headcount <5 years and PNC visits within 6 days were due to the immediate effect of the March 2020 Covid-19 lockdown which led to a drop in utilisation services. However, the effect on ANC 1st visits before 20 weeks was a continuous decline in utilisation throughout the Covid period (Table 4). Service delivery and outcome indicators were negatively affected though not significantly. There were no significant recoveries and some indicators rather became worse post-lockdown.

The nature of the adverse impact of Covid-19 on MNCH indicators was similar across all five districts, although the degree of disruption varied among the districts and services. The decline in service utilisation for PHC headcount <5 years, ANC 1st visits before 20 weeks and PNC visits within 6 days was statistically significant in all districts, except for ANC 1st visits in Johannesburg (Table 4). The decline in PHC headcount <5 years was significantly larger in the three metropolitan districts (Johannesburg, Ekurhuleni and Tshwane) compared to the two non-metropolitan districts (Sedibeng and West Rand) (Table 5). ANC 1st visits before 20 weeks significantly decline in the Ekurhuleni, Sedibeng and West Rand districts compared to Johannesburg. While the decrease in PNC visits within 6 days was significantly worse in Johannesburg compared to the other four districts (Figure 4). Pneumonia fatality <5 years significantly declined in the pooled analysis, in the Tshwane district alone.

Qualitatively, the majority of the respondents agreed that the Covid-19 pandemic disrupted essential healthcare services but a few disagreed. Several reasons were advanced for the disruption. On the supply side, they included: (i) the reallocation of resources to fighting Covid-19; (ii) healthcare worker

shortages due to Covid-19 illness; (iii) healthcare facilities turning away non-Covid-19 patients; and (iv) Covid-19 screening that increased waiting times. On the demand side are; (i) restrictions on movement and limited public transport during the lockdown; (ii) fears of being infected by Covid-19 at health facilities; and (iii) misinterpretation of health information about the availability of non-Covid services. According to the respondents, the disruption of essential healthcare services had significant consequences, particularly for chronic patients, including treatment interruption, loss-to-follow-up, and death. The 'catch-up' plan and technology were used to improve service delivery during Covid-19.

4.3 Critical analysis of findings

In this section, we will critically examine our findings by comparing and contrasting them to existing literature.

4.3.1 The disruption of essential healthcare services during Covid-19

Overall, this study suggests that the Covid-19 pandemic disrupted essential public maternal and neonatal and child healthcare (MNCH) services in Gauteng province, South Africa. The disruption caused a drastic decline in health service utilisation at the province level.

Our finding is consistent with several local and international studies that highlighted the disruptive impact of Covid-19 on routine healthcare (7,17,19,21,43,48–54). There is also comparable evidence from South Africa. In a similar study in the KwaZulu-Natal province, child health access and service delivery were found to have proportionately declined during the Covid-19 pandemic (7). Our findings are also similar to the KwaZulu-Natal study (7). For example, they reported a reduction of 42% in PCH headcount <5 years in April 2020 due to Covid-19, while we report a 45% decline in PCH headcount <5 years for the same period in Gauteng. Another study in the Gauteng province estimated a 30% decline in primary health utilisation from March to April 2020, attributed to Covid-19 (21). Also, the decline in immunisation in the Sedibeng district in the present study aligns with earlier findings from another South African health system study which found that Covid-19 negatively affected the delivery of health services, particularly for immunisation (54).

Our quantitative and qualitative findings both merged, highlighting that the Covid-19 pandemic disrupted essential healthcare services in Gauteng province. We further verified these findings by double-checking the claim made by one of the respondents who recounted that the GDoH annual report for 2020/2021 and 2021/2022 acknowledged the disruption of essential healthcare services by Covid-19. We found evidence that this was not a mere opinion but a fact because the GDoH had published this disruptive impact of Covid-19 on routine healthcare services (55,56). The 2020/2021 annual report documented a 20.0% reduction in primary healthcare visits and a 3.2% decline in ANC booking in 2020/2021 during Covid-9 compared to the 2019/2020 pre-Covid-19 financial year.

Also, our findings at the Gauteng provincial level showed a reduction in MNCH, particularly for ANC 1st visits before 20 weeks and mother postnatal visits within six days due to the disruptive effect of Covid-19. This provides support for the predictions of Roberton et al (19) about the devastating impact of Covid-19 on maternal and child health in low and middle-income countries. A number of studies confirm this finding by showing the disruption of routine services and increased maternal and child mortality as a direct effect due to the disruption of routine services by Covid-19 (7,17,18,50).

Similar to our findings, the disruption of essential public healthcare services has been reported in previous infectious disease outbreaks (48,57). For example, the Ebola outbreak in West Africa limited access to and the utilisation of healthcare by disrupting services for vulnerable women and children (48). The outbreak resulted in many deaths attributed to the country's strained health system rather than Ebola itself. More concretely, the Ebola outbreak in Sierra Leone decreased antenatal and postnatal visits causing a 34% increase in maternal mortality and a 24% increase in the stillbirth rate (57).

4.3.2 The effect of the March 2020 (level five) lockdown on essential services

Our findings from the ITS analysis further suggest that the adverse effect of Covid-19 on routine healthcare was worst during the implementation of the March 2020 Covid-19 level five lockdown (**β_2**). The similarity in figures of 45% for Gauteng from this current study and 42% in KwaZulu-Natal (7) reductions in PHC headcounts <5 years for these two South African provinces in April 2020 is a scientific demonstration of the disruptive impact of the March 2020 Covid-19 nationwide lockdown. Another finding from a longitudinal cohort study in KwaZulu-Natal also reported a statistically significant reduction in access to child healthcare immediately after the Covid-19 level five lockdown imposition (22).

Likewise, evidence from a Liberia cross-sectional study that used a mixed method approach (qualitative and quantitative) and exploring routine health data, equally shows that the Covid-19 lockdown harmed healthcare services. Just a month after the Liberia March 2020 lockdown, April 2020 witnessed a 30.0% decrease in all inpatient admission, 40% in malaria diagnoses and 28% in antenatal obstetric care (18). Similarly, our finding reports a reduction of 39% in fully immunised <1 year and 35% in measles 2nd dose in the same period of April 2020. Therefore, our findings of a significant decline in PHC headcount <5 years, ANC visits before 20 weeks and PNC visits within six days, during the Covid-19 pandemic and precisely the March 2020 lockdown add to the body of existing evidence that acknowledges the disruption of maternal and neonatal, and child healthcare and generally essential healthcare services by the Covid-19 pandemic.

4.3.3 The recovery of essential healthcare services

Generally, our findings suggest there was no significant recovery in any of the provincial MNCH indicators post-lockdown, over the study period. Any recovery could only be examined statistically

through the ITS analysis (Figure 3 and Table 3). Nonetheless, service delivery indicators (measle and fully immunised) and one utilisation indicator (PHC headcount <5 years) and health outcome indicators attempted to recover. Although the recovery for PHC headcount <5 years and delivery indicators is appreciated, there is a need to support ANC and PNC indicators that deteriorated during the post-lockdown period. Moreover, efforts are needed to halt the recovery or the increase in the mortality (outcome) indicators.

The present study among a few other ITS analyses seems to be isolated and advantageous because of the examination of service recovery trends (post-lockdown). Contrary to our findings that showed no recovery in healthcare services post-lockdown, a study in Uganda with an ITS analysis found that immunisations and ANC visits significantly recovered once the lockdown was lifted (58). The recovery disparities between the present study and this Ugandan study may arise from the different data sources, qualities and study periods among other factors.

4.3.4 District variations in Covid-19's impact on essential services

Our findings from the regression analysis identified a slight geographical/district variation of Covid-19's adverse impact on essential healthcare services. The scale of service utilisation was different among the districts but the nature of the change was often the same (a decrease). For example, in Table 4, the decrease in PHC headcount <5 years was significant among all five districts in Gauteng province. But the size of the effect (decrease) is slightly different among the districts. And Table 5 proves that these differences are only significant between the metro and non-metro districts, implying that the effect (decrease) of PHC headcount <5 years was more in the metro than in the non-metro districts. The differences could be attributed to the noise in the data. By the time this study was concluded, very few statistical analyses had been performed on the geographical variations of Covid-19's impact on essential public healthcare services. However, a few studies (9,26–28) have signposted geographical variations in the disruptive impact of Covid-19 on essential public healthcare services as discussed below.

Also, the five districts in Gauteng province all differ in the effect of Covid-19 and as such suggest that the factors that influenced routine service disruption varied across the different districts. Given that the effects are mostly for utilisation services, they are more likely demand-side variations but we did not know how they occurred.

Our analyses are similar to the reports from a study on the variation of Covid-19 impact on maternal and reproductive health in South Africa which showed that different provinces were impacted differently (26). The authors of this review argued that the rural provinces witnessed more pressure on health services because pregnant women migrated to their home (rural) locations due to the fears of concentrated Covid-19 infections in the urban provinces.

On the other hand, the present study suggests a dichotomy in the adverse impact of Covid-19 wherein, PHC headcount <5 years reduced significantly more in the metropolitan municipalities of Johannesburg, Tshwane/Pretoria and Ekurhuleni compared to the non-metropolitan municipalities of West Rand and Sedibeng. We support the argument that the disparities between the metro and non-metro districts could have been that the metros had a high burden of Covid-19 and hence diverted more resources to fight Covid-19 than the non-metros which led to more services disruption in the metros (9). This aligns with and supports the evidence from a similar and lone study with a reference region which found that Covid-19 severely reduced the number of surgical specialities trainees in the UK. And added that the impact was different across the various regions which reflected the inequalities in regional resources before the Covid-19 pandemic which influenced the way the different regions responded to the pandemic (27).

Our finding of an increase in facility deaths in 0-6 days in the Tshwane/Pretoria district compared to the other districts, is similar to a previous prospective observational study that took place in Nepal and concluded that neonatal mortality increased significantly during the Covid-19 pandemic while the quality of care decreased (59).

One of our findings suggests that pneumonia case fatality <5 years reduced significantly in Tshwane/Pretoria district compared to the other four districts. This meant that child health outcomes became better during the process of service disruption except that deaths in facilities 0-6 days in Tshwane increased significantly. We suggest that this could have resulted from underreporting of pneumonia deaths in the Tshwane district during Covid-19. Studies in New Zealand and Canada have demonstrated that under-reporting gives a false impression of realities in maternal and perinatal and pertussis studies respectively (60,61).

This objective presents the importance of understanding the heterogeneity of Covid-19's impact on district-level essential healthcare services for maternal, neonatal and child health to develop urgent policies to redress the affected services while prioritising specific districts. The present study is the first study from low and middle-income countries to statistically assessed district variations in the impact of Covid-19 on essential healthcare services.

4.3.5 Reasons for and mechanism of service disruption during Covid-19

Our study highlights several reasons and mechanisms for the disruption or deferment of essential public healthcare services. From the supply perspective: firstly, it was important to reallocate resources and focus attention on fighting the Covid-19 pandemic. Our study pinpoints this decision as a clinical risk intended to save lives. Similarly, other studies have reported that to fight the Covid-19 pandemic, there was a need to reallocate resources (10,11). Most studies have focused their attention on the

redeployment of health personnel, ignoring the material aspect of resources that were redeployed (10,11).

Secondly, our respondents suggested that the shortage of healthcare workers, particularly nurses and doctors, was one major challenge which led to the disruption of essential public healthcare services during the Covid-19 pandemic. This finding agrees with studies that have assessed health system challenges during Covid-19 and highlighted a shortage in the healthcare workforce, including a South African study focusing on the World Health Organization (WHO) system building blocks (54). These studies (12,35) from different settings seem to concur that most healthcare workers' shortages were because workers were in quarantine, absent for fear of being infected or because the healthcare workers were redeployed to fight Covid-19 (5,6,17).

The recruitment of new nurses and doctors, and the use of incentives to discourage resignation by existing healthcare workers, were proposed as solutions to increase healthcare workforce capacity (54). Another South African study found that healthcare workers were redirected from TB services to Covid-19 care and that this caused a deterioration in the health of TB patients and increased the burden of TB because their conditions were left unattended (12). Non-South African studies across China, Africa, Italy, the UK and the USA, and Spain, have identified shortages in healthcare personnel and medical equipment as key challenges in the Covid-19 response (1,2,62–64).

Another finding from our study as a reason for service disruption from the supply side is that health facilities actively turned away patients who went to facilities for non-Covid-19 services. This was not unique to Gauteng or LMICs. For example, a study found that more than 1 in every 10 methadone clinics in the US and Canada refused to accept new patients due to Covid-19 challenges (65). In a bid to fight Covid-19, healthcare facilities sought to reduce routine services utilisation globally, with inadequate consideration of the consequences.

From the demand perspective, our study suggests that the fear of being infected by Covid-19 at healthcare facilities reduced health-seeking behaviour during critical Covid-19. Interestingly, other studies reported similarly that fear of being infected at facilities reduced the number of people seeking healthcare, due to public opinions that Covid-19 was concentrated at healthcare facilities. Such fear increases if people were found with Covid-19, plus the stigma that already existed towards vulnerable groups like TB and HIV clients (35). Again, such fear influenced the utilisation of newborn care as reported in a study from Northern Ghana (66). Similarly, the fears of contracting Covid-19 at hospitals coupled with movement restrictions were postulated to have been responsible for the reluctance of pregnant women to use antenatal care causing increased stillbirths in India, Nepal and England (59,67).

In addition, we found that two overlapping factors that contributed to service disruption were the restriction of public movement and limited public transportation during the lockdown. Another related study has also reported that the lockdown movement restrictions were the main explanation for delays in child vaccination and the utilisation of other routine services (68). In China, people living with HIV stayed in their homes during the lockdown and were not able to refill their medication due to movement restrictions (69). Hence, our findings support previous studies to show that movement restrictions affected the demand and supply of routine healthcare services during Covid-19 (68,69).

Our findings also suggest that the misinterpretation of health information contributed to lower healthcare utilisation. Many studies have investigated barriers to accessing healthcare focusing on language and misinterpretation (70). In present-day studies, misinterpretation and misinformation from social media have escalated vaccine hesitancy against Covid-19 (30,71,72), both in high and low-income countries (71,73) and even among medical personnel (74,75). However, there seems to be no study on the misunderstanding of health information by patients themselves. We have not investigated the quality of the information provided in this study. Healthcare managers and workers should have training in communication skills. Better use could also be made of behavioural change and communication experts for delivering public health information (76,77).

Lastly, our interviewees identified a barrier to health-seeking due to measures imposed in facilities such as compulsory screening against Covid-19, which results in long queues and waiting times. That seems likely to have been a factor, but we were not able to find evidence in the existing literature to support or refute this claim. These reasons and mechanisms explain the changes behind the statistical results.

4.3.6 Consequences of essential service disruption during Covid-19

Our findings show that although essential healthcare services were disrupted during the Covid-19 pandemic, there was little significant impact on MNCH health outcomes. The only effects of health outcomes were observed in the Tshwane district (Table 4) where facility deaths 0-6 days significantly increased while pneumonia fatality <5 years decreased. Even Johannesburg as the reference district did not experience such a positive impact on pneumonia fatality compared to Tshwane (Table 5). Our study respondents reported that due to service disruption, some outcomes were immunocompromised, loss-to-follow-up of HIV, TB and elderly clients and subsequent deaths. Some studies have shown a similar pattern of the deleterious impact of Covid-19 service disruption on health outcomes. HIV, cancer, and soli-organ transplant patients among other malignancies who were immunocompromised were at risk of Covid-19 and death as reported in one study (78). Another study from Nepal has shown the disruptive effect of Covid-19 where the redeployment of healthcare resources to fight Covid-19 caused an increase in neonatal mortality (59).

However, Figure 2 shows some trends of the impact of service disruption on MNCH indicators but a majority of them lack a statistical effect. This may arise from the quality of the data or the choice of indicators. Also, it is difficult to ascertain the opinions of the participants as they are "opinions" per se. Perhaps further analysis that focuses only on outcomes indicators and from randomised control trials (RCT) studies could capture the real effect of Covid-19 service disruption on health outcomes.

4.3.7 Strategies to maintain routine services during Covid-19 and future outbreaks

Our study suggests that the integration of routine healthcare services into the Covid-19 response package was effective because it ensured the continuation of basic healthcare and minimised the undesired poor outcomes during the Covid-19 pandemic. Though this was implemented late in the epidemic in South Africa. Multiple studies encouraged the integration of routine services into Covid-19 services, arguing that service integration increases health systems equity and efficiency, especially in low-income countries with limited resources (79–83). Rather than forgo routine services to focus on an outbreak, services such as immunisation could have been integrated into the Covid-19 response. For example, the could be the simultaneous immunisation of vulnerable children while screening against Covid-19 (83,84).

Also, GDoH managers suggested that technology played an important role in service delivery during the Covid-19 pandemic. During Covid-19 with movement restrictions, social distancing and fears of visiting facilities, follow-up of some chronic disease cases was done through electronic and technological devices. There are several terminologies for remote routine service delivery which include telemedicine, telehealth, mobile health (m-health), and electronic health (e-health). Telemedicine is the distance practice of medicine and is enhanced by telemedicine peripherals (85). Several studies have highlighted the role of high-tech in healthcare service delivery during the Covid-19 pandemic. In China, 42.3% of physical hospitals nationwide were transformed into 'internet hospitals' (1,86). Companies such as WeDoctor and Alibaba Health in China were at the forefront of implementing Internet hospitals (87). Others took advantage of 5G to extensively assist hospitals and frontline medical workers (88), and to install robots for automated medical services such as temperature measurements, drug delivery, disinfections and repetitive tasks (89). This reduced the influx of people into hospitals and scaled-up routine service delivery. However, some studies have evaluated the cost-effectiveness of telemedicine and have had contradictory results but often concluded that the implementation of telemedicine should be motivated by benefits other than finance alone (90,91).

Lastly, our study respondents suggested that routine services during Covid19 were eventually addressed and improved by the adoption of a catch-up plan. Although "catch-up plans" are traditionally used to improve immunisation, our participant seemed to use the term "catch-up plans" in a broader context to involve not just immunisation but all other services with lost-to-follow-up cases. There is evidence that

catch-up campaigns increased measles immunisation rates in Uganda (58) and a study has recommended a catch-up to improve immunisation in South Africa (22). Another study conducted nationwide in Japan found that routine childhood vaccination dropped remarkably during the Covid-19 outbreak and recommended a catch-up vaccination program to redress the deficit (68).

4.3.8 Mixed findings of the effect of Covid-19 on essential healthcare services

Despite the pronouncement of Gauteng as the epicentre of Covid-19 in South Africa and overwhelming evidence about the disruptive impact of Covid-19 on essential healthcare, some of our quantitative and qualitative findings suggest that not all services were affected by Covid-19. This could be supported by the number of essential healthcare indicators that were not significantly affected during severe Covid-19 such as provincial immunisation in Gauteng. Also, GDoH managers argued that services were not affected because the GDoH established an additional healthcare capacity or employed extra resources to cater for the demands of Covid-19 and this led to the continuation of routine healthcare services. In addition, the limited impact on routine service disruption was influenced by the realisation of the gap in service delivery and early efforts to mobilise resources and maintain essential services (54).

Similarly, another South African study reported that adult ambulatory care was not impacted by Covid-19 (22). Some other studies have also found that Covid-19 did not affect certain routine healthcare services (7,21,26,50). One such analysis is a pre-post study by Desta et al (50) in Tigray in Northern Ethiopia which found that even though the Covid-19 pandemic impacted some essential health services, others like outpatient visits and admissions were not affected. In the current study, the plots in Figures 1, 2 and 3 suggest downward patterns at the start of the lockdown, but not all of these changes proved statistically significant. This suggests that not all services were significantly disrupted by Covid-19.

In contrast to our findings that the disruption of services utilisation by Covid-19 was more in the metropolitan municipalities compared to the non-metropolis and supported by other studies (9,27), we also found that some services like ANC 1st visits before 20 weeks were more impacted (declined) in non-metropolis like Sedibeng and West Rand districts compared to a big metropolis like Johannesburg. This corroborates with the study by Pattinson R (26) who reported an increase in the pressure of routine healthcare services in rural provinces in a South African health review.

4.4 Study limitations

The findings of this study should be considered alongside the following limitations: As with all secondary data analyses, this study does depend on the quality of the primary DHIS data. However, missing data and inaccuracies were mitigated by checking and correcting the values with the District Information Officers (92) and the GDoH statistician.

The DHIS only provides information for patients presented at public facilities, which does not represent the entire population's experience of Covid-19. However, in the absence of a more comprehensive dataset, DHIS data can still allow useful analyses. Also, the large sample size emanates from all the 426 public healthcare facilities within Gauteng province strengthens the internal validity of the analyses.

The use of the DHIS dataset only permitted us to do observations. There were no potential confounding, counterfactual or control variables which could provide alternative explanations for the observed changes. In addition, the qualitative component of the study also did not extensively explain the changes in MNCH services but rather emphasised on chronic diseases for which there was no analytical analysis. In the absence of an RCT, we used the ITS analysis as an alternative (quasi-experimental).

Also, it was difficult to disentangle the supply and demand effects in the data. And finally, the DHIS did not capture monthly data for chronic diseases like HIV and TB for the study period hence, we could not conduct statistical analysis on chronic diseases although the participants frequently discussed it.

4.5 Study strengths

This study has some strengths that make the findings valid and useful. Firstly, the study was conducted over a longer period of 12 months (1 year), after the March 2020 lockdown compared to some previous local studies conducted only a few weeks (21) or three months (7) into Covid-19. These earlier studies recommended further studies over a longer period, as the present study has done.

Secondly, other studies conducted in South Africa in this regard were either a document review (54) or a descriptive study (21) or a few quantitative studies (7,22). The present study used mixed methods which added additional insights because the quantitative findings were better explained by the qualitative data. The large sample size and the power of the analysis avoided type I and type II errors (93).

Moreover, the ITS quasi-experimental analysis is also the strength of this study because ITS analysis helped to determine the immediate impact of the Covid-19 lockdown, the change in gradient and the post-lockdown trends which were compared to the pre-lockdown trends to establish the effect of the Covid-19 pandemic on essential healthcare services (45). This leads to the credibility and internal validity of the findings.

In effect, the present study is seen as the first study in low and middle-income countries to statistically assess district variations in the impact of Covid-19 on essential healthcare services. Furthermore, the strength of this study is backed by the multiple quantitative analysis for robustness.

Another strength of this study is that we controlled for seasonality and therefore captured the real impact of Covid-19 on health services. Finally, most of the policy recommendations are from senior GDoH managers, therefore, we anticipate that they will accept and implement their policy suggestions.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The Covid-19 pandemic disrupted the utilisation of essential healthcare services for MNCH. Although service delivery and health outcomes were less impacted, some outcome indicators at district levels deteriorated. While there were recovery attempts for service delivery like immunisation, some services rather deteriorated post-Covid-19 lockdown. However, there were mixed findings, fewer routine services were not affected by Covid-19. It is important to continuously assess and redress the unintended impacts of outbreaks even while they are occurring. This requires an understanding of the reasons and mechanisms of service disruption from demand and supply perspectives. Critical policies like lockdowns should be a collective decision, implemented without undermining routine services. High-level policymakers must consider addressing geographical variations of an outbreak's impact on essential healthcare services. Covid-19 may have more complex long-term effects, especially for individuals with adverse social determinants. And it may take longer for some healthcare services to fully recover hence, the need for health systems interventions to prioritise the affected services.

5.2 Recommendations

From our findings, we have suggested recommendations to be implemented by national, provincial, and district health management authorities as well as other government and non-governmental institutions, and stakeholders, with an expectation to improve essential healthcare service utilisation and delivery and health outcomes during an outbreak. These include:

1. During outbreaks like Covid-19, health systems should balance dealing with the outbreak and maintaining the delivery of essential public healthcare services. In the worst-case scenario, the disruption of routine healthcare should be minimised.

2. Important healthcare information about service delivery during an outbreak should be communicated clearly and effectively to avoid misinterpretation and misinformation. In addition, to advert the fear and panic of visiting facilities and being infected during outbreaks such as Covid-19, we suggest that there should be a central and specialised unit of communication whose staff should be health communicators. This expertise could bridge the gaps in misunderstanding or misinformation of health messages. Likewise, our study supports the patients' education.

3. High-level inter-sectoral, inter-ministerial, provincial and district engagements should address the reasons and mechanisms through which Covid-19 impacted routine healthcare services. During lockdowns and movement restriction periods, public authorities should provide alternative forms of transporting people to healthcare facilities.

4. The continuous decline in some indicators, for example, provincial mother postnatal visits within six days and antenatal 1st visits before 20 weeks even before the Covid-19 outbreak is a concern hence, we recommend a further investigation of possible factors or causality that influences the perpetual decline in these indicators. As well as the indicators that show no signs of recovery and have rather gone worst in the post-lockdown period such as deaths in facilities 0-6 days.

5. These study's results were based on March 2020- February 2021 data. We recommend further study with more recent data to confirm the present situation, and whether or not routine healthcare services have properly recovered.

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APPENDICES

Appendix A: Interview guide

1. How severe was the coronavirus in the province (Gauteng)?
2. How has it affected the delivery and utilization of routine health service delivery?
3. In your opinion, is there a group of people who are more vulnerable than others in terms of their routine medical care because of COVID-19 lockdown measures?
4. Are there geographical variations by districts in COVID-19 effects within the province? And what may account for these variations?
5. Is there a plan by GDoH to protect routine healthcare services against the potential new resurgence (wave) of COVID-19 in the future and what are they?
6. Do you have any questions for me? Is there anything else that's important to know about how your department responded to the disease?

Supplementary questions

a. What lessons have the health system in Gauteng learned from the Covid-19 outbreak?
b. Are there any strategies to handle Covid-19 that you adopted from other provinces and they were effective in Gauteng?
c. What has worked best in some districts and facilities in Gauteng that others should emulate when handling a pandemic such as Covid-19?
d. Has Covid-19 created any opportunities for the health system?
e. What recommendations can be made to ensure the continuation of essential healthcare services delivery? And that the population utilises them during a pandemic such as Covid-19.

Appendix B: Information sheet

Study title:
The impact of the Covid-19 pandemic on essential public healthcare services in Gauteng province, South Africa.

Greetings:
Good morning, my name is Cyril Bernsah Fonka. I am a Master of Public Health student at the University of the Witwatersrand-Johannesburg.

Introduction
This research aims to assess the impact of the Covid-19 pandemic on access to, service delivery and health outcomes for maternal and child health, HIV/AIDS, and TB services in Gauteng, South Africa.

Invitation
You have been invited for an in-depth interview based on your responsibilities and roles as senior managers in the GDoH. The purpose of this interview and study is to understand the GDoH senior managers' perspectives on the impact of Covid-19 on essential public healthcare services in Gauteng and the policy implications of this for managing future epidemics. You will be asked open-ended questions and the session will last for an average of 30 minutes. The interview will be audio-recorded if you agree and a note will be taken as well.

Risks of being involved in the study:
There is no risk associated with your involvement in this study.

Benefits of being in the study
There will be no personal costs to you or direct benefits if you participate in this study. There are no disadvantages or penalties if you do not choose to participate.

Participation is voluntary
Your participation in this study is strictly voluntary. You are free to withdraw at any time and as such, any data collected from you will be destroyed unless you specifically consent to its retention.

Confidentiality and Anonymity
Your confidentiality is fully guaranteed. We will stick to the ethics regulations to protect your identity. The report will be anonymous. We will use codes such as senior manager 1, 2 or respondent X, Y etc, to represent managers in the final research report.

Outputs
The results will be submitted to the School of Public Health at the University of the Witwatersrand for the assessment of my degree qualification (Master of Public Health-Health Economics). The results will be published in an academic journal. Presentations will be done at conferences and seminars to inform GDoH, public health experts and Non-Governmental Organisations about the research findings.

Contact Information
For any ethical issues or follow-up contact:
The Chairperson of Wits Human Research Ethics Committee (HREC) Professor Clement Penny,
Tel No: 011 717 2301, e-mail: Clement.Penny@wits.ac.za. The Committee secretariat Tel: 011 717 2700/1234, e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Researcher: Cyril Bernsah Fonka, Tel No: 078 869 728, e-mail 2371513@students.wits.ac.za
Supervisors: Dr Duane Blaauw, Tel No: 0822 9573 77, e-mail Duane.Blaauw@wits.ac.za
Dr Worku Eshetu, Tel No: 0727 0380 37, e-mail Eshetu.Worku@gauteng.gov.za

Appendix C: Consent form

Project Title: The impact of the Covid-19 pandemic on essential public healthcare services in Gauteng province, South Africa.

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the study would immediately be destroyed, unless I give consent for it to be retained.
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Principal investigator: Cyril Bernsah Fonka, e-mail 2371513@student.wits.ac.za

Supervisors: Dr Duane Blaauw, e-mail Duane.Blaauw@wits.ac.za
Dr Worku Eshetu, e-mail Eshetu.Worku@gauteng.gov.za
Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: _____
Date: _____
Place: _____
Signature or mark _____

Witnessed by:
Name of Witness: _____
Signature: _____
Date: _____

Appendix D: Audio/visual recording consent form

The researcher has my permission to audio/visual record my interview and he has clearly explained the reasons for the process. I have been assured that I can stop the focus group discussion/interview process at any time and ask for the recorded file to be deleted at my request.

I understand that the recording and its transcription will be kept confidential at all times and stored in a password-protected computer until such time that it is permanently deleted.
I consent to have the interview audio-recorded.

Participant's name_____
Participant's signature:_____Place:_____Date:_____

Researcher's name_____
Researcher's signature_____Place:_____Date:_____

Appendix E: Ethics clearance-Wits HREC Ref No; M220149

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Mr CB Fonka

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M220149

NAME: (Principal Investigator)	Mr CB Fonka
DEPARTMENT:	School of Public Health Medical School University
PROJECT TITLE:	*The impact of the Covid-19 pandemic on essential public healthcare services in Gauteng Province, South Africa*
DATE CONSIDERED:	2022/01/28
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:	Drs D Blaauw and W Eshetu
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/03/24

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 January and therefore reports and re-certification will be due in the month of January each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

24/03/2022
Date

Appendix F: GDoH approval, NHRD Ref no: GP_202203_031

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Multi- District Research Sub-Committee of Gauteng Health

Enquiries: c/o Ms. Sibongile Khumalo
Email: Nozi.Khumalo@gauteng.gov.za

Date: 24th May 2022

ATT: Mr Cyril Fonka

Email: fcyrilbernsah@gmail.com

Dear Sir/Madam

TITLE OF STUDY: THE IMPACT OF THE COVID-19 PANDEMIC ON ESSENTIAL PUBLIC HEALTHCARE SERVICES IN GAUTENG PROVINCE, SOUTH AFRICA.

NHRD Ref no: GP_202203_031

OFFICIAL APPROVAL

The Gauteng Multi-District Research Sub-Committee has reviewed your application. This letter serves as a Final Permission letter to conduct this study in the following Health Districts of the Gauteng Department of Health: Johannesburg, Ekurhuleni, Tshwane, Sedibeng and West Rand. See list at the end for details.

The following conditions must be observed:

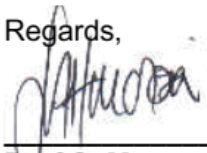
- This permission does not cover any hospitals NOT listed above.
- These facilities will be visited from: **24/05/2022 to 24/03/2027**
- Please liaise with relevant DRC Coordinators to assist you further.
    - Jhb: Prof. S. Moosa (shabir@profmoosa.com)
    - Sedibeng: Prof O. Omole (Babatunde.Omole@gauteng.gov.za)
    - West Rand: Dr E. Wenegieme (doctoreggy@yahoo.com)
    - Ekurhuleni: Dr R. Kellerman (DRC) Ronel.Kelleman@gauteng.gov.za
    - Tshwane: Dr. M. Letebele (Manei.Letebele@gauteng.gov.za).
- Participants' rights and confidentiality will be maintained all the time.
- No resources (financial, material and human resources) from the above facilities will be used for the study. Neither the District nor the facility will incur any additional cost for this study.
- The study will comply with Publicly Financed Research and Development Act, 2008 (Act 51 of 2008) and its related regulations.
- You will submit an annual / final progress report to the Multi-District Research Committee.

- The Gauteng Department of Health must be acknowledged in all reports/publications generated and a copy of these reports/publications must be submitted to the Multi-District Research Committee.
- Your supervisor and the university (if applicable) will ensure that these reports are being submitted to the Multi-District Research Committee.

We reserve our right to withdraw our approval, if you breach any of the conditions mentioned above. Please feel free to contact us, if you have any further queries.

On behalf of the Multi-District Research Committee, we would like to thank you for choosing Gauteng Health Districts to conduct such an important study.

Regards,



Prof S. Moosa (Jhb DRC)
on behalf of Multi-District Research Sub-Committee: Prof O. Omole (Sedibeng DRC), Dr E. Wenegieme (West Rand DRC), Dr R. Kellerman (Ekurhuleni DRC) and Dr. Manei Letebele (Tshwane DRC).
Date: 24th May 2022

The ethics approval from the individual districts is with the researcher and could be made available upon request.

Appendix G: 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

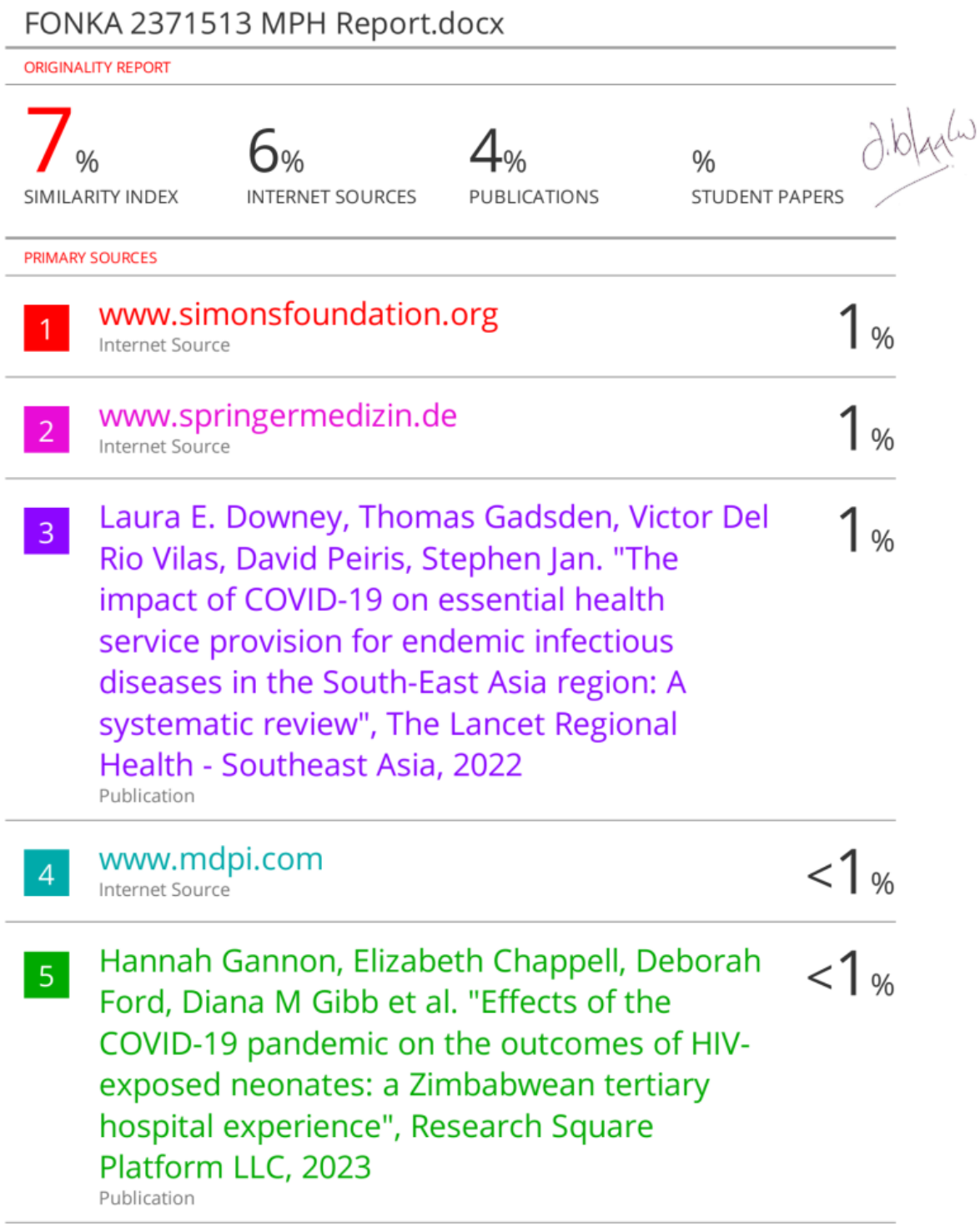
I Cyril B. Fonka (Student number: 2371513) am a student registered for the degree of MPH-Health Economics in the academic year 2023.

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: Cyril B Fonka Date: 28/03/2023

Appendix H: Signed Turnitin report



FONKA 2371513 MPH Report.docx

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3	Laura E. Downey, Thomas Gadsden, Victor Del Rio Vilas, David Peiris, Stephen Jan. "The impact of COVID-19 on essential health service provision for endemic infectious diseases in the South-East Asia region: A systematic review", The Lancet Regional Health - Southeast Asia, 2022 Publication	1%
4	www.mdpi.com Internet Source	<1%
5	Hannah Gannon, Elizabeth Chappell, Deborah Ford, Diana M Gibb et al. "Effects of the COVID-19 pandemic on the outcomes of HIV-exposed neonates: a Zimbabwean tertiary hospital experience", Research Square Platform LLC, 2023 Publication	<1%