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Impact of the COVID-19 pandemic on maternal, neonatal and child health service utilisation, delivery and health outcomes in Gauteng province, South Africa: an interrupted time series (ITS) analysis

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ABSTRACT

Background Gauteng was one of the provinces in South Africa most hit by COVID-19. However, there has been no assessment of the pandemic's impact on essential maternal, neonatal and child health (MNCH) services in Gauteng, for planning against future emergencies. This study sought to assess the impact of the COVID-19 pandemic on essential MNCH service utilisation, delivery and health outcomes in Gauteng province.

Methods We employed a quasi-experimental interrupted time series (ITS) study design, using the District Health Information System (DHIS) data set to evaluate the impact of COVID-19 on eight key MNCH indicators between March 2019 to February 2021. Using Stata V.17.0 and 5% alpha, a segmented linear regression (ITS) model quantified the trends of the indicators before COVID-19 (March 2019 to February 2020) (β1), the immediate change in level due to the March 2020 lockdown (β2), the post-lockdown (March 2020 to February 2021) trend (β4) and the change in gradient from before to after the lockdown (β3).

Results COVID-19 lockdown exerted a significant decline in primary healthcare headcount<5 years (n) (β2= −60 106.9 (95% CI, −116 710.4; −3503.3), p=0.039); and postnatal care visits within 6 days (rate) (β2=−8.2 (95% CI, −12.4; −4.1), p=0.001). Antenatal care first visits before 20 weeks (rate) declined during COVID-19 (β3=−0.4 (95% CI, −0.7; −0.1), p=0.013) compared with the pre-COVID-19 period. COVID-19 adverse effects on service delivery (measles second dose coverage and fully immunised<1 year) and health outcomes (facility deaths 0–6 days, maternal mortality ratio and pneumonia case fatality<1 year) were insignificant. While some indicators post-lockdown attempted to recover, others deteriorated.

Conclusion In Gauteng province, the COVID-19 pandemic significantly disrupted essential MNCH service utilisation, particularly during the March 2020 lockdown. The mechanism of MNCH service disruption by COVID-19 was induced by both supply and demand services. It is imperative to strike a balance between maintaining routine healthcare services and managing an outbreak.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The inclusion of all 426 public healthcare facilities in Gauteng province provides a population perspective of the real impact of COVID-19 on maternal, neonatal and child health services in the province.
⇒ The equal number of data points: 12 points pre-COVID-19 and 12 points during COVID-19 sufficiently powered the study, controlled for seasonality and autocorrelation.
⇒ The routine District Health Information System only reports public facility data which is subject to data entry errors. However, missing data was double-checked and the large sample in the study compensate for generalisation.
⇒ It was difficult to disentangle the supply and demand effects in the data but this was halfway attained by classifying the MNCH services as service delivery, utilisation and outcome indicators.
⇒ The interrupted time series analysis is a quasi-experimental study design and highlights the interruption of COVID-19 in March 2020, hence, the attribution of MNCH service disruption to the pandemic.

INTRODUCTION

COVID-19 is one of the most significant healthcare challenges of the 21st century that has exposed the unpreparedness of health systems globally, to adequately prevent, detect and manage a pandemic.[1] COVID-19 is a highly contagious severe viral respiratory infectious disease that has contributed to a significant increase in global mortality.[2] Worldwide, the response to mitigate the spread of COVID-19 and the treatment of infections indirectly affected essential healthcare service delivery and utilisation and health outcomes. For instance, in Latin America and the Caribbean, COVID-19

attention undermined health service coverage for women and children, circumventing the efforts made to attain the Sustainable Development Goal (SDG) 3 targets, crafted to substantially reduce maternal, neonatal and under-5 mortality by 2030 through universal health coverage.[3] Even in developed countries like Britain, the disruption extended to access to sexual and reproductive health,[4] endorsing the adoption and transfer to technological alternatives like telehealth and internet hospitals for remote service delivery.[5]

Sub-Saharan Africa (SSA) and generally low- and middle-income countries (LMICs) experienced more of a disruption in healthcare access attributed to the COVID-19 pandemic. These countries witnessed significant disruption specifically in maternal and child healthcare service delivery and utilisation, further exacerbating the weakening of the health system already strained before the COVID-19 pandemic.[6 7] Prior to the outbreak of COVID-19, there was a decrease in the maternal mortality rate in SSA by 38%. This corresponds to a decline of 2.9% on average each year. Despite this reduction, it falls short of the 6.4% annual rate required to reach the global SDG of 70 maternal deaths per 100 000 live births. Global estimates of the indirect impacts of COVID-19 suggested a 38.6% increase in maternal mortality and a 44.7% increase in child mortality per month across 118 LMICs.[8] As such, public health advocated for the urgency to prioritise mother and child health like immunisation to protect these vulnerable populations against the pandemic.[7] Hence, minimising the morbidity and mortality related to COVID-19 among pregnant women and obstetrical outcomes like stillbirth predominantly correlated with the Delta variant of COVID-19.[9] However, adequate surveillance systems and timeliness of vaccination during the pandemic were shown to be important for ensuring essential maternal and child service delivery, resulting in increased routine childhood vaccination coverage and better health outcomes in Gambia.[10]

South Africa is one of many countries that implemented multiple mitigation responses, including lockdowns, to limit the spread of the infections. However, these measures disrupted the access to and delivery of routine healthcare services,[1 11] particularly for maternal and child health.[12] According to the National Institute for Communicable Diseases,[13] the first COVID-19 case in South Africa was reported on 5 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.[14] 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 pandemic. Lockdowns, though necessary, also affected the utilisation of routine healthcare services, producing poorer health outcomes in non-COVID-19 patients who could not access healthcare facilities for treatments.[12] For example, the WHO highlighted that due to COVID-19, 24 counties postponed measles immunisation, which could make 117 million children more susceptible to measles.[15] Also, the service disruption caused an increase in maternal mortality, stress, depression and anxiety, in general, mental health exacerbation in pregnant women due to changes in medical care and lack of social support, even with infants and children, compared with the pre-pandemic rates.[16 17] Inadequate human resources in the national health system were partly responsible for the disruption in the supply of essential healthcare services during COVID-19.[18–20] Evidence suggests that in addition to this, other factors that resulted in poor maternal and child health outcomes include reduced attendance for routine antenatal care among pregnant women due to fear of getting infected and the redeployment of healthcare workers to fight the pandemic.[21]

Several South African studies have investigated changes in essential healthcare service provision, access and utilisation during the COVID-19 pandemic.[12 13 22] In an observational cohort study that used an interrupted time series (ITS) analysis in rural South Africa, clinical attendance and hospital admission dropped drastically when compared with the baseline monthly average before the COVID-19 outbreak.[13] Also, a retrospective review in the KwaZulu-Natal province revealed that neonatal and child health experienced low rates of both service delivery and utilisation due to COVID-19 restrictions.[12] The analysis indicated a 42% and 30% reduction in facility headcounts and immunisation coverage respectively for children under 5 years, in April 2020 against the base year average from 2019 to 2020 pre-COVID-19. Another South African study conducted in Gauteng province, that was descriptive, using administrative data from the District Health Information System (DHIS), showed a decrease of 30% in client visits for primary healthcare (PHC) between March and April 2020, a 45% reduction in clients seeking contraceptives each month, and a 5% decline in abortion services.[23] The observations in April 2020 when compared with April 2019 pre-COVID-19, showed a negative impact of COVID-19 on family planning uptake.

Gauteng was one of the provinces in South Africa most hit by COVID-19[24–26] and it is also the most populous and representative of diversity in the country hence, the generalisability of findings for informing future policy and practice during health emergencies. However, there has been no assessment of the pandemic's impact on maternal, neonatal and child health (MNCH) services in the province, despite the importance of maintaining MNCH service delivery and decision-making against future emergencies. Therefore, this study seeks to investigate the impact

of the COVID-19 pandemic on essential maternal, neonatal and child healthcare services utilisation, delivery and health outcomes in Gauteng province.

METHODS

Study design

The study used a quasi-experimental interrupted time series design to investigate the impact of COVID-19 on essential public healthcare services in Gauteng, through an ecological data analysis, comparing key indicators of MNCH 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 Gauteng Department of Health (GDoH) over 2 years from March 2019 to February 2021, aggregated monthly.

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 some areas characterised as semi-urban and rural. DHIS data is reported daily from 426 public healthcare facilities comprising both fixed and mobile facilities. Gauteng is a highly urbanised and the most populated province in South Africa with a population of over 16 million people,[27] and has had the highest number of COVID-19 infections in South Africa but the third-highest mortality rate.[25]

Study population

The study population is patients who attended MNCH services in all 426 public healthcare facilities in Gauteng province from March 2019 to February 2021.

Data collection and management

In the DHIS, de-identified 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.[12 23] 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 3 years for improvement by the National Department of Health (NDoH).[12] Examples of domains include MNCH, HIV/AIDS and tuberculosis among many others.

All the dependent variables are numerical and continuous and were computed as counts, percentages and ratios. The independent variables of interest were the two time periods before COVID-19 (March 2019 to February 2020) and during COVID-19 (March 2020 to February 2021). We deliberately avoided the term 'after or post-COVID-19' because this study was conducted during the pandemic hence the term 'during-COVID-19' is reasonable. The data was obtained in a Microsoft Excel sheet from the GDoH, imported into Stata V.17.0 software and cleaned. Missing data were checked with the statistician of the DHIS for GDoH. All data was stored electronically in Google Drive-password encrypted.

Analysis

The impact of COVID-19 was robustly evaluated through ITS analysis.[28 29] In the absence of a randomised control trial, ITS analysis is a quasi-experimental alternative for analysing changes in trends and levels at a specific point.[29] We used the date of the first lockdown (March 2020) as the interruption point for this analysis. Appendix 1 shows a summary description of an ITS analysis.

A segmented ITS regression model was formulated to determine changes in the level and slope (trend) of the indicators at the interruption point. 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.[17] The segmented linear regression model tested the equation:

$$I_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 T X_t + \varepsilon_t$$

Where:

I_t is the indicator at time t,

T is the study time in months,

X_t is the dummy variable coded (0) and (1) before and during the COVID-19 lockdown respectively,

β_0 is the baseline I at T=0, and

ε_t is the error term,

Therefore:

β_1 is the trend in the pre-COVID-19 period,

β_2 is the change in level due to the COVID-19 lockdown, and

β_3 is the change in slope due to the COVID-19 lockdown.

β_4 is the post-lockdown trend which is calculated as $\beta_4 = \beta_1 + \beta_3$.

Autocorrelation was tested with the Durbin-Watson test.

RESULTS

To quantify the changes in the four parameters of the ITS analysis per indicator, we first draw ITS plots as presented in figure 1. Figure 1 shows that antenatal care (ANC) first visit before 20 weeks (rate) is the only indicator that 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 (rate) which saw an increase in its level during the lockdown and ANC whose lockdown level did not change, all the other six indicators witnessed a downward shift in their lockdown levels. The size of the change was different among the indicators. For example, the size of the decline at the lockdown (level) is much bigger in mother postnatal care (PNC) visits within 6 days (rate) and PHC headcount under 5 years (n) compared with the Maternal Mortality Ratio (MMR). The segmented regression results are presented in table 1 for the determination of significant changes in the indicators and parameters.

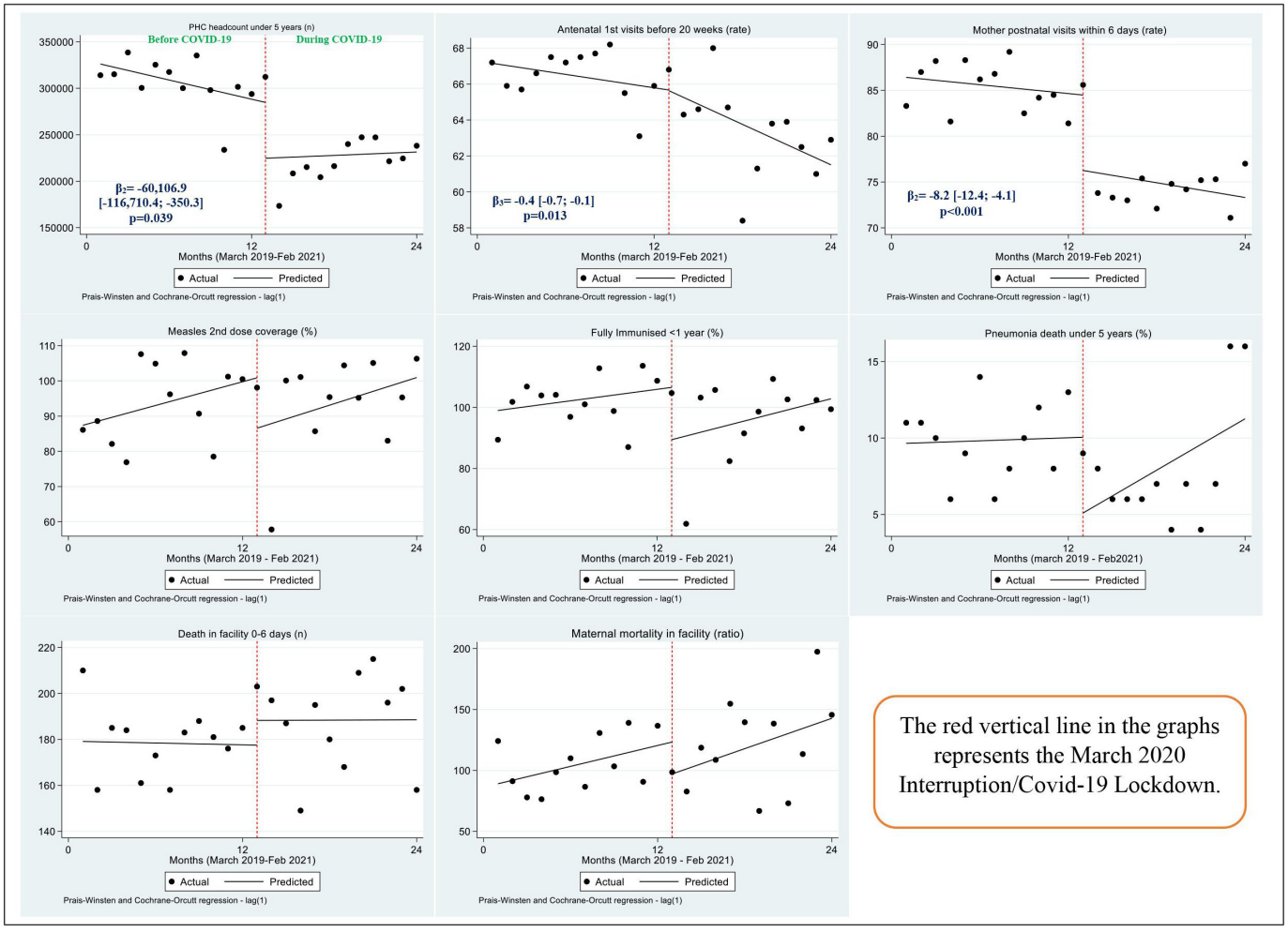


Figure 1 Interrupted time series plots of Gauteng provincial indicators (March 2019 to February 2021).

Table 1 shows a statistically significant impact of the COVID-19 lockdown for three of the eight indicators in this analysis. The immediate effect of the lockdown (β_2) was a significant decrease in the levels of two utilisation indicators, namely PHC headcount<5 years (n) and PNC (rate). In other words, there was a significant reduction in the number of children under 5 years and the number of mothers who took their children within 6 days after birth to healthcare facilities as a consequence of the level five lockdown of March 2020, well demonstrated in figure 1.

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. This implies that the gradient of ANC was less steep (fewer ANC first visits) during COVID-19 compared with the pre-lockdown period, illustrating that COVID-19 exacerbated the decline in ANC in Gauteng province.

All other changes in MNCH service utilisation parameters as well as service delivery and health outcome indicators were not statistically significant although some approached significance leaving a marginal effect. For example, MMR showed an increase in the post-lockdown trend compared with the pre-lockdown trend (β_3), which was almost significant (p=0.079).

Despite the changes in trends observed in figure 1, there was no significant change in the post-lockdown trends (β_4) in all eight indicators. 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 for certain indicators like deaths in facilities 0–6 days, Pneumonia case fatality under 5 years and MMR is undesired. Hence, only measles second dose, fully immunised, PNC, ANC and PCH headcount<5 years warranted a post-lockdown recovery. Moreover, deaths in facilities 0–6 days (rate) though statistically insignificant in the post-lockdown period, remained concerning because they became worse compared with the pre-lockdown period.

DISCUSSION

This study assessed the impact of the COVID-19 pandemic restrictions on essential MNCH service utilisation, delivery and health outcomes in Gauteng province. The study suggests that COVID-19 significantly

Table 1 Interrupted time series analysis of Gauteng provincial indicators (March 2019 to February 2021)

Category	Types of essential health services	Dependent variables	Pre-lockdown trend (Mar 2019 to Feb 2020)		Immediate change at lockdown (Level 5)		Change in trend (gradient) between pre and post lockdown		Post-lockdown trend (Mar 2019 to 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	**−60 106.9 (−116 710.4;−3503.3)**	**0.039***	611 (−6.1; 7334.7)	0.852	4054.2 (−4080.5; 12 188.9)	0.311
	Maternal and neonatal	ANC first 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 second 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

Statistically significance; *p=0.05, **p=0.001.
ANC, antenatal care; PHC, primary healthcare; PNC, postnatal care.

disrupted essential MNCH utilisation in Gauteng province, causing a drastic decline in PHC headcount<5 years (n) and PNC as an immediate effect of the March 2020 lockdown. And, a substantial decline in ANC during COVID-19, compared with the pre-COVID-19 period was observed. The pandemic caused an insignificant disruption in service delivery (measles second dose coverage and fully immunised<1 year). Health outcome indicators of facility deaths 0–6 days and MMR were insignificantly affected but remained concerning due to the increases in these two mortality indicators as a consequence of the COVID-19 disruption in service utilisation and delivery. Despite recovery attempts in some MNCH performance indicators post-lockdown, there were no significant improvements with some indicators deteriorating.

The current study highlights a significant disruption in MNCH service utilisation in Gauteng province as a result of the COVID-19 pandemic. The MNCH service disruption is consistent with several local and international studies that demonstrated the disruptive impact of COVID-19 on routine healthcare services.[12 23 30–39] For example, the current findings report a disruption in MNCH service utilisation in Gauteng province, particularly for PHC headcount under 5 years, ANC, and PNC due to the COVID-19 pandemic, which corroborates with the prediction model of Roberton *et al*[37] about the devastating impact of COVID-19 on maternal and child health in LMICs. In South Africa, a similar study that used the ITS analysis demonstrated a >50% reduction in child healthcare visits at the start of the national lockdown to show the disruptiveness of COVID-19 on essential healthcare services just like the present study.[22] In a broader perspective, an ITS analysis also highlighted the interruption of MNCH services as the immediate consequence of the lockdown in 18 LMICs.[6] Again, the disruption in MNCH service utilisation was a direct effect of non-pharmaceutical interventions such as lockdowns aimed at allowing health systems the opportunity to prepare and adequately respond to the pandemic.

The disruption of essential healthcare services utilisation by COVID-19 in the present study supports the evidence reported in previous studies about the adverse effect of infectious outbreaks on routine services.[30 32] For instance, the Ebola outbreak in West Africa limited access to and the utilisation of healthcare by disrupting services for vulnerable women and children.[30] The outbreak resulted in many deaths attributed to the country's strained health system rather than Ebola itself. Similarly, the Sierra Leone Ebola outbreak decreased antenatal and postnatal visits causing a 34% increase in maternal mortality and a 24% increase in the stillbirth rate.[40] Likewise, a Liberia cross-sectional study that used a mixed-method approach equally shows that the COVID-19 lockdown halted healthcare services, as the pandemic compromised access to facilities and the delivery of healthcare through movement restriction.[41] Therefore, our findings of a significant decline in PHC headcount<5 years, ANC and PNC, in general, MNCH service utilisation during COVID-19 adds to the body of existing evidence that acknowledges the disruption of MNCH by COVID-19. The trend of service disruption by Ebola and COVID-19 in previous studies[30 40] and the current study is an important reminder that the health system should anticipate and prepare against service disruption

during future outbreaks. Importantly, the response to future outbreaks should not undermine the continuum of essential healthcare. As policymakers consider plans to reallocate staff and resources, they might need to prioritise interventions. In our scenarios, maintaining coverage of four childbirth interventions (parenteral administration of uterotonics, antibiotics, anticonvulsants and clean birth environments) would save 60% of additional maternal deaths in future crises.[37] Maintaining coverage of antibiotics for neonatal sepsis and pneumonia and oral rehydration solution for diarrhoea would save 41% of additional child deaths. Disruption of these interventions (for childbirth and child curative services) cannot be mitigated through post-outbreak activities or easily averted through vertical health programmes outside of the public health system. The vulnerability of these interventions to disruption, and their substantial consequences for mortality, highlight the need to ensure the provision of these services throughout outbreaks or pandemics and support citizens in using these services as safely as possible.[37]

However, the current study also highlights some controversies by showing the mixed effect of COVID-19, which on the other hand and fortunately so, failed to significantly disrupt the delivery of routine services in Gauteng province as observed with measles second dose (%) and fully immunisation<1 year (%). Only three of eight indicators evaluated in the present study and three of the 32 parameters (4-ITS parameters (β_1, β_2, β_3 and β_4) per indicator) showed significant disruption in MNCH during COVID-19, possibly suggesting that GDoH response to the pandemic may have been mindful enough to avoid a major disruption in most essential healthcare services. We affirm that COVID-19's inability to disrupt some health services or that this mixed effect of the pandemic is not unique to the current study. For instance, Gambia experienced high childhood vaccination coverage and an improvement in timeliness during COVID-19.[10] Likewise, in the neighbouring Mozambique province of Nampula, COVID-19 did not interfere with ANC and surprisingly, stillbirth and neonatal sepsis significantly decreased during the pandemic.[21] This Mozambican study speculated that the reasons for service improvement could be attributed to the resilience of the provincial health system through effective communication, and the availability of essential services during the pandemic delivered by various stakeholders and actors.[21] South Africa on its part after the March 2020 lockdown measure,[14] called for the 'close collaboration between essential services and COVID-19 teams to identify priorities, restructure essential services to accommodate physical distancing, promote task shifting at the primary level',[38] and the mobilisation of resources and health system capacitation, COVID-19 grants and specifically, Gauteng province comprehensive response to COVID-19 with additional recruitments of healthcare workers, for example,[42] may have helped to prevent the disruption of child immunisation as noted in the current study. Also, Gambia prioritised childhood vaccination which was strategically integrated into COVID-19 vaccination sites (package), and community visits and radio sensitisation about COVID-19 and continuous childhood immunisation were responsible for its childhood vaccination success.[10] Therefore, the evidence suggests that a tactical response to outbreaks is a lesson for SSA countries through their political leadership to build robust and resilient health systems to adequately, timely and proactively respond to future emergencies.

On the other hand, the disruptive effect of COVID-19 on MNCH service utilisation and delivery in Gauteng province, led to an adverse impact on health outcomes, causing an increase in facility deaths of 0–6 days (rate) and MMR though statistically insignificant. This increase in neonatal deaths and MMR is of major concern for interventions to redress the mortality by revising the GDoH and NDoH strategic plans and implement more stringent interventions to achieve the SDG target 3.[3] Likewise, an earlier study in one of the South African provinces-KwaZulu-Natal, showed a significant but temporal increase of 47% in neonatal facility deaths in May 2020 during COVID-19.[12] Still, another study conducted in Kampala-Uganda from electronic medical records assessment using a similar ITS analysis reported a significant increase in neonatal mortality during COVID-19.[43] Therefore, the increased neonatal fatality and MMR in the current study and the aforementioned studies could only be attributed to the disruption in ANC service utilisation already highlighted in our findings, and supported by WHO recommendations that highlight a potential increase in maternal and child mortality in the absence of ANC[44] as well as the redeployment of services from routine care.[41] Additionally, COVID-19 disruption of vaccination coverage in the present study, though insignificant, still had meaningful implications. The recent 2022 measles outbreak in South Africa which started in the Ekurhuleni district in Gauteng province[45] is likely a result of COVID-19 disruption of measles immunisation in the province as suggested by the current study which was already predicted by WHO.[15] This corroborates a similar pattern wherein, there was an increase in measles incidence in Liberia and Guinea in 2016, following the disruption of measles immunisation in 2014 and 2015 caused by the Ebola outbreak.[10 46] Notwithstanding, it is emphasised that although MNCH service delivery and health outcomes in the current study were insignificantly affected by COVID-19, the trends of these performance indicators particularly the decline in immunisation and the increase in facility deaths 0–6 days (rate) and MMR should be taken serious, as they still depict the adverse effect of the pandemic on health. This could help inform future strategies aimed at mitigating the impact of future emergencies on MNCH services.

As earlier mentioned, one advantage of the ITS analysis is its ability to examine the recovery patterns of the MNCH indicators post-lockdown. Overall, the present study suggested a recovery attempt in one service utilisation indicator (PHC headcount<5 years), two service

delivery indicators (measle second dose (%) and fully immunised<1 year (%) and two outcome indicators (MMR and pneumonia case fatality<5 years (%) but all the recoveries attempts were statistically insignificant. Although the recovery in PHC headcount<5 years, measle second dose and fully immunised<1 year is appreciated, the recovery in MMR and pneumonia case fatality<5 years is undesired. Rather, there is a need for special support of the ANC and PNC indicators that deteriorated during the post-lockdown period to recover while maintaining the decline of mortality indicators and generally, ensuring continued MNCH service delivery to prevent the need for efforts to recover from potentially devastating MNCH outcomes post-pandemic. Contrary to our findings, a similar Ugandan ITS study found that immunisations and ANC visits significantly recovered once the lockdown was lifted.[43] The recovery disparities between the present study and this Ugandan study may arise from the different data sources and qualities and the study periods among other factors.

The present study suggests that routine MNCH services disruption by COVID-19 occurred through two critical dynamics namely the demand and supply mechanisms as similarly reported in Liberia.[41] The demand side disruption is explained by the decline in MNCH service utilisation indicators such as PHC headcount, ANC and PNC as mothers could not take their children to facilities due to lockdown restrictions that limited public transportation. On the other hand, the supply-side disruption of MNCH service is accounted for by the fact that facilities reallocated resources deploying staff, particularly nurses and doctors from routine services like measles immunisation to intensive care units to fight COVID-19[18] causing the increase in facility deaths 0–6 days and MMR. The increase in facility deaths from the demand perspective could be that parents failed to take their children on time to facilities and only arrived there when their medical conditions had escalated beyond treatment. From the supply dimension, the children could have been taken to facilities on time but staff and medical resources had been diverted to deal with COVID-19 at the expense of non-COVID-19 clients. It is conceivable that these two possibilities occurred side by side leading to an interception of the demand and supply effects hence, the increase in service disruption and facility deaths during COVID-19. Finally, the current study has demonstrated an important underlying principle, showing that the disruption in MNCH service utilisation and delivery leaves an adverse effect on health outcomes.

The disruption of MNCH services in this current study like in most others highlights a weakness in the health system response to the COVID-19 pandemic hence, it is suggested that during outbreaks health systems should balance dealing with the outbreak and maintaining the delivery of essential healthcare services. High-level intersectoral, interministerial, provincial and district engagements are needed to address the mechanisms of COVID-19 routine healthcare disruption[38] in this study, considering that critical factors that impact healthcare are often outside the health sector known as social determinants of health. During lockdowns and movement restriction periods, public authorities should provide alternative forms of transportation to healthcare facilities to enable the continuation of essential service access and delivery. The causality and the reasons for the continuous decline in service indicators like PHC headcount, ANC and PNC even before the COVID-19 outbreak should be investigated by future studies, as well as the indicators that deteriorated in the post-lockdown period like PNC and ANC. This study was based on March 2020 to February 2021 data hence we recommend further study with the most recent data to assess the recovery of the affected services. Also, we recommend that studies should investigate the geographical variations of COVID-19's impact on MNCH services among the five districts in Gauteng province for an understanding of the most impacted areas for awareness, support and special attention during further emergencies.

Limitations and strengths

This study is not without limitations. First, as with all secondary data analyses, the study depended on the quality of the DHIS data. Second, the DHIS only provides information about public facilities, which does not represent the entire population's experience of COVID-19 as the private facilities are left out. However, the large sample size that emanates from all the 426 public facilities in Gauteng province strengthens the internal validity of the analyses. Third, there were no potential confounding variables in the DHIS data set, which could provide alternative explanations for the observed changes. Lastly, it was difficult to disentangle the supply and demand effects in the data but this was halfway attained by classifying the MNCH services as service delivery, utilisation and outcome indicators. Despite the limitations of the study, the ITS analysis as a quasi-experimental approach was purposefully chosen due to its ability to capture the real effect of COVID-19, such as the interruption effect of the lockdown as well as the determination of the pre and post-COVID-19 trends. The ITS analysis is widely used in evaluation studies and is well known for its strengths in determining the effect of interventions/interruptions hence, enabling the current study to confidently attribute the observed disruption in MNCH service utilisation, delivery and increased mortality to the COVID-19 pandemic.

Conclusion

In Gauteng province, the COVID-19 pandemic disrupted the utilisation of essential MNCH services. The effect of service disruption was more severe during the March 2020 lockdown. Although the effect of the pandemic on MNCH service delivery and health outcomes was insignificant, the increase in facility deaths 0–6 days (rate) and MMR during the pandemic is the consequence of the disruption in service utilisation and delivery. The mechanism

of service disruption by COVID-19 had both supply and demand implications. While there were recovery attempts for some service indicators post-COVID-19 lockdown, others rather deteriorated. It may take longer for some services to fully recover hence, the need for health system interventions to support the affected services and prioritise them during future crises. It is imperative to strike a balance between maintaining routine healthcare services and managing an outbreak and this lesson serves as a guide for future policy and response to health emergencies.

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