




# BMJ Open Effects of the COVID-19 pandemic on maternal and perinatal health service utilisation and outcomes in Mozambique: an interrupted time series analysis

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## ABSTRACT

**Objectives** To measure the effects of the COVID-19 pandemic on maternal and perinatal health services and outcomes in Mozambique.

**Design** This is an observational study analysing routine service delivery data using interrupted time series analysis. We used 43 months of district-level panel data with April 2020 as the point of interruption, adjusting for seasonality and population growth to analyse service utilisation outcomes.

**Setting** The 222 public health facilities in Nampula Province, Mozambique, from January 2018 to July 2021.

**Outcome measures** The change in the number of antenatal care (ANC) visits and facility deliveries, and the change in the rate of adverse birth outcomes at pandemic onset and over time compared with expected levels and trends, respectively.

**Results** There were no significant disruptions to ANC at pandemic onset. Following this, there was a significant monthly increase of 29.8 (18.2–41.4) first ANC visits and 11.3 (5.5–17.2) ANC visits within the first trimester per district above prepandemic trends. There was no significant change in the number of fourth ANC visits completed. At the onset of COVID-19, districts experienced a significant decrease of 71.1 (–110.5 to –31.7) facility deliveries, but the rate then increased significantly above prepandemic trends. There was no significant increase in any adverse birth outcomes during the pandemic. Conversely, districts observed a significant monthly decrease of 5.3 uterine rupture cases (–9.9 to –0.6) and 19.2 stillbirths (–33.83 to –4.58) per 100 000 facility deliveries below prepandemic trends. There was a significant drop of 23.5 cases of neonatal sepsis/100 000 facility deliveries per district at pandemic onset.

**Conclusion** Despite pandemic interference, Nampula Province saw no disruptions to ANC, only temporary disruptions to facility deliveries and no increases in adverse birth outcomes. ANC visits surprisingly increased, and the rates of uterine rupture, stillbirth and neonatal sepsis decreased, suggesting that Nampula Province may offer insights about health system resilience.

## INTRODUCTION

The onset of the COVID-19 pandemic prompted concerns about the continuation of essential reproductive health services and effects on related health outcomes, especially in low and middle-income countries

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Examination of 43 months (27 before the pandemic and 16 during the pandemic) allowed for observation of changes in health service use and adverse birth outcomes beyond the initial effect of the COVID-19 pandemic.
- ⇒ The interrupted time series models in this study account for historical trends, seasonality, and population growth, as well as serial autocorrelation.
- ⇒ This analysis used routine service statistics that may include systematic data entry and reporting errors, under-reporting of cases and missing data; however, data quality assessments were performed and several measures were applied to increase the reliability of the data.
- ⇒ The inclusion of all public health facilities across Nampula Province provides a near population perspective that captures cases of obstetric and neonatal complications regardless of any changes to referral patterns or care-seeking behaviour during the pandemic.

(LMICs).<sup>1,2</sup> Some studies have since explored the effect of the COVID-19 pandemic on maternal health service utilisation in sub-Saharan Africa but few have assessed the maternal and perinatal outcomes in this region.

Research on service utilisation throughout the pandemic has demonstrated mixed effects across countries, with significant decreases in antenatal and delivery care in Nigeria, Mali, Sierra Leone and Ethiopia, whereas no change, or a significant increase, has been observed in the Democratic Republic of Congo (DRC), Somalia, Zimbabwe and Cameroon.<sup>3–7</sup> This variation may be attributed to a myriad of factors including differences in pandemic mitigation measures, health system resilience and social risk perception; therefore, it is necessary to continue studying and documenting changes to service utilisation

to provide decision-makers with evidence to inform continued mitigation efforts.

To date, there have been few studies that have assessed the effects of the pandemic on maternal and perinatal health outcomes in sub-Saharan Africa. A systematic review and meta-analysis examining this question globally identified 40 relevant studies, of which few were conducted in LMICs and only one in Africa.<sup>8</sup> Moreover, many of the studies were single-centre studies that assessed changes over a short period and lacked adjustment for confounding factors. The meta-analysis identified significant increases in stillbirths and maternal deaths during the pandemic as compared with the prepandemic period but highlighted important differences between study settings, calling for more research to be conducted in LMICs.<sup>8</sup>

From the review, the study in Botswana examined adverse birth outcomes including stillbirth, preterm birth and small for gestational age.<sup>9</sup> The findings showed no significant difference in the risk of these adverse outcomes in the first month of the pandemic compared with 3 prior months. Another recent study included data from a large hospital in Zimbabwe and identified no significant changes in maternal mortality, morbidity or stillbirth in the initial 3 months of the pandemic compared with the 3 months prior.<sup>6</sup>

The current study analyses data from Mozambique, an under-researched country with a weak health system and poor health outcomes. One study assessing maternal service utilisation at two health facilities in Nampula Province, Mozambique, noted a significant decrease in facility deliveries in the first 3 months of the pandemic compared with the matched calendar months the previous year, and no significant changes in antenatal care (ANC).<sup>10</sup> Our study aims to offer a more comprehensive assessment, comprising long-term trends and all public health facilities across Nampula Province, the most populous province in the country. We provide a robust analytical approach to distinguish between regular variations in the data and real changes in trends due to the pandemic. This research contributes to the mapping of changes in service utilisation and addresses a gap in robust analysis of maternal and perinatal outcomes in response to the COVID-19 pandemic, particularly in sub-Saharan Africa. Further, in a context where multiple antenatal visits and facility delivery are not ubiquitous, it is imperative to examine the dynamics between service utilisation and health outcomes to better understand the effects of the COVID-19 pandemic—this study offers a side-by-side comparison of changes in both service use and health outcomes to elucidate these dynamics.

## METHODS

### Study context and setting

The first case of COVID-19 in Mozambique was confirmed on 22 March 2020, with the government announcing a state of emergency on 30 March 2020.<sup>11 12</sup> Policy measures

to limit COVID-19 transmission, and their enforcement, have evolved throughout the pandemic in response to the rapidly changing situation. In Mozambique, such measures have included restrictions on social gatherings, limiting public transportation and school closures.<sup>13</sup> Similar to other sub-Saharan African countries, the prevalence of COVID-19 cases and deaths has remained relatively low in Mozambique.<sup>14</sup> These pandemic dynamics may be due to limited testing, a young population, pre-existing immunity and early adoption of mitigation measures.<sup>15</sup>

Over the last two decades, maternal mortality has improved in Mozambique but remains high, with a maternal mortality ratio estimated at 408 in 2011.<sup>16</sup> Haemorrhage represents the most common direct cause of maternal death in the country, followed by pre-eclampsia and eclampsia.<sup>17</sup> This study takes place specifically in Nampula Province, located in northern Mozambique and home to over 6 million residents, making it the most populous province nationwide.<sup>18</sup> Facility delivery rates in Nampula Province have risen considerably from 53% in 2011<sup>16</sup> to 74% in 2017.<sup>19</sup> However, the province continues to face widespread poverty, major health and gender inequities, insufficient numbers of health workers, poor health system infrastructure and persistent commodity shortages.<sup>16 18 20</sup>

### Data source and processing

We extracted routine service data reported monthly by health facilities to the national health management information system (HMIS), from January 2018 to July 2021, for which we had full access. The start of the study period was selected to limit inclusion of secular trends related to changes in data collection or other health system shocks. Data from all public health facilities providing antenatal or maternity services during the study period in Nampula Province were included in the analysis. This includes 222 health facilities (9 hospitals and 213 primary care facilities) across the 23 districts in Nampula Province. There are few private health facilities offering maternity services in Nampula Province and they do not report to the HMIS, as such, they were not included in this analysis.

We assessed four indicators of service utilisation including number of clients attending a first ANC visit (ANC-1), number of clients attending ANC-1 within 12 weeks of pregnancy (early ANC), number of clients attending a fourth ANC visit (ANC-4) and number of health facility deliveries. We examined seven maternal health outcomes (number of cases of severe pre-eclampsia/eclampsia, postpartum haemorrhage, uterine rupture, obstructed labour, sepsis, caesarean delivery and death) and three perinatal outcomes (number of stillbirths, cases of neonatal sepsis and asphyxia).

The use of HMIS data presents some challenges, including lack of completeness and reporting errors. To limit the effect of these issues, we examined all data entries above the 95th percentile for each outcome variable, for each health facility type, and identified logical

inconsistencies (eg, if the number of maternal deaths was higher than the number of deliveries reported by a health facility in a given month). We then reviewed these entries with Ministry of Health staff at the health facility and district level, comparing the HMIS data to the facility registers, to verify and correct any errors. We assumed zero values for health facilities that do not offer certain services (antenatal, intrapartum or surgical). There were less than 4% missing data for ANC-1, ANC-4 and facility deliveries during the study period, with little change during the pandemic period (see online supplemental figure S1). Reporting of early ANC increased over time, but this was independent of the pandemic. Since the service utilisation outcome variables had a small degree of missing data, we performed linear interpolation of missing values based on values before and after the missing points at each health facility for its period of operation.

Health outcome data (maternal and perinatal outcomes) were almost exclusively reported by health facilities when there were cases to report, such that fewer than 0.5% of facilities reported zero cases for any given month in the prepandemic period (online supplemental table S1). Health facilities are required to report on a monthly basis, and all facilities submitted data each month during the study period, indicating that they did not miss a reporting period. Given this, we assumed that missing values for these outcomes were zero. Completeness of health outcomes did not change in response to the onset of the pandemic but did increase around November to December 2020 (online supplemental figure S1).

Monthly health facility data were then aggregated to the district level to account for the health system networks of care within districts. District counts of adverse maternal and perinatal outcomes were calculated as rates using the number of health facility deliveries reported in a given district-month per 100 000 deliveries. Annual district-level population projections from the 2017 Mozambique census were linked to the routine service statistics dataset by district to account for population growth.<sup>18</sup> Data were imported into Stata V.15 for preparation and analysis.<sup>21</sup>

### Statistical analysis

Descriptive analyses were conducted to characterise the mean monthly volume of visits or cases as well as the mean rate of cases in the prepandemic and pandemic periods. We performed an interrupted time series regression analysis for each outcome of interest with April 2020 as the point of interruption, since Mozambique issued a state of emergency on 30 March 2020.<sup>22</sup> This model uses district-level panel data and provides ordinary least-squares estimates with robust standard errors for the trends and changes in trends before and after interruption.<sup>23</sup> We observed strong evidence of seasonality in the time series of each outcome variable (see online supplemental figure S2). As such, we adjusted for seasonality by including a fixed effect for each calendar month from February through December, with January as the reference. This

accounted for effects associated with the same month over different years that may affect timing of pregnancy, care-seeking and quality of care. The correlation between the calendar month and time index variables was small (0.06) and not statistically significant. The models of service utilisation outcomes also included a covariate to adjust for population growth. Models of health outcomes are per 100 000 facility deliveries. For health outcomes, we used the model

$$Y_{td} = \beta_0 + \beta_1 T_{td} + \beta_2 X_{td} + \beta_3 X_{td} T_{td} + \sum_{(k=2)}^{12} \gamma_k \text{Month}_k + \epsilon_{td},$$

where  $Y_{td}$  represents the average of district  $d$  at time  $t$  (month);  $X_{td}$  is a postinterruption indicator (0 for pre; 1 for post);  $T_{td}$  is an index to represent the time in months, with  $t=\{1, \dots, 43\}$ ; and  $\text{Month}_k$  is a dummy indicator representing the  $k$ th calendar month of observation, with  $k=\{2, \dots, 12\}$ . Here,  $\beta_0$  represents the average number of services provided/cases reported across districts at the beginning of the pre-COVID-19 period;  $\beta_1$  represents the average monthly change in the number of services provided/cases reported during the prepandemic period;  $\beta_2$  represents the change in the outcome in the first pandemic month;  $\beta_3$  represents the difference in the outcome trend between the pandemic and the prepandemic periods;  $\gamma_2$ – $\gamma_{12}$  represent the changes associated with the months February through December, with January as the reference; and  $\epsilon_{td}$  is an error term that follows a second-order autoregressive process (lag chosen based on Cumby-Huizinga tests for time series autocorrelation<sup>24</sup>). For service utilisation outcomes, we fit a model as just described, with the addition of a variable to represent the annual district estimate of the population of reproductive-age women to account for population growth.

Linear combinations were used to estimate the difference in trends across the two periods. We used the model for each outcome to obtain a prediction of the counterfactual—the expected trend had there not been an interruption. We calculated the difference between the model prediction and the actual observation for each month. For health outcome variables, this was calculated in rates per 100 000 deliveries as well as the absolute number of cases. The sum of the monthly differences represents the cumulative effect of the interruption over the months observed. Results are considered significant at the  $p < 0.05$  level for two-sided comparisons.

### Patient and public involvement

This research was done without patient or public involvement.

## RESULTS

### Descriptive findings

During the prepandemic period, approximately 31 700 ANC-1 visits were conducted each month across Nampula Province, of which about 2400 were completed while the client was within their first trimester of pregnancy. About

**Table 1** Provincial mean monthly services delivered, volumes and rates of cases reported, by period

	Prepandemic (n=27 months)		During the pandemic (n=16 months)	
	Mean monthly number of visits conducted (SD)		Mean monthly number of visits conducted (SD)	
ANC-1	31 712.6 (4280.9)		33 712.9 (3838.9)	
Early ANC	2403.8 (1155.7)		6104.4 (1780.1)	
ANC-4	16 435.8 (2404.8)		19 555.4 (2194.4)	
Facility delivery	19 613.9 (879.3)		20 496.5 (1086.9)	
	Mean monthly volume of cases (SD)	Mean monthly rate of cases (SD)	Mean monthly volume of cases (SD)	Mean monthly rate of cases (SD)
Caesarean delivery	481.4 (40.5)	2453.4 (179.9)	515.2 (50.4)	2503.6 (232.6)
Pre-eclampsia/eclampsia	89.9 (24.2)	458.1 (122.3)	135.8 (30.9)	658.4 (144.5)
Postpartum haemorrhage	67.3 (13.8)	343.7 (71.9)	60.7 (22.9)	294.0 (104.5)
Obstructed labour	84.1 (20.4)	428.4 (101.4)	88.9 (16.4)	433.4 (84.7)
Uterine rupture	34.1 (7.7)	173.2 (35.4)	30.6 (8.1)	149.7 (43.9)
Maternal sepsis	7.3 (3.3)	37.2 (16.5)	5.8 (2.7)	28.2 (12.8)
Maternal death	15.4 (5.0)	78.2 (24.6)	13.2 (5.8)	65.0 (28.9)
Stillbirths	229.1 (23.3)	1167.0 (103.2)	241.3 (31.9)	1174.5 (161.5)
Neonatal sepsis	10.1 (3.8)	51.2 (18.9)	4.9 (2.2)	23.9 (10.3)
Neonatal asphyxia	148.2 (19.5)	755.6 (97.1)	176.5 (18.1)	856.8 (76.1)

Rates are per 100 000 facility deliveries.  
ANC, antenatal care.

16 400 ANC-4 visits and 19 600 facility deliveries were conducted each month across the province. The average monthly volume of each of these services increased during the pandemic (table 1).

Approximately 480 caesarean deliveries were performed each month across the province before the pandemic, equating to 2.4% of facility deliveries. The volume of reported maternal and perinatal cases ranged from more common adverse outcomes such as stillbirths (229/month), neonatal asphyxia (148/month) and pre-eclampsia/eclampsia (90/month) to rarer outcomes such as maternal death (15/month), and maternal and neonatal sepsis (7/month and 10/month, respectively). The volumes and rates of outcomes increased for some and decreased for others during the pandemic (table 1).

### Interrupted time series modelling findings

Table 2 presents the parameter estimates for each of the interrupted time series models. Models with significant results are represented in figure 1. Each point denotes the actual observed average number of visits or cases/100 000 facility deliveries across districts each month. The solid blue line illustrates the fitted trend based on the observed data prior to pandemic initiation. The dotted blue line is an extension of the prepandemic trend (solid blue line), indicating the expected trend had no interruption occurred (ie, the counterfactual). The red line is a visual depiction of the fitted trend after interruption based on the observed data during the pandemic months. The grey area represents the difference between what we would

have expected to observe in the absence of the pandemic and what actually occurred due to the pandemic.

### Service utilisation trends

Results from the interrupted time series models showed no significant changes in the volume of ANC visits (ANC-1, early ANC or ANC-4) at the onset of the COVID-19 lockdown (table 2). There were, however, significant increases in the change in average monthly district ANC-1 and early-ANC visits during the pandemic period compared with the prepandemic period. The number of ANC-1 visits rose to a district average of an additional 29.8 (95% CI 18.2 to 41.4) visits per month above pre-COVID-19 trends. Early-ANC visits increased by 11.3 (95% CI 5.5 to 17.2) visits per month over prepandemic trends. There was no significant change observed in the trend of ANC-4 visits post-COVID-19 versus pre-COVID-19 (p=0.91). Facility deliveries dropped at the onset of COVID-19, whereby districts experienced an average decrease of 71.1 (95% CI -110.5 to -31.7) facility deliveries in April 2020. Following this initial drop, the monthly change in facility deliveries then increased to a rate above prepandemic trends such that districts saw an average growth of 6.1 (95% CI 0.03 to 12.2) deliveries per month higher than pre-COVID-19 trends that historically showed no significant increase.

### Health outcome trends

Prior to the pandemic, the rate of facility-based births that were delivered through surgery was significantly increasing at a rate of 15.9 per 100 000 deliveries each

**Table 2** Parameter estimates for monthly district-level indicators in Nampula Province from January 2018 to July 2021

Indicator	Average monthly change in number of visits/cases during pre-pandemic period $\beta_1$ (95% CI)	Change in the average monthly number of visits/cases at the onset of the pandemic $\beta_2$ (95% CI)	Difference between the average monthly change in number of visits/cases during the pandemic compared with the pre-pandemic period $\beta_3$ (95% CI)	Linear trend during pandemic $\beta_1 + \beta_3$ (95% CI)
<b>Service utilisation†‡</b>				
ANC-1	-3.5 (-7.2 to 0.2)	-53.6 (-146.5 to 39.2)	29.8 (18.2 to 41.4)**	26.3 (16.8 to 35.8)**
Early ANC	3.9 (2.2 to 5.7)**	-13.0 (-31.4 to 5.4)	11.3 (5.5 to 17.2)**	15.3 (9.7 to 20.8)**
ANC-4	5.9 (2.3 to 9.5)**	23.6 (-28.2 to 75.4)	0.5 (-8.8 to 9.9)	6.4 (-0.7 to 13.6)
Facility delivery	0.6 (-1.9 to 3.1)	-71.1 (-110.5 to -31.7)**	6.1 (0.03 to 12.2)*	6.7 (2.0 to 11.5)**
<b>Maternal outcomes (per 100 000 facility deliveries)†</b>				
Caesarean delivery	15.9 (2.7 to 29.0)*	85.6 (-77.1 to 248.4)	-30.1 (-55.0 to -5.3)*	-14.29 (-31.1 to 2.5)
Pre-eclampsia/eclampsia	-1.7 (-3.9 to 0.6)	101.4 (-42.4 to 245.2)	6.3 (-1.2 to 13.8)	4.65 (-1.9 to 11.2)
Postpartum haemorrhage	-2.57 (-7.8 to 2.8)	52.5 (-59.6 to 164.6)	-4.2 (-13.0 to 4.5)	-6.71 (-12.8 to -0.6)*
Obstructed labour	3.5 (-2.1 to 9.0)	-2.1 (-167.0 to 162.9)	-9.7 (-26.3 to 6.8)	-6.28 (-20.9 to 8.3)
Uterine rupture	0.7 (-0.8 to 2.2)	2.4 (-50.4 to 55.2)	-5.3 (-9.9 to -0.6)*	-4.56 (-8.8 to -0.3)*
Maternal sepsis	0.3 (-0.2 to 0.8)	-5.4 (-23.9 to 13.1)	-0.9 (-2.3 to 0.6)	-0.59 (-1.9 to 0.7)
Maternal mortality	0.5 (-0.4 to 1.5)	-13.6 (-37.7 to 10.6)	-1.8 (-5.1 to 1.6)	-1.22 (-4.2 to 1.7)
<b>Perinatal outcomes (per 100 000 facility deliveries)†</b>				
Stillbirths	1.9 (-7.8 to 11.7)	42.6 (-159.3 to 244.5)	-19.2 (-33.8 to -4.6)**	-17.3 (-28.6 to -6.0)**
Neonatal sepsis	-0.1 (-1.0 to 0.9)	-23.5 (-41.9 to -5.2)*	-0.2 (-1.8 to 1.5)	-0.2 (-1.6 to 1.1)
Neonatal asphyxia	3.9 (-2.6 to 10.4)	43.4 (-119.0 to 205.7)	-11.3 (-29.2 to 6.6)	-7.4 (-23.2 to 8.4)

\*P<0.05; \*\*p<0.01.  
 †Adjusts for seasonality.  
 ‡Adjusts for population growth.  
 ANC, antenatal care.

month on average per district (table 2). There was no immediate change observed in the caesarean delivery rate at pandemic onset; however, the long-term trend showed a significant decline. The proportion of deliveries where surgery was performed dropped by 30.1 (95% CI -55.0 to -5.3) deliveries per 100 000 each month on average per district below the pre-pandemic rate.

There were no significant changes in the proportions of facility deliveries with reported maternal health complications at pandemic onset ( $p > 0.05$  for all). Similarly, there were no significant changes in the trends of the rates of pre-eclampsia/eclampsia, postpartum haemorrhage, obstructed labour, maternal sepsis or maternal death throughout the pandemic period compared with the pre-pandemic period. There was however a significant decrease in the rate of uterine rupture such that districts saw an average decrease of 5.3 uterine rupture cases/100 000 deliveries (95% CI -9.9 to -0.6) per month below pre-pandemic trends.

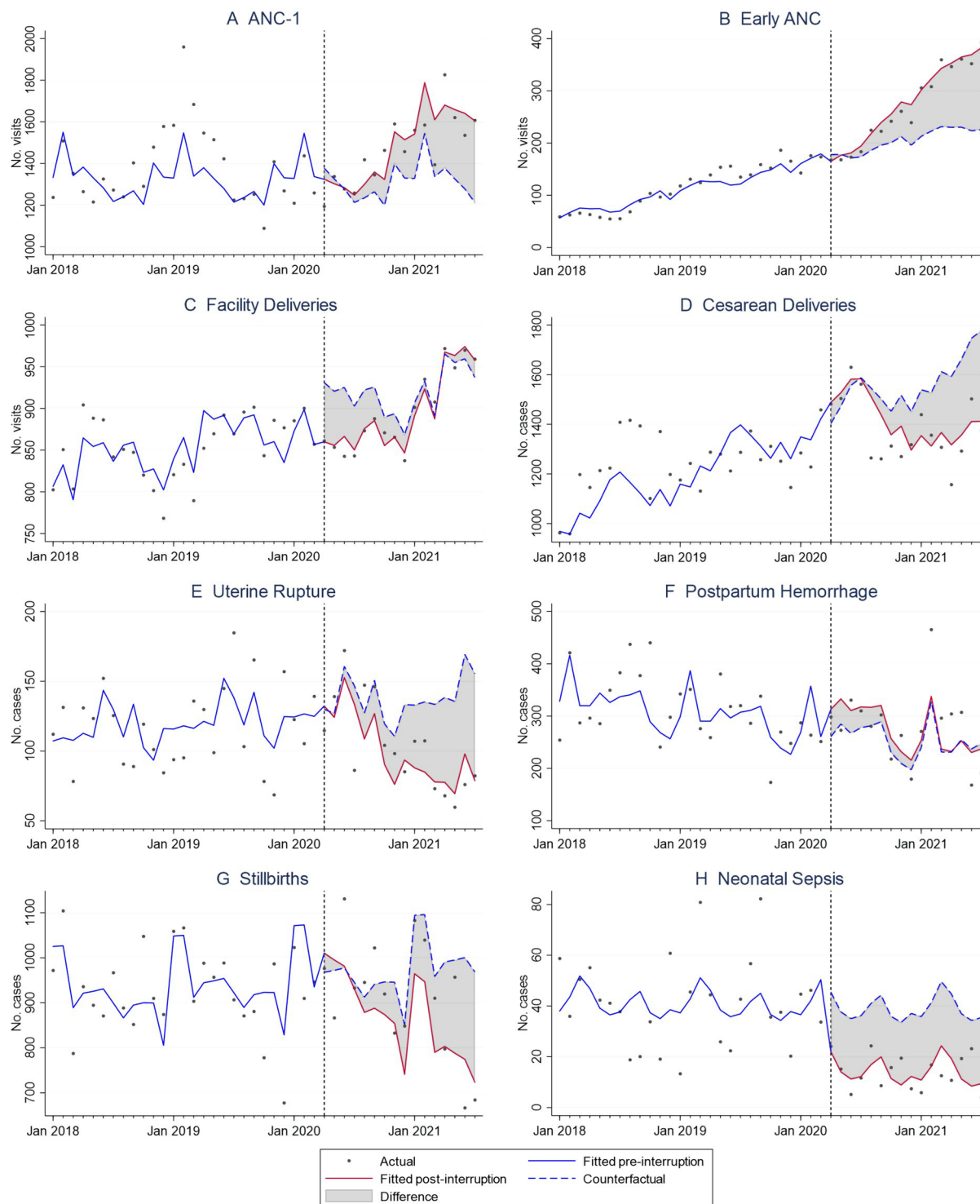
Among perinatal outcomes, there was a significant downward shift in the neonatal sepsis rate in April 2020. Districts experienced an average decrease of 23.5 cases/100 000 facility deliveries (95% CI -41.9 to -5.2) at pandemic onset. No significant change in the trend in neonatal sepsis rate was observed during the pandemic period as compared with the pre-pandemic period beyond

this initial shift. There was no immediate change to the rate of stillbirths reported; however, there was a significant decrease in the trend over time such that districts observed a monthly decrease of 19.2 stillbirths/100 000 deliveries (95% CI -33.8 to -4.6) on average below pre-pandemic trends. There were no significant changes observed in the rate of neonatal asphyxia.

### Cumulative effect of changes observed

We calculated the cumulative effect of the significant changes observed in the interrupted time series analysis to understand the magnitude of change at the provincial level and over the entire pandemic period (table 3). The cumulative effect is also depicted in figure 1 by the shaded area, demonstrating the difference between the trend in the observed values during the pandemic, fitted through the interrupted time series model, and the counterfactual (the trend we would have expected based on the pre-pandemic model). These findings highlight a surplus of approximately 62 500 ANC-1 visits and 26 500 early-ANC visits.

As seen in table 2, there was a significant decrease in facility deliveries at the pandemic onset, but this was followed by a significant increase in its trend, above the pre-pandemic levels. Despite the rebound in the use of health facilities for delivery, the initial drop still results



\*Cases are per 100,000 facility deliveries

**Figure 1** Interrupted time series models of average monthly number of visits or case rates at districts across Nampula Province, January 2018- to July 2021 with interruption at in April 2020. Panels A) ANC-1, B) Early ANC, C) Facility deliveries, D) Cesarean deliveries, E) Uterine Rupture, F) Postpartum hemorrhage, G) Stillbirths and H) Neonatal sepsis.

in a net shortfall of about 9200 facility deliveries across Nampula Province, over the 16 months after the onset of the pandemic (table 3). However, after April 2021, the increasing trend in facility deliveries begins to surpass the counterfactual (figure 1). There was also a cumulative shortfall of around 392 caesarean deliveries. At the same

time, there were reductions in adverse maternal and perinatal outcomes throughout this period such that there was a decrease in nearly 216 cases of uterine rupture, 84 cases of neonatal sepsis and 918 stillbirths across Nampula Province.

**Table 3** Cumulative effect of significant changes in indicators in Nampula Province during the pandemic

Indicator	Change observed on average by one district over 16 pandemic months	Change observed across all 23 districts over 16 pandemic months	Average monthly change across province
ANC-1	2717.1	62494.2	3905.9
Early ANC	1154.4	26552.5	1659.5
Facility deliveries	-402.0	-9246.7	-577.9
Caesarean deliveries	-17.0	-392.1	-24.5
Uterine rupture	-9.4	-216.3	-13.5
Stillbirths	-39.9	-917.9	-57.4
Neonatal sepsis	-3.6	-83.7	-5.2

ANC, antenatal care.

## DISCUSSION

As the COVID-19 pandemic began, the public health community voiced concerns about potential disruptions to essential maternal and perinatal health services, especially in LMICs. Our analysis shows there was indeed a decrease in facility deliveries at pandemic onset, but no other service utilisation disruptions were observed in Nampula Province, Mozambique. In fact, the rate of increase in the number of ANC-1 and early-ANC visits accelerated since pandemic initiation, leading to higher numbers of observed visits than expected. These significant changes translate to meaningful increases across the province: more than 62 000 pregnant people who were expected to give birth without receiving any ANC received at least one visit during their pregnancy, and over 26 500 who were expected to start ANC late were able to access care in their first trimester. These results signal health system resilience whereby health sector actors in Nampula Province were able to maintain delivery of these essential services in the face of COVID-19 and were able to increase ANC service delivery and utilisation. These increases may point to efforts taken by stakeholders during the pandemic, such as effective communication about service availability and encouraging service use, or they may reflect ongoing social behaviour change and health system strengthening efforts in the region, unrelated to the pandemic. Further research is needed to understand the contributing factors.

ANC offers an opportunity for screening and diagnosis during pregnancy to detect and manage complications, provide health counselling and deliver preventative services.<sup>25</sup> It also serves to connect those who are pregnant to the healthcare system. While ANC-1 attendance is generally high in Mozambique and other countries in the region, the timing of this first visit remains a challenge. Most start ANC after their first trimester such that they miss out on the full benefits of ANC. Efforts to increase early-ANC visits have been slow.<sup>16 26</sup> As such, the gains made in early ANC in Nampula Province throughout the

pandemic are especially remarkable. While some countries have reported pandemic-related service delivery disruptions, Nampula is not alone in experiencing positive effects on service utilisation. A recent study examined the use of ANC in eight sub-Saharan African countries and identified increased ANC visits during the pandemic in DRC, Somalia and Cameroon.<sup>3</sup>

The findings related to facility deliveries are more complex. Prior to the pandemic there was little change in the trend in facility deliveries, accounting for population growth and seasonality. At the onset of the pandemic, there was a drop in facility deliveries below what would have been expected that month. Similar findings have been highlighted in multiple studies examining the initial months following pandemic lockdowns across various geographies.<sup>3 27 28</sup> However, few studies have assessed the long-term trends in facility deliveries throughout the pandemic. This analysis demonstrates that the initial downward shift in facility deliveries had a lasting effect. Even though the rate of increase in facility deliveries during the pandemic was significantly higher than the prepandemic trend, it took a full year to return to the levels we would have expected based on the historical trend. This gap resulted in a net shortfall of around 9200 facility deliveries across the province, meaning an estimated 9200 families delivered outside of the health system. At the same time, this trend offers a hopeful perspective on pandemic recovery. Through concerted efforts, the level of facility deliveries was able to catch up to expected levels and even surpass them. While the factors related to this increase remain unstudied, anecdotal evidence suggests strong political will, collaboration and coordination of partners, and effective health communication.<sup>29–32</sup>

The study that included DRC, Somalia and Cameroon, previously described, examined five pandemic months and similarly noted increases in facility deliveries in these countries.<sup>3</sup> These countries, along with Mozambique, may offer important insights about how to effectively recover from shocks to health systems.

Prior to the pandemic, the caesarean delivery rate was rising but was still very low, ranging from 1% to 1.5% of facility deliveries. A systematic review conducted by the WHO shows that at the population level, caesarean delivery rates of 10%–15% are associated with decreases in maternal and neonatal mortality.<sup>33</sup> The current analysis identified a declining trend in caesarean delivery rates since pandemic onset, which is concerning given the low prepandemic rates. Mozambique's Ministry of Health developed *Operational Guidelines for the Care of Pregnant Women and Novel Coronavirus Infection* shortly after initial lockdown measures were imposed.<sup>34</sup> The guidelines specified that type of delivery (vaginal, assisted vaginal or surgical) should be based on obstetric indication and should not be influenced by a client's COVID-19 status unless the respiratory condition of the client required urgent delivery. While some countries noted an increase in caesarean deliveries of clients with suspected COVID-19 as a strategy to reduce COVID-19 transmission,

the guidance in Mozambique may have prevented application of this non-evidence-based approach.<sup>35 36</sup> The guidelines also stipulated that elective procedures should be cancelled. While this could have contributed to a decline in the caesarean delivery rate, in Nampula Province it is unlikely that elective surgical deliveries contribute a large proportion to the overall caesarean delivery rate.<sup>37</sup> At the same time, there may have been challenges related to the interpretation and implementation of the guidelines such that the definition of 'essential' caesarean deliveries may have been understood to be unnecessarily narrow. Other possible reasons for the observed declining trend may include decreased availability of surgeons and anaesthetists or anaesthesiologists, which was already a challenge before the pandemic, and lack of sufficient infection prevention and control products, limiting the ability to perform surgery; however, further research is needed to confirm the factors related to this trend.

Importantly, our analysis demonstrates no significant increases in maternal or perinatal morbidities or mortality during COVID-19 in this setting. Some studies in LMICs have found significant increases in stillbirths during the pandemic; however, they were conducted in India and Nepal which are contextually different from Mozambique, such that both experienced higher COVID-19 caseloads and more health system strains than Mozambique.<sup>27 38 39</sup> The results of the current analysis are consistent with others conducted in sub-Saharan Africa that have similarly demonstrated no significant increases in adverse birth outcomes.<sup>6 9</sup> Differences in the epidemiological context, COVID-19 mitigation measures and their level of enforcement, as well as health system factors (eg, availability of health providers and personal protective equipment, as well as pandemic-related adaptations to service delivery) and population characteristics (eg, sociodemographic and health profile of pregnant people, population density, trust in the health system and risk perceptions) may underpin some of the regional variations in health outcomes.

In fact, during the pandemic, significant declines were observed in some maternal and perinatal outcomes in Nampula Province. This is particularly striking given that the rate of maternal and perinatal outcomes had remained largely stagnant between January 2018 and March 2020. It is important to recall that the data in this analysis only represent facility-based deliveries and we observed a drop in facility deliveries at pandemic onset. As such, there may have been under-reporting of adverse birth outcomes during this initial period. At the same time, the declining trend in rates of uterine rupture and stillbirths became more substantial throughout the study period, and the drop in the rate of neonatal sepsis remained constant, even when the number of facility deliveries rebounded and surpassed expected levels. In addition, there is a high facility delivery rate in Nampula Province, recently estimated at 96% by the Ministry of Health.<sup>40</sup> In such a context, it is likely that most obstetric and neonatal emergencies reach the facility. The other consideration when interpreting these data is

the change in the percent of health facilities reporting indicators over time. There was an increase in reporting of health outcome indicators towards the end of 2020 which may bias the results. However, with increased reporting, we would have expected to see increasing cases of complications rather than the significantly declining trends identified. Our assessment also showed that the increased reporting was largely related to reporting the absence of cases in a particular month. Given this, we are confident in the significant trends identified in the current analysis.

The declines in uterine rupture, stillbirths and neonatal sepsis identified in this analysis represent critical improvements to maternal and perinatal health. While still relatively rare events, at the population level, the changes observed in this analysis equate to 216 cases of uterine rupture, 84 cases of neonatal sepsis and 918 stillbirths averted over 16 months. These numbers cannot fully capture the effects on the women, children, families and communities affected. Maternal and perinatal morbidity and mortality remain difficult problems to resolve globally. As such, the major achievements seen in Nampula Province in the face of COVID-19 require further investigation, through qualitative case study methods, so that effective strategies, pandemic-related or otherwise, can be replicated and scaled.

Uterine rupture is the second most lethal cause of maternal mortality in Mozambique.<sup>41</sup> Its decrease cannot be attributed to surgical management as we observed a decline in the caesarean delivery rate. As such, it is likely related to antepartum prevention, which aligns with the increases in ANC we noted, or improved non-surgical intrapartum quality of care.

Mozambique continues to have one of the highest rates of stillbirth globally.<sup>42</sup> Classification of stillbirth was not consistently reported in this setting, and we therefore were unable to disaggregate our analysis by antepartum and intrapartum stillbirths. Further research is needed to discern whether the observed declines are related to increased service use or health service improvements during the antenatal or intrapartum periods. Some studies have demonstrated an inverse relationship between preterm births and stillbirths during the pandemic.<sup>43</sup> Due to the lack of high-quality, consistently available data on gestational age in the study setting, we are unable to examine this connection but wish to note that while the declines in stillbirths in Nampula Province are promising, a potential increase in preterm births should be assessed and preparations made to ensure quality care for small and sick newborns.

Sepsis is among the top leading causes of neonatal death in Mozambique.<sup>44</sup> It is possible that infection prevention and control efforts that were expanded at pandemic onset had a positive spillover effect on the care of newborns, resulting in the initial drop in the neonatal sepsis rate observed. This downward shift in neonatal sepsis then persisted throughout the remainder of the study period, suggesting any improvements made to quality of care were maintained.



This study is prone to the general limitations associated with use of routine service statistics. This may include systematic data entry and reporting errors, under-reporting of cases and missing data. There were also concerns that data quality may decline during the pandemic due to overstretched health systems. To minimise any bias of these issues, we performed several data quality assessments. This included examination of outliers, reconciliation of logical inconsistencies, assessment of reporting completeness and reporting of zero cases. These measures increased the reliability of the data used in the current analysis and lend confidence to the findings. Some challenges such as under-reporting of cases existed prior to the pandemic and likely remained at a consistent level during the pandemic period as there were no reports of health facilities in Nampula Province overwhelmed with patients during this time. As such, while the relative shifts and trends observed in this study remain unaffected, the rates may be underestimated. As noted earlier, this study reflects facility-based data and while Nampula is a setting with high facility delivery rates, not all people deliver in the health facility and even more delivered outside of a facility in the months following pandemic onset. Following this, accurate estimates of complication rates and mortality necessitate population-level research. Another limitation of this analysis is the loss of health facility-level variability through aggregation to the district level; however, our selected approach offers a better approximation of population-level dynamics in response to the pandemic given the distribution of facility deliveries and referral patterns of emergency obstetric and neonatal cases.

To date, studies examining the effects of the pandemic on maternal and perinatal outcomes have not been rigorous: several lack a control, many do not account for confounding factors such as historical or seasonal trends and most are narrowly focused at one or only a few health facilities. The current study offers a near population perspective, capturing overall cases of complications even if individuals changed their care-seeking behaviour during the pandemic. An assessment of the entire health system allows us to gain a better understanding of the burden of adverse maternal and perinatal outcomes, as the choice of delivery location may be dynamic in response to the changing pandemic situation.

## CONCLUSION

Nampula Province, Mozambique did not experience any service disruptions to ANC due to the COVID-19 pandemic; rather, there were significant increases observed in ANC-1 and early-ANC visits above prepandemic trends. There was an initial disruption to facility deliveries that had a lasting effect; however, through intentional local efforts, the number of facility deliveries rebounded and even surpassed the expected levels after 1 year. In addition, there were no pandemic-related increases to adverse maternal or perinatal outcomes observed in this analysis.

In contrast, there were significant declines in the rates of uterine rupture, stillbirths and neonatal sepsis. Further research is required to understand what efforts led to these critical improvements during an especially challenging pandemic context.

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