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ORIGINAL RESEARCH

The impact of the COVID-19 pandemic on theatre use at the Rahima Moosa Mother and Child Hospital

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Background: SARS-COV-2, the viral pathogen that resulted in the COVID-19 pandemic, was first identified by the World Health Organization (WHO) on 31 December 2019. Efforts to curb the spread of this virus, as well as the effects of viral infections and resulting complications thereof, have placed immense strain on healthcare systems throughout the world. In South Africa, a nationwide lockdown was instituted on 27 March 2020 which resulted in the suspension of all elective surgical services. The effect of this suspension of services has not been fully elucidated, but it has been postulated that a significant surgical backlog may have been created due to limited resources and massive pre-existing patient loads.

Methods: We conducted a retrospective descriptive review of theatre records at the Rahima Moosa Mother and Child Hospital (RMMCH) for the time period 1 March 2019 to 28 February 2021.

Results: A total of 8 176 cases amounting to 9 656 hours and 20 minutes of theatre time occurred from 1 March 2019 to 29 February 2020 (pre-COVID-19). From 1 March 2020 to 28 February 2021 (post-COVID-19), a total of 7 717 cases amounting to 9 148 hours and 2 minutes were conducted. This calculated to a 5.61% reduction in cases and a 5.26% reduction in theatre hours. There was a statistically significant reduction in theatre use both in terms of cases done and hours of theatre time after the onset of the COVID-19 pandemic.

Conclusion: The onset of the COVID-19 pandemic significantly reduced the number of cases completed at the RMMCH. It also led to a significant reduction in total theatre use. Both of these findings were most pronounced in elective gynaecology and paediatric surgery services. There was, however, no statistically significant increase in intensive care unit (ICU) and high care (HC) admissions as well as mortalities for the period studied.

Keywords: COVID-19, theatre use, elective surgery, emergency surgery, surgical backlog

Introduction

SARS-COV-2 was identified by the World Health Organization (WHO) on 31 December 2019.[1] Within three months, a global pandemic was declared. In South Africa, a national state of disaster was announced and a national "lockdown" was implemented on 27 March 2020.[2] Subsequently, elective surgeries were cancelled, non-essential clinics were closed, and staff and resources were redirected towards combatting COVID-19.[3]

The provision of surgical services is a vital component of any healthcare system. According to the WHO, emergency surgery comprises interventions that are considered critical to prevent premature death and disability.[4] Elective surgery implies that the surgery may be scheduled in advance.[5] It is, however, a misconception that elective surgery is always optional. Elective surgery may include surgery for malignant conditions and conditions that can significantly affect a patient's quality of life, if left untreated.

The Rahima Moosa Mother and Child Hospital (RMMCH) is a regional public hospital, although it provides many tertiary services, and it is located in Coronationville, Johannesburg, South Africa. It is a 345-bed hospital offering various surgical services across obstetrics, gynaecology and paediatric surgical disciplines. In accordance with national guidelines, the RMMCH received a directive on 19 March 2020 to suspend all elective surgeries.[6] The ramifications of this directive were yet to be formally investigated.

Both locally and internationally, studies have shown a significant decline in the number of surgical procedures performed. Furthermore, an increase in morbidity and mortality related to postponed surgeries has been observed.[7] The effect of the suspension of services in South African hospitals has also not been fully elucidated. This study aims to assess the extent to which the onset of the COVID-19 pandemic affected the provision of surgical services and theatre use at the RMMCH.

Theatre use is the measure of actual theatre performance versus typical theatre performance.[8] For this study, theatre use is defined by the number of cases within a "typical" time period versus the number of cases after the onset of the COVID-19 pandemic. Additionally, theatre use was assessed by comparing the number of hours in which the theatre was in use, within the same time periods.

Methods

We conducted a retrospective descriptive review of theatre records at the RMMCH between 1 March 2019 and 28 February 2021. Records included all theatre registers, anaesthetic charts,

high care (HC) and intensive care unit (ICU) records, as well as mortality records for the specified time period.

The following five theatres are used at the RMMCH:

- Theatre A – 24 hours; obstetric and gynaecological emergencies
- Theatre B – 8:00–16:00; elective obstetrics theatre; and 16:00–8:00; emergency or elective obstetrics
- Theatre C – 08:00–16:00; elective gynaecology
- Theatre D – 8:00–16:00; septic/contaminated theatre prior to the COVID-19 pandemic; reallocated to paediatric surgeries following the onset of the pandemic; 16:00–8:00; used for any paediatric emergencies following the onset of the pandemic
- Theatre E – 24 hours; paediatric theatre (elective and emergency prior to the COVID-19 pandemic); converted to a dedicated theatre for confirmed or suspected cases of COVID-19 following onset of the pandemic

Theatre time available for usage is dictated by staff availability. During the day, each theatre is allocated at least one anaesthetist, surgeon and nursing team. At night, two anaesthetists and nursing teams are available. Thus, maximally four theatres can run during the day (8:00–16:00) and two theatres can run concurrently after hours (16:00–8:00). These details were the same for both study periods.

Morbidities are defined as any temporary or permanent non-planned adverse event or disability that may occur during the surgery or the immediate postsurgical period. Thus, data pertaining to haemorrhage requiring transfusion, unplanned ICU or HC admissions, as well as any documented cardiac event were included. This information was obtained from anaesthesia charts and from the HC and ICU admission books.

Mortality data were collected from ward record books, HC and ICU record books, as well as anaesthesia charts in cases of a death on table. Names were cross-referenced to eliminate duplications and data were anonymised for confidentiality. Theatre cancellations were obtained from theatre reception records.

Primary objectives of this study:

- To determine and compare the number of cases performed per theatre and in total for 12 months prior to and after the onset of the COVID-19 pandemic.
- To determine and compare the number of hours that theatres were used by theatre and in total for 12 months prior to and after the onset of the COVID-19 pandemic.
- To determine and compare the number of surgical cancellations/postponements for 12 months prior to and after the onset of the COVID-19 pandemic.

Secondary objectives of this study:

- To describe the surgical morbidity/mortality that occurred for 12 months prior to and after the onset of the COVID-19 pandemic (1 March 2019 to 29 February 2020 compared to 1 March 2020 to 29 February 2021).

Statistical analysis

The study sample analysed included details relating to all surgeries performed on patients at the RMMCH during the specified time periods. Specifically all completed records regarding cases done, theatre hours from time of patient entry to time of exit from theatre, as well as morbidity and mortalities that occurred among surgical patients during their hospital stay, were included.

All analyses were performed using R statistical software (version 4.2.1). Monthly data are reported as median number of cases (interquartile range [IQR]).

The effect of the COVID-19 pandemic on the number of cases was modelled using multivariable Poisson regression with period (one year before the onset of the COVID-19 pandemic, and one year after the onset of the COVID-19 pandemic) and time (in months) as main effects. Interactions were not assessed. Data were checked for overdispersion, and where detected, the modelling was conducted using a negative binomial distribution. Where there was heteroskedasticity and/or autocorrelation of errors, robust errors were calculated.

The effect on the number of hours that theatres were used was modelled using multivariable linear regression with period as the main effect. No interactions were assessed. Each model generated was checked for outliers and heteroskedastic residuals. No outliers were detected in any of the models, but where heteroskedasticity was detected, robust errors were calculated.

The number of surgical cancellations/postponements was analysed using multiple logistic regression (dependent variable: cases cancelled/postponed versus not cancelled/postponed) with period as the main effect. No interactions were assessed.

Morbidities and mortalities were analysed using chi-squared analysis of total morbidities and mortalities that occurred for the two periods.

Results

A total of 8 176 and 7 717 cases were performed prior to and after the onset of the pandemic, respectively. There was a statistically significant decrease in the median number of cases performed per month after the onset of COVID-19 ($p = 0.010$) with a median of 684 (IQR 659–713) and 628 (IQR 611–672) cases being performed per month during each period.

Table I depicts the total number cases per month prior to and after the onset of the pandemic as well as presence or absence of a statistically significant change between the two periods.

There was a statistically significant decrease in the number of gynaecological elective cases, paediatric dental, paediatric plastic surgery, paediatric urology and paediatric ear, nose and throat (ENT) cases.

Table I: Number of cases done per month per discipline performed prior to and after the onset of the pandemic

Surgical discipline	Total number of cases *n* (median per month; IQR)		*p*-value
	Period 1	Period 2	
Gynaecology emergency	1 117 (96; 87–102)	1 110 (91; 90–104)	$p = 0.913$
Gynaecology elective	592 (50; 42–58)	389 (34; 24–42)	$p = 0.002$
Obstetric caesarean emergency	4 344 (361; 354–372)	4 515 (376; 362–383)	$p = 0.069$
Obstetric caesarean elective	985 (86; 74–89)	984 (82; 72–92)	$p = 0.990$
Other obstetric cases	102 (8; 8–10)	103 (8; 7–10)	$p = 0.994$
Paediatric orthopaedic; elective	44 (4.5; 2–5)	57 (4; 3–6)	$p = 0.197$
Paediatric orthopaedic; trauma	231 (18; 17–22)	243 (18; 16–27)	$p = 0.582$
Paediatric ENT	304 (26; 18–33)	142 (5; 1–14)	$p = 0.037$
Paediatric plastic surgery	117 (10; 6–12)	27 (2; 0–3)	$p < 0.001$
Paediatric gastroenterology	71 (6; 5–6)	72 (6; 4–8)	$p = 0.963$
Paediatric urology	31 (2.5; 1.75–4)	14 (0.5; 0–3)	$p = 0.014$
Paediatric dental	238 (21; 16–22)	61 (1; 0–12)	$p < 0.001$

ENT – ear, nose and throat

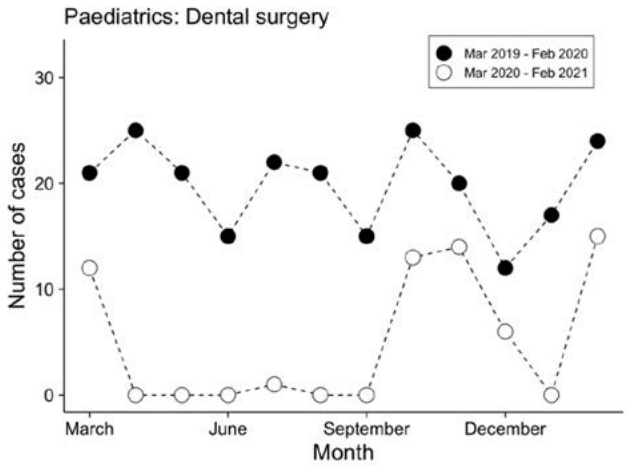


Figure 1: Number of paediatric dental surgeries per month pre-COVID-19 (March 2019–February 2020) and during the pandemic (March 2020–February 2021)

Although the difference in case rate in paediatric dental surgery was statistically significant ($p = 0.037$), such that period 2 was associated with a lower case rate than period 1, and while the point estimate indicated a strong effect, the estimate lacked precision (95% CI for the incidence rate ratio: 0.22–0.86). Moreover, in both periods, the number of cases was erratic, and subject to large month-on-month changes. The number of paediatric dental cases done between the two period is shown in Figure 1.

In paediatric plastic surgery, the effect was strong (incidence rate ratio point estimate: 0.22), but the precision of the estimate was low (95% CI for the incidence rate ratio: 0.12–0.40). Due to the low case count and lack of precision, care should be taken when interpreting this result.

For paediatric urological surgery, the effect was strong (incidence rate ratio point estimate: 0.45), but the precision of the estimate was very low (95% CI for the incidence rate ratio: 0.24–0.85). Again, because of the low case count and low precision of the estimate, care should be taken when interpreting the result.

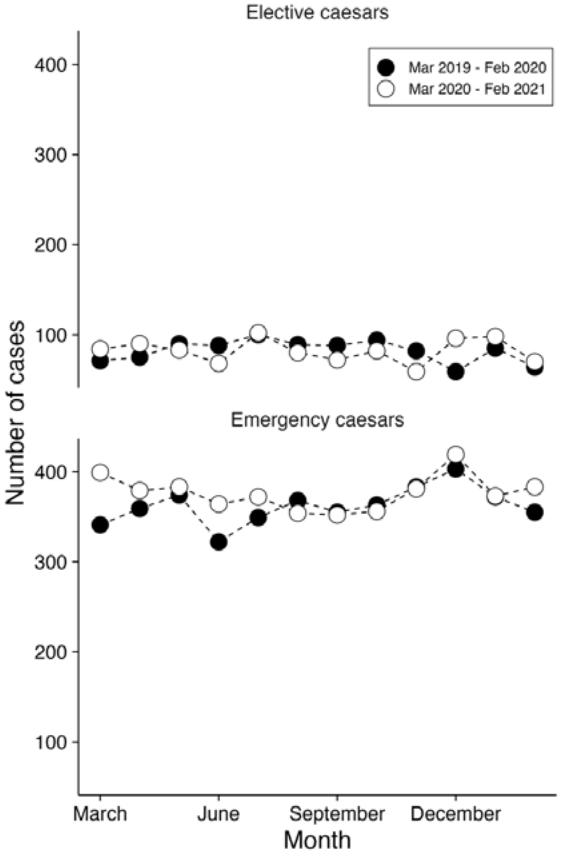


Figure 2: Number of elective and emergency caesareans performed monthly prior to and after the onset of the pandemic

For paediatric ENT cases, while the point estimate indicated a strong effect, the estimate lacked precision (95% CI for the incidence rate ratio: 0.22–0.86). Moreover, in both periods, the number of cases was erratic, and subject to large month-on-month changes.

There was no statistically significant decrease in the number of cases done in obstetrics, including elective, emergency and other obstetric cases, or paediatric orthopaedics (both elective

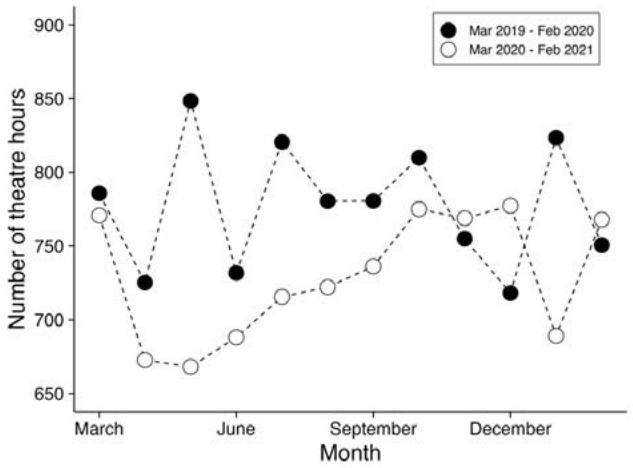


Figure 3: Total number of hours the theatre was used per month in period 1 and period 2

and trauma) and paediatric gastroenterology. The number of caesareans performed monthly is shown in Figure 2.

In paediatric orthopaedics, due to the low case count in general, care should be taken when interpreting the results. In terms of trauma/emergencies, period 1 and 2 saw a total number of 231 (18 cases per month; 17–22) and 243 (18 cases per month; 16–27) trauma/emergency cases, respectively ($p = 0.582$).

After case number analysis, total theatre hours were examined. In total, 9 656 (median of 781 per month; IQR 746–813) and 9 148 (median 729 per month; IQR 689–769) hours of surgery were conducted at the RMMCH during period 1 and 2, respectively. The number of theatre hours for period 2 was statistically significantly lower than the number of theatre hours for period 1 ($p = 0.012$). This relationship is shown in Figure 3.

Each discipline was analysed individually and results are displayed in Table II. There were no significant differences in gynaecological emergency surgery ($p = 0.30$), obstetric elective ($p = 0.70$) or emergency ($p = 0.90$) surgery, paediatric orthopaedic elective surgery ($p = 0.758$), paediatric orthopaedic emergencies ($p = 0.20$) or paediatric gastrointestinal procedures ($p = 0.30$). There was significantly poorer theatre use in gynaecological elective surgery ($p < 0.05$), paediatric dental surgery ($p < 0.001$), paediatric ENT ($p < 0.01$), paediatric plastic surgery ($p < 0.05$) and paediatric urology ($p < 0.05$).

Cancellations/postponements

The number of cancellations or postponements pre- and post-COVID-19 are shown in Table III. The majority of cancellations/postponements were attributable to overbooked lists or limited time for elective cases, with other reasons contributing a small fraction of the total cancellations/postponements. For this reason, only the total number of cancellations/postponements, and not each cause of cancellation/postponement, was analysed.

Overall, there was a statistically significant difference between period 1 and 2 ($p < 0.001$). There was a moderately strong (95% CI for the odds ratio: 1.36–1.79) association between the period and cancellations/postponements, with post-COVID-19 being associated with greater odds of cancellation/postponement compared to pre-COVID-19.

Surgical morbidity/mortality

While mortality was absent or negligible in most settings, there were 77 and 51 ICU admissions, 255 and 190 high care (HC) unit admissions, 436 and 482 transfusions, and two and three cardiac events pre- and post-COVID-19, respectively. In terms of mortalities, there were six mortalities pre-COVID-19 and 13 mortalities post-COVID-19. The values were used in a chi-squared test to produce the following findings.

There was no statistically significant change in ICU or HC admissions ($p = 0.100$ and $p = 0.056$, respectively). There was also no statistically significant change in transfusions ($p = 0.056$), cardiac events ($p = 0.66$) or mortality rate ($p = 0.133$).

Table II: Theatre use hours by surgical discipline

Discipline	Total number of hours *n* (median per month; IQR)		
	Period 1 (pre-COVID-19)	Period 2 (post-COVID-19)	*p*-value
Gynaecology emergency	1 236 (111; 93–115)	1 330 (108; 101–129)	0.30
Gynaecology elective	1 114 (86; 78–113)	844 (74; 52–94)	< 0.05
Obstetric caesarean emergency	4 915 (401; (389–419)	4 940 (416; 394–428)	0.90
Obstetric caesarean elective	1 214 (105; 90–113)	1 184 (95; 89–109)	0.70
Other obstetric cases	131 (11; 7.0–13.8)	139 (11; 8.8–14.2)	0.80
Paediatric orthopaedic elective	48 (4; 1.71–5.22)	53 (4; 2.68–4.76)	0.758
Paediatric orthopaedic trauma	278 (23; 21–26)	343 (26; 22–36)	0.20
Paediatric ENT	357 (29; 24–36)	142 (7; 1–15)	< 0.01
Paediatric plastic surgery	80 (8; 4.08–8.25)	44 (2; 0.00–5.92)	< 0.05
Paediatric gastroenterology	53 (4; 3.50–5.40)	68 (6; 3.23–7.85)	0.30
Paediatric urology	59 (4; 1.81–6.73)	19 (0.58; 0.00–3.50)	0.03
Paediatric dental	172 (13; 12.1–15.5)	41 (0.3; 0.0–7.4)	< 0.001

ENT – ear, nose and throat

Table III: Cancellations or postponements pre- and post-COVID-19

Total number of cancellations/postponements *n* (median per month; IQR)			
Reason for cancellation	**Period 1 (pre-COVID-19)**	**Period 2 (post-COVID-19)**	***p*-value Uncorrected *p*-value (Holm corrected *p*-value)**
Overbooked list/no time for elective cases	1 643 (130; 86–164)	3 110 (234; 218–284)	0.005 (0.05)
Patient inadequately prepared or unfit	37 (2; 1–6)	36 (2; 1–4)	0.8 (> 0.9)
Infrastructure equipment related	32 (0; 0–4)	5 (0; 0–1)	0.6 (> 0.9)
List replaced by emergency cases	59 (1; 0–7)	12 (0; 0–1)	0.12 (0.84)
Surgeon not available	2 (0; 0–0)	2 (0; 0–0)	0.7 (> 0.9)
HC or ICU beds not available	19 (1; 1–2)	7 (0; 0–1)	0.07 (> 0.9)
Re-evaluated and management changed	108 (9; 7–12)	106 (8; 6–9)	0.5 (> 0.9)
Staff shortage	1 (0; 0–0)	(0; 0–0)	> 0.9 (> 0.9)
Total postponements	1 901 (151; 106–186)	3 297 (248; 235–288)	0.006 (0.054)
Total cases	8 176 (684; 659–713)	7 717 (628; 611–672)	0.05 (0.4)
Proportion of cases postponed (median (IQR))	0.22 (0.15–0.26)	0.39 (0.35–0.48)	0.004 (0.044)

HC – high care, ICU – intensive care unit, IQR – interquartile range

Discussion

At the RMMCH, fewer cases were performed and theatre use was lower in the 12 months following the onset of the COVID-19 pandemic. This finding is similar to other South African studies conducted by Chu et al.[1] and Laäs et al.[9]

The number of cases performed and theatre hours used varied significantly by both discipline and whether cases were classified as elective or emergency surgery. The statistically significant reduction in the number of elective gynaecological cases performed during the first year of the COVID-19 pandemic is in line with the directive issued on 19 March 2020 suspending all non-emergency theatre cases.[2]

At the RMMCH, gynaecological cases considered to be elective included both benign and malignant pathologies. The significant reduction in the number of elective gynaecological cases may have significant ramifications in each category. For patients suffering from malignancies, a delay in surgery may equate to advancement of disease. Similar to a study conducted by Stöss et al.[10] in Europe, this study found a 34.3% reduction in gynaecological elective cases; many of which constitute oncological surgeries which could lead to poorer long-term oncological outcomes. Further study is recommended to confirm the long-term effects of delays/cancellations.

Regarding delays for benign pathologies, delayed myomectomies for multifibroid uterus can result in prolonged pain, bleeding and infertility.[11]

Throughout all surgical disciplines there was a notable reduction in the number of elective cases done. The only exception was obstetrics; where there was no statistically significant reduction both in terms of cases done and completed theatre hours. This may be explained by the fact that although termed 'elective' caesareans are procedures that need to be done timeously to avoid risks associated with patients transitioning into labour. In our setting, 'elective' caesareans include those done for mothers who have had two or more previous caesareans, twin pregnancies, have an obstructed birth canal, breech presentation or foetal macrosomia. These indications are in keeping with international guidelines on absolute and relative indications for caesarean delivery, and as such are not truly 'elective' procedures.[12]

Paediatric surgery subspecialities were most affected by the pandemic with the exception of orthopaedic surgery. This may be attributed to the fact that the large majority of paediatric orthopaedic surgeries done at the RMMCH are trauma related, and therefore not considered elective surgery and would have continued to be conducted throughout the lockdown period.

In paediatric urology, dental, ENT and plastic surgery, there were statistically significant reductions in cases during period 2 compared to period 1. Park et al.[13] conducted an interrupted time series analysis on low- and middle-income countries and found a similar decline in total paediatric surgical cases by a third in the first month following March 2020, followed by slow recovery thereafter.

Similar to Gunadi et al.[14] and Banerjee et al.,[15] this study showed a significant reduction in the number of elective paediatric surgical cases completed. The reduction in theatre use could have consequences for patients, healthcare workers and medical students as the RMMCH is an academic hospital affiliated to the University of the Witwatersrand (Wits) and plays an important role in the education and training of specialising doctors and students. The reduction in case load may limit opportunities for learning due to decreased exposure to many types of elective procedures.

This study shows that the odds of cancellation/postponement was greater after the pandemic onset. The reason for cancellation/postponement in the majority of cases was attributable to "overbooked lists" or "no time for elective procedures". A possible reason for this may be various delays experienced throughout the pandemic, for example late results of COVID-19

testing, or increased anaesthetic and surgical time due to new COVID-19 protocols. This, however, is anecdotal and further research to delineate reasons for cancellation/postponement is required. Although statistically significant, the total number of cancellations/postponements may appear lower than expected as it does not include cases that were never booked for reasons pertaining to the pandemic. These cases are reflected in the reduced number of cases done and decreased theatre hours. Sims et al.[16] have found that cancellations/postponements also lead to increased anxiety and decreased functional activity in certain patient groups.

Analysis of rates of surgical morbidity and mortality produced extremely sparse data. We therefore analysed total morbidity and mortality between the two periods, rather than that for each subspeciality. Surgical mortality is defined as any death, regardless of cause, occurring within 30 days after surgery in or out of the hospital.[17,18] In our study, only data pertaining to deaths occurring in hospital were accessible.

Changes in ICU and HC admissions, as well as in theatre related mortalities, can be attributed both directly and indirectly to the COVID-19 pandemic. Indirectly, issues such as delayed time to surgery due to waiting for COVID-19 test results and prolonged surgical time due to difficulty in operating in personal protective equipment (PPE) may be potential contributing factors. The findings of this study were contrary to those by Farsi et al.[19] However, the lack of change in morbidity or mortality may be due to the restricted period of study, and patient demographics.

Directly, concomitant COVID-19 infections may increase the risk of HC and ICU admissions and in some cases, the progression to mortality. In this study, specific causes of morbidity and mortality were not investigated beyond being theatre or surgery associated. Knisely et al.[20] found that surgical patients with concomitant COVID-19 had both an increased rate of ICU admission and perioperative mortality. Frequently, in our setting, diagnosis of COVID-19 was unknown at the time of surgery, ICU or HC admission, or at time of death.

The COVID-19 status of ICU, HC admissions and mortalities were not recorded in this study. Thus, further research is recommended.

This study found that approximately 20% of gynaecological emergency cases required blood product transfusion. This is significant as the RMMCH currently does not have access to an onsite blood bank after hours. This data may be useful in the assessment of, and motivation for, the establishment of a 24-hour blood bank service.

Study limitations

Due to the nature of this research, the study was limited by the accuracy with which records were recorded and stored. Illegible, incomplete and damaged records were excluded. In such cases, the entire record was excluded and not counted as a case number despite the presence of a chart indicating that a case was done. The possibility of incorrect filing, mislabelling or missing records is a further limitation and cannot be exactly quantified.

This study comprised convenience sampling which may result in some degree of sampling bias. Also, due to its contextual nature, the results may not be generalisable to other institutions. Importantly, the RMMCH is a mother and child hospital offering paediatric medical and surgical as well as obstetric and gynaecological services only. Thus, results cannot be compared to hospitals that include all adult surgical disciplines and departments such as internal medicine. These hospitals likely faced a much higher influx of COVID-19 positive patients and would have been more likely to reallocate staff according to need especially during the highest phases of the pandemic.[1,21]

Conclusion

Theatre use hours and the number of cases performed were significantly reduced after the onset of the COVID-19 pandemic. At the RMMCH, these findings were most pronounced for elective gynaecology and paediatric surgical disciplines other than paediatric orthopaedic surgery. The onset of the COVID-19 pandemic also coincided with an increased rate of cancellation/postponement of surgeries. This study showed no statistically significant increase in surgical morbidity or mortality associated with the onset of the COVID-19 pandemic. Further research is required to determine the effect on patient satisfaction and long-term outcomes.

Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

Ethical approval was obtained from the University of the Witwatersrand Human Research Ethics Committee (M210845)

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