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Research paper

Impact and projections of the COVID-19 epidemic on attendance and routine vaccinations at a pediatric referral hospital in Cameroon

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ABSTRACT

Background: At the beginning of March 2020, Cameroon experienced its first cases of infection with the new coronavirus (SARS-COV-2). Very quickly, there was a drop in the rate of hospital attendance. The purpose of this study was to observe the variations in the uptake of pediatric consultations and vaccinations in a pediatric hospital.

Methods: A descriptive and retrospective cross-sectional study was carried out using consultation and vaccination statistics from a pediatric hospital in the city of Yaoundé, political capital of Cameroon, from January 2016 to May 2020. Data were entered in Microsoft Excel and exported to R software (Version 3.3.3) for statistical analysis. First, time series raw data (before and after COVID-19) were plotted and the trend estimated by locally weighted scatterplot smoothing (LOWESS) methods. Then a classic seasonal decomposition was performed to distinguish between seasonal trends and irregular components using moving averages. The Webel–Ollech overall seasonality test (WO test) was also run to formally check for seasonality. The results of the study are presented as narrative tables and graphs.

Results: Following the partial confinement recommended by the government of Cameroon, the number of pediatric consultations decreased by 52% in April and by 34% in May 2020 compared with rates during the same periods in 2019 ($P = 0.00001$). For antenatal visits, the rates dropped by 45% and 34%, respectively, in April and May 2020 compared with 2019. The demand for immunization services also declined. As a result, the demand for BCG vaccines, third-dose tracer vaccines (diphtheria, tetanus, pertussis), polio, and MMR in children as well as tetanus vaccines in childbearing women dropped significantly.

Conclusion: The start of the COVID-19 pandemic was accompanied by a significant drop in consultation and vaccination activities. If no action is taken to correct this phenomenon, the ensuing months could be marked by a considerable increase in patients, sometimes suffering from vaccine-preventable diseases. The death rate could increase considerably in the pediatric population.

1. Introduction

Declared in Wuhan, China in December 2019, the coronavirus infection (COVID-19) quickly became a pandemic [1]. It is a respiratory infection caused by the new SARS-CoV-2 coronavirus, which is transmitted from human to human through respiratory droplets and contaminated surfaces [2,3].

From the start of the pandemic until July 8, 2020, 11,892.382 cases were diagnosed in 188 countries, including 545,618 deaths. In Cameroon, the first case was declared on March 6, 2020 and by July 8, 2020, the country had 14,916 diagnosed cases with 359 deaths [4].

On March 17, 2020, Cameroon implemented a government response strategy to the COVID-19 pandemic with a series of measures including the closing of borders, schools, and universities as well as social distancing measures [5].

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In Cameroon, the Expanded Immunization Program provides for the bacillus Calmette–Guérin (BCG) and oral polio vaccine at birth. At 6, 10, and 14 weeks of age, the diphtheria–tetanus–pertussis (DTP), hepatitis B, *Haemophilus influenzae* b1, oral polio, rotavirus, and pneumococcal vaccines are administered plus a dose of injectable polio vaccine at 14 weeks. Vaccines against measles and rubella (MR) and yellow fever (AA) are administered at 9 months of age. As of April 13, 2020, the World Health Organization (WHO) provided guidance on the importance of continuing routine immunization services as well as an alert on the risks associated with its interruption, be it temporary, during the COVID-19 pandemic. The WHO also insisted on the need to continue these activities while respecting optimal safety conditions both for healthcare providers and for beneficiaries [6]. The Centers for Disease Control and Prevention (CDC) also reported in April 2020 a decline in vaccine coverage related to the COVID-19 pandemic in the state of Michigan in the United States [7]. Experiences from previous epidemics in Africa indicate that any disruption of immunization services is likely to lead to epidemics of vaccine-preventable childhood illnesses with, as a corollary, an increase in infant mortality in the months or years to come [8].

A longitudinal cohort study in rural South Africa to assess changes in access to primary health care during the confinement period in the fight against COVID-19 showed a significant drop in visits of children under the age of 5 [9].

The purpose of this study was to assess the impact of the COVID-19 pandemic on the uptake of consultation and immunization services in a level-3 referral pediatric hospital in Yaoundé, Cameroon.

2. Methods

2.1. Study

2.1.1. Study type

This was a descriptive and retrospective cross-sectional study.

2.1.2. Study site

This study was carried out at the Mother and Child Center of the Chantal Biya Foundation (MCC/CBF). It is a mother and child hospital with a 262-bed capacity. The hospital has 65 doctors, 302 paramedics, and approximately 101 support staff. Half of the staff is made up of civil servants paid by the state, while the other half comprises providers recruited by the hospital and paid from the funds generated by the costs of services (consultations, hospitalizations, paraclinical examinations). The average annual attendance of the MCC/CBF in the past 4 years is around 34,601 patients. The hospital offers consultations for children and women. Pediatric consultations are divided into three main pools: emergency consultations operating 24 h a day; outpatient consultations only during the day; and special consultations at the day unit that deals with HIV/AIDS. These consultations are carried out by pediatricians, general practitioners, and residents in pediatrics. The mothers' consultations (by gynecologists and midwives) are divided into gynecology, obstetrics, and family planning consultations as well as care for women living with HIV/AIDS. Vaccination services are open to children from birth to adolescence as well as women of reproductive age. The hospital offers hospitalizations only to children. To these must be added the activities of the laboratory (biochemistry, bacteriology, hematology) and radiology units. MCC/CBF is also a teaching hospital and receives nursing students, medical students, and residents specializing in pediatrics for their internships.

All services have remained fully functional since the start of the pandemic in Cameroon.

2.1.3. Study period

The study was conducted from June 1 to 30, 2020 and covered the period from January 1, 2016, to May 31, 2020.

2.1.4. Study population

The study included all the children and women received at the MCC/CBF during the study period for consultations and vaccinations.

2.2. Data collection procedure

Data were collected from the hospital's computerized database as well as statistical records from various departments of the MCC/CBF. All the children and women received in outpatient consultations as well as at the vaccination units were included. Concerning vaccination services for children, the vaccines included from the Expanded Program on Immunization (EPI) were: BCG, third dose of DTP, and measles. In women, data relating to the first, second, and fifth dose for tetanus vaccines (VAT) were analyzed.

2.3. Ethical considerations

Prior to initiating this study, ethical clearance was obtained from the ethics committee of the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé I. In addition, we obtained research authorization from the administration of the MCC/CBF. As this study is retrospective, the ethics committee exempted the consent of the parents of the children to be included in the study. All data collected were kept confidential; only investigators had access to anonymous patient data.

2.4. Data analysis

Data were entered into Microsoft Excel and exported to R software (Version 3.3.3) for statistical analyses. First, time series raw data (before and after COVID-19) were plotted and the trend was estimated by locally weighted scatterplot smoothing (LOWESS) methods. Then a classic seasonal decomposition was performed to distinguish between seasonal, trend, and irregular components using moving averages. This allowed to graphically visualize whether the time series displayed seasonal variation. The Webel–Ollech overall seasonality test (WO test) was also performed to formally check for seasonality. This was followed by testing for stationarity using the augmented Dickey–Fuller test; when seasonality was present, a seasonal autoregressive and moving average (ARIMA) model (Box–Jenkins models) was used for modeling, otherwise a simple ARIMA model was used. Models were identified using the sample autocorrelation function (ACF) and partial autocorrelation function PACF and parameters were estimated. The model adequacy was assessed with the diagnostic plots of standardized residuals, the ACF of the residuals, a boxplot of the standardized residuals, and the *P*-values associated with the Q-statistic. When the model passed the diagnostics, it was used for forecasting and determining 12-month ahead 95% prediction intervals for forecasts from June 2020 to May 2021.

3. Results

Between January 1, 2016, and May 31, 2020, MCC/CBF received 151,413 children and 22,561 women for consultation. During the same period 5522 BCG, 6034 DTP3, and 5435 measles vaccine doses were administered. For the tetanus toxoid vaccine in women of childbearing age, 2197 VAT1, 1805 VAT2, and 528 VAT5 (first, second, and fifth doses) were administered.

3.1. Consultations

3.1.1. Pediatric consultations

Fig. 1 summarizes the monthly trend in pediatric consultations over the years. Fig. 1 shows the possibility of an overall increasing trend of monthly pediatric consultations over time, with similarities between the observed data and the seasonal component (with seasonal decomposition plot); thus, the time series is seasonal. The results of the Webel–Ollech overall seasonality test (WO test) shown in Fig. 2 confirm this seasonality by classifying the number of consultations over time as a 12-month seasonal time series (QS test $P = 0.002$ and kwman test $P = 0.01$). The results of the augmented Dickey–Fuller test showed a *P*-value of 0.04, proving that the series was marginally stationary. The only nonzero value

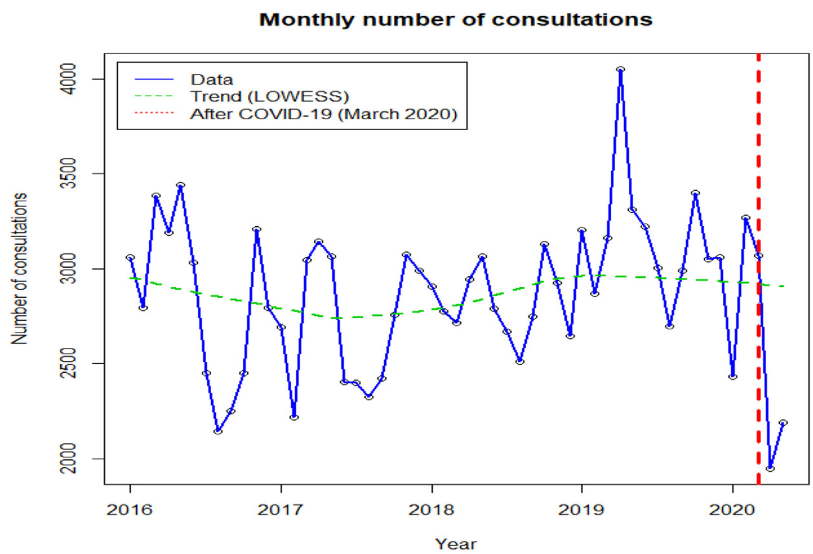

Fig. 1. Trend in monthly pediatric consultations from January 2016 to May 2020.

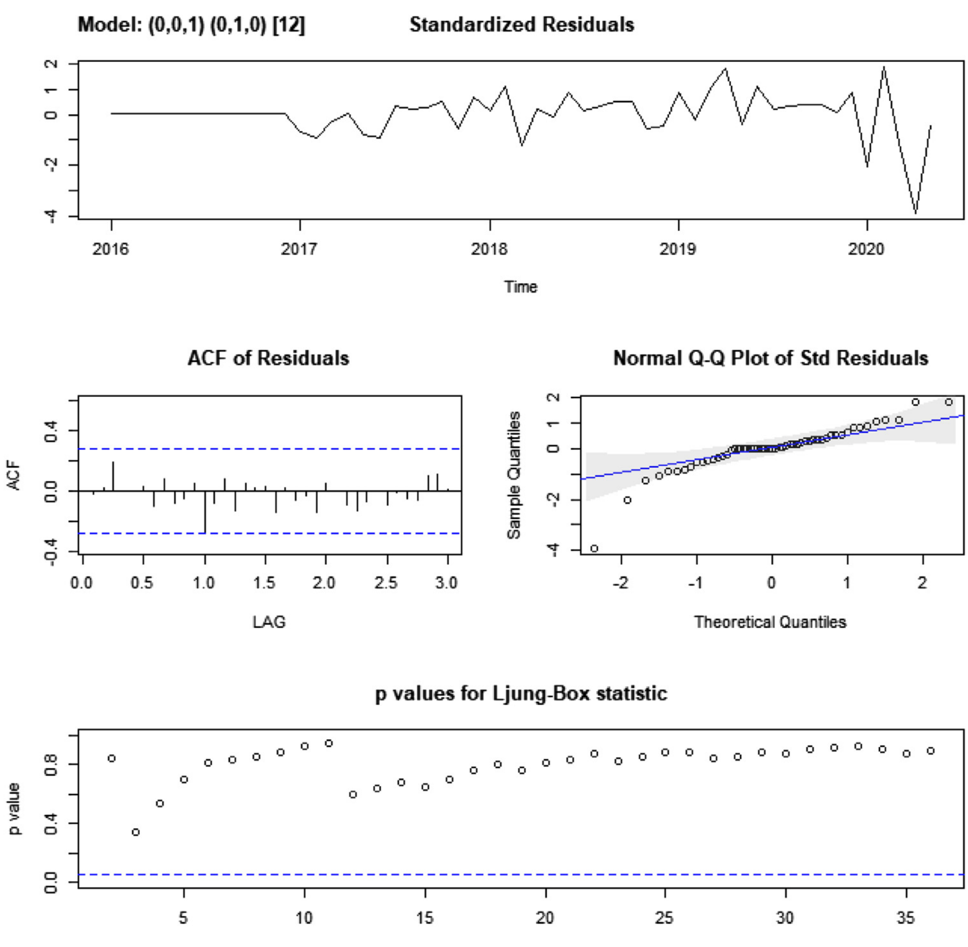

Fig. 2. Diagnostics of the residuals from the seasonal ARIMA(0,0,1) × $(0,1,0)_{12}$ model fit on the number of pediatric consultations.

in the theoretical ACF and PACF is for lag 1 with all other autocorrelations equal 0. Thus, this is an indicator of a possible nonseasonal MA(1) model. For the seasonal component, differentiating once resulted in the seasonal component being stationary with clearly a monthly effect and no obvious trend. A candidate model for both seasonal and nonseasonal models is ARIMA(0,0,1) $\times$ $(0,1,0)_{12}$.

Thus, over the years, there have been seasonal variations in the number of pediatric consultations. The months of April and May are the periods with the highest attendance at the hospital. However, we note a drastic drop in the number of consultations, reaching levels never equaled after the start of the COVID-19 epidemic in March 2020. This drop was 52% and 34%, respectively, in April and May 2020 compared with the same period in 2019 (P = 0.00001).

Fig. 2 displays a plot of the standardized residuals, the ACF of the residuals, a boxplot of the standardized residuals, and the P-values associated with the Q-statistic at lags $H = 1$ through $H = 37$ (with corresponding degrees of freedom $H - 2$). Inspection of the time plot of the standardized residuals shows no obvious patterns. The ACF of the standardized residuals shows no apparent departure from the model assumptions, and the Q-statistic is never significant at any lags. The normal Q-Q plot of the residuals shows that the assumption of normality is reasonable. This confirms that the seasonal ARIMA (0,0,1)$(0,1,0)_{12}$ model appears to fit well with a significant coefficient (MA(1): coefficient = 0.49, SE = 0.15, P = 0.002); and can be used for predictions.

The seasonal ARIMA (0,0,1) $\times$ $(0,1,0)_{12}$ model predicts trends in pediatric consultations over the next 12 months if no intervention is made (Fig. 3). In the absence of any intervention and if the COVID-19 pandemic continues, pediatric consultations could drop drastically and fall below 2000 patients in May 2021.

3.1.2. Maternal consultations

Gynecological and obstetrical consultations followed a similar trend (Figs. 4 and 5).

Fig. 4 shows an overall downward trend in gynecology–obstetrics consultations since 2016; the drop during the COVID-19 epidemic was greater. This drop was 45% and 34%, respectively, in April and May 2020 compared with the same period in 2019 (P = 0.00001).

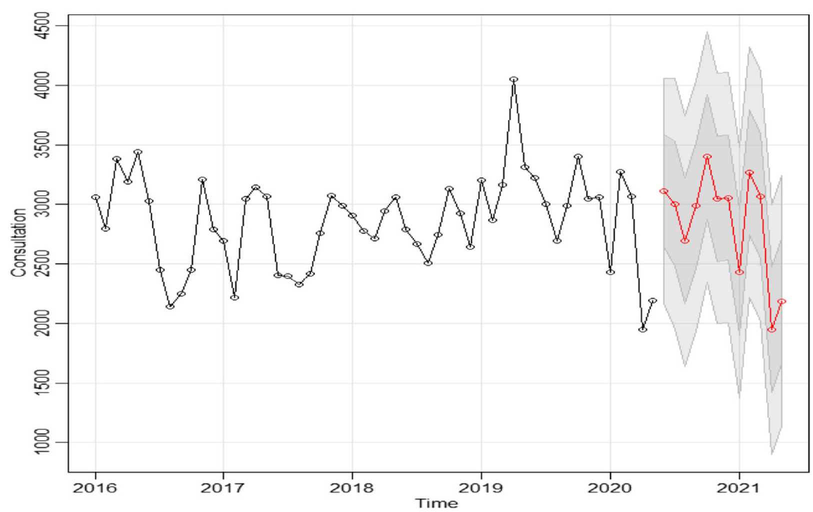

Fig. 3. A 12-month prediction with predictive intervals of the number of consultations from June 2020 to May 2021 using the seasonal ARIMA(0,0,1) $\times$ $(0,1,0)_{12}$ model.

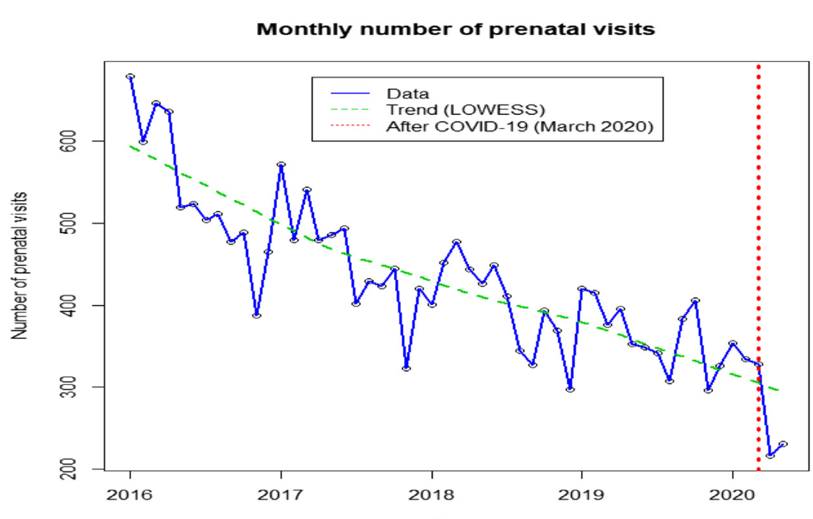

Fig. 4. Progression of the number of monthly prenatal visits over time with the trend estimated by locally weighted scatterplot smoothing (LOWESS) between January 2016 and May 2020.

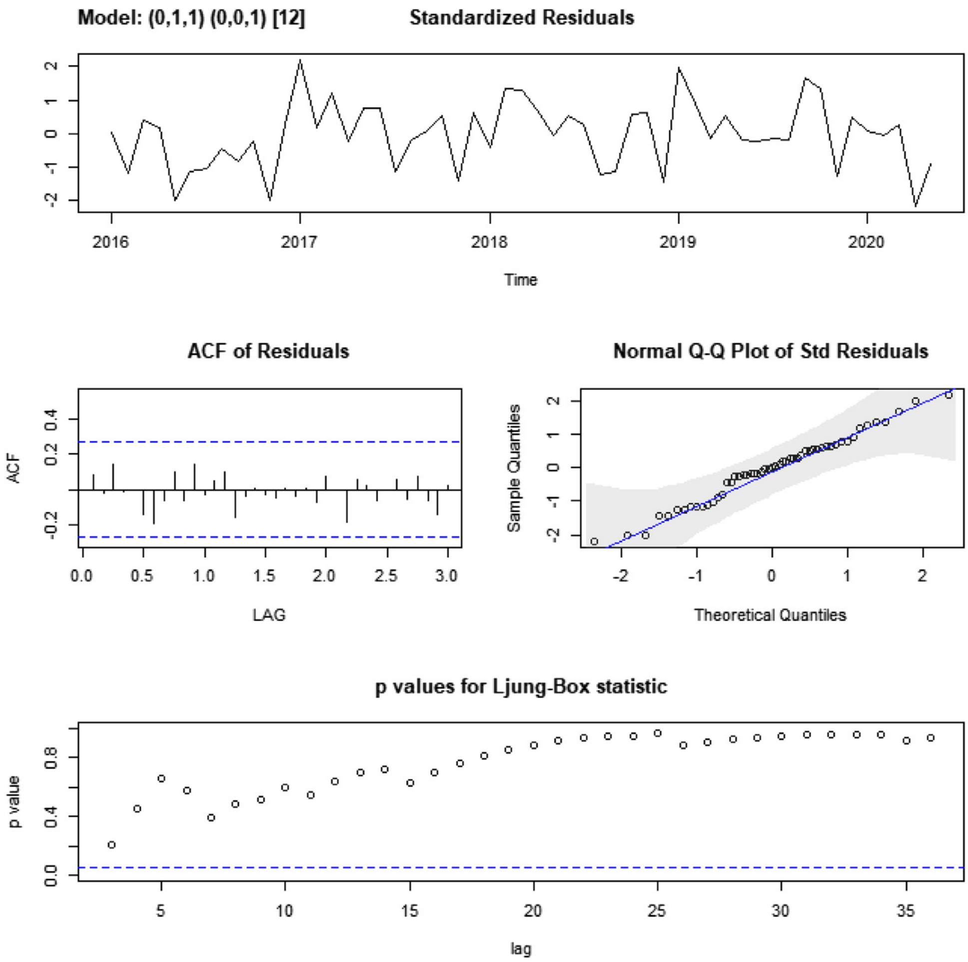

Fig. 5. Diagnostics of the residuals from the seasonal ARIMA$(0,1,1) \times (0,0,1)_{12}$ model fit on the number of prenatal visits.

Seasonality was confirmed (P-value QS test = 0.01 and kwman test $P = 0.02$) as was stationarity (augmented Dickey–Fuller test $P = 0.01$). Model identification shows ARIMA$(0,1,1) \times (0,0,1)_{12}$ as a candidate model for both seasonal and nonseasonal terms.

Inspection of Fig. 5 shows no obvious patterns of the standardized residuals and no violation of model assumptions; the Q-statistic is never significant at any lags, and residuals are normally distributed. Thus, the seasonal ARIMA $(0,1,1)(0,0,1)_{12}$ model is an appropriate model with a significant coefficient (MA(1): coefficient = −0.70, SE = 0.21, $P = 0.001$; SMA(1): coefficient = −0.33, SE = 0.17, $P = 0.04$), and can be used for predictions.

Predictions (Fig. 6) show that consultations by women could reach very low levels, as low as less than 200 patients for some months in the year 2021.

3.2. Vaccination

3.2.1. Pediatric vaccinations

Immunization activities experienced a decreasing trend with nonseasonal activities (QS test $P = 0.12$ and kwman test $P = 0.09$), and appear to be non-stationary (augmented Dickey–Fuller test $P = 0.5$). Model identification shows that ARIMA$(0,1,0) \times (0,0,0)_{12}$ is a candidate nonseasonal model.

While already declining since the beginning of 2020, the demand for the BCG vaccine experienced a sharper decrease after the start of the COVID-19 outbreak in March 2020. However, there was a resurgence during the month of May 2020 (Fig. 7).

Fig. 8 shows no violation of the normal assumption of the residuals and other assumptions. The nonseasonal ARIMA $(0,1,0) \times (0,0,0)_{12}$ model appears to fit the model data well (coefficient = −0.04, SE = 3.54, $P = 0.66$).

Fig. 9 projects that the decline will continue in the coming months in the absence of any intervention.

Following the same identification methods as described previously, the ARIMA $(0,1,1) \times (1,0,0)_{12}$ model was appropriate to fit the monthly number of children who received tracer vaccines; a decreasing trend was observed during the period (Fig. 10) with non-stationary series augmented Dickey–Fuller test $P = 0.58$ and a seasonal component (QS test $P = 0.04$ and kwman test $P = 0.02$). Fig. 11 presents the predictions of a very low monthly number of children who will receive tracer vaccines, which could be lower than 50 in certain months in 2021.

Fig. 12 shows an overall non-stationary trend (augmented Dickey–Fuller test $P = 0.39$) for the monthly number of children who received the MMR vaccine, but a drop after the appearance of COVID-19. The series does not display any seasonal component (QS test $P = 0.06$ and kwman test $P = 0.07$). The nonseasonal ARIMA $(1,0,0) \times (0,0,0)_{12}$ model fit the data very well as shown by the quality of residuals. Predictions show a constant picture throughout the year 2021 (Fig. 13) after a significant drop due to COVID-19.

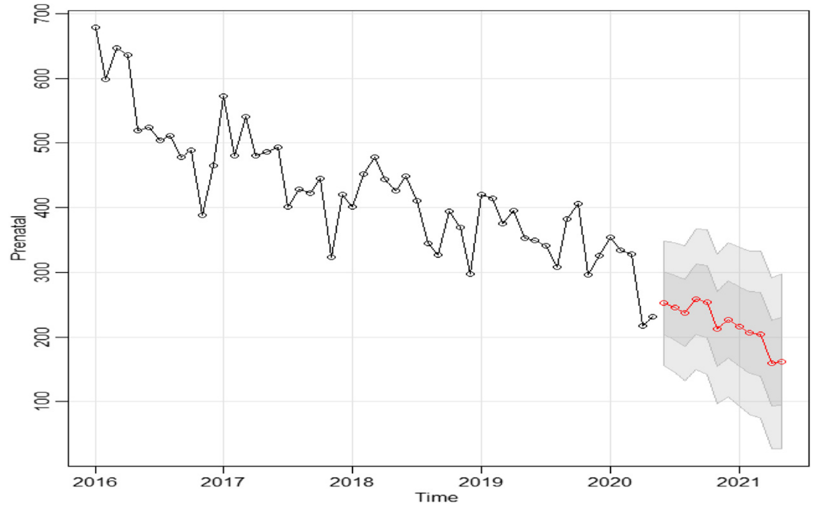

Fig. 6. A 12-month prediction with predictive intervals of the number of prenatal visits from June 2020 to May 2021 using the seasonal ARIMA(0,1,1) $\times$ (0,0,1)$_{12}$ model.

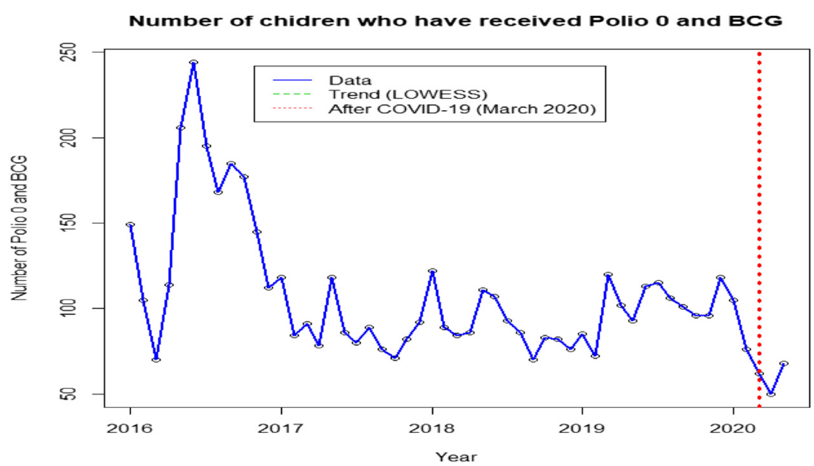

Fig. 7. Progression of the monthly number of children who received polio 0 and bacillus Calmette–Guérin (BCG) vaccines over time with the trend estimated by locally weighted scatterplot smoothing (LOWESS) between January 2016 and May 2020; data are related to polio and BCG together, because the two vaccines are administered at the same time.

Predictions indicate that about 100 children will receive the MMR vaccines in 2021.

3.2.2. Women's vaccinations

The tetanus toxoid (TT) vaccination of women of childbearing age followed the same pattern as the pediatric vaccinations whatever the dose considered (TT1, 2, 3, 4, and 5). We observed a pronounced decline in the demand for vaccinations in April and May 2020 compared with the four previous years. The progression of the second dose of this vaccine was as follows: in April and May 2020, the doses administered were 23 and 18, respectively. In previous years, in April and May, the doses administered were, respectively, 37 and 32 in 2019, 36 and 31 in 2018, 35 and 32 in 2017, and 48 and 34 in 2016.

4. Discussion

Our goal was to assess the effect of the pandemic on hospital attendance, including consultations and vaccinations in a pediatric hospital.

The month of April 2020 saw a considerable drop in consultations compared with other months of the year and especially when compared with the same months of the previous four years. The decrease was even more evident because, over the years, the months of April and May proved to be the months with the greatest influx at MCC/CBF [10,11]. The rainy season in the center region where the hospital is located begins in April and is usually accompanied by an increased prevalence of malaria – the major ailment treated at the hospital [10,12]. Until mid-March, hospital use was in its normal course. The drop in consultations coincides with the Cameroonian government's containment measures decided on March 17, 2020, in the face of this disease for which no treatment was yet known [5]. These measures, which were signs of concern from the public authorities, were perceived by the population with anxiety. The atmosphere of fear created by the disease may have discouraged parents from taking their children to the hospital – a place that was considered by many to be a high-risk area for infection. This phenomenon of fear of the hospital is in fact not limited to our hospital or our country [13,14]. Consequently, the population might have resorted to alternatives for the care of sick children [15]. The recourse to care within our population is indeed manifold and varied, ranging from simple self-medication to the solicitation of alternative medicine [16]. It should be noted that a large fraction of the population works in the informal sector [17]. This economic sector was

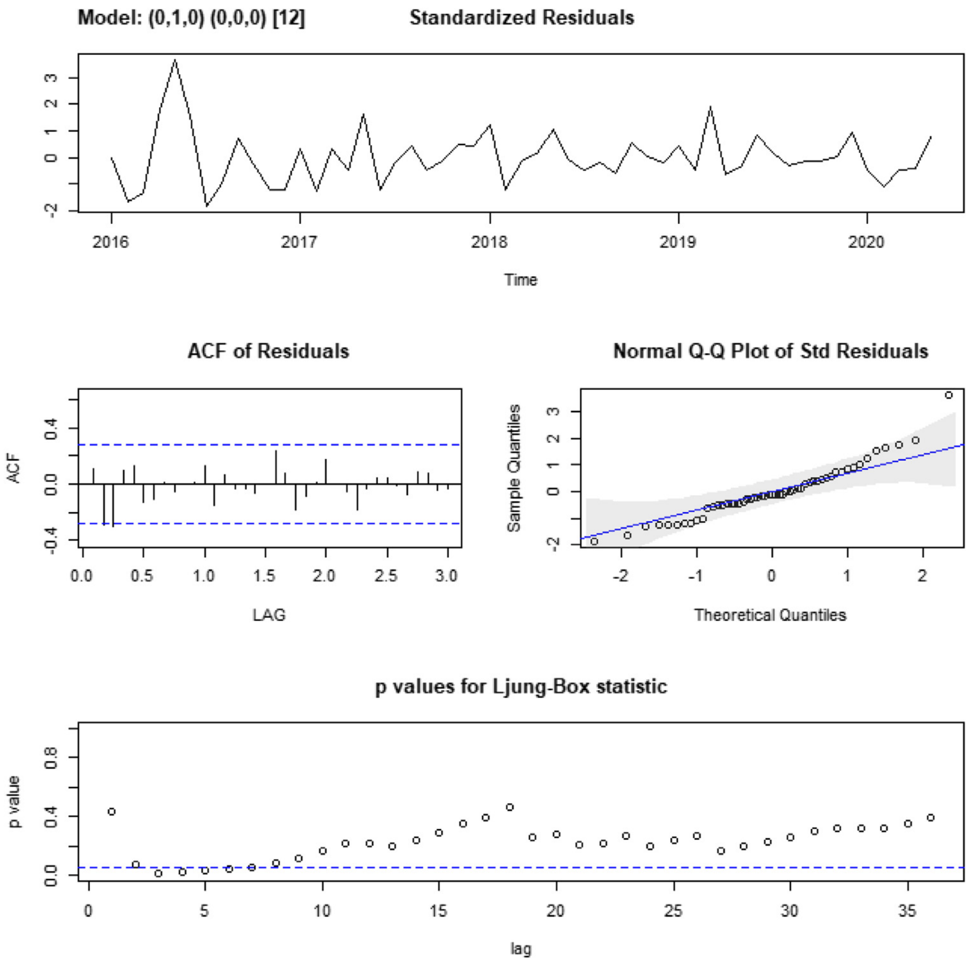

Fig. 8. Diagnostics of the residuals from the nonseasonal ARIMA(0,1,0) × $(0,0,0)_{12}$ model fit on the monthly number of children who received polio 0 and bacillus Calmette–Guérin (BCG) vaccines.

negatively impacted by the containment measures [18]. Moreover, in Cameroon, patients pay out of pocket for their medical care [19–21]. Insufficient finances to pay for consultations and workups as well as to purchase the necessary medications may have also prevented parents from coming to the hospital with their children. The relaxation of partial confinement with the resumption of activities at the end of April coincided with a slight increase in hospital attendance in May. This could also explain the increase in activities in the maternal care unit, where there had been a significant drop in consultations during the confinement period.

Pediatric preventive care activities were not spared in any way. The demand for vaccination services declined significantly from

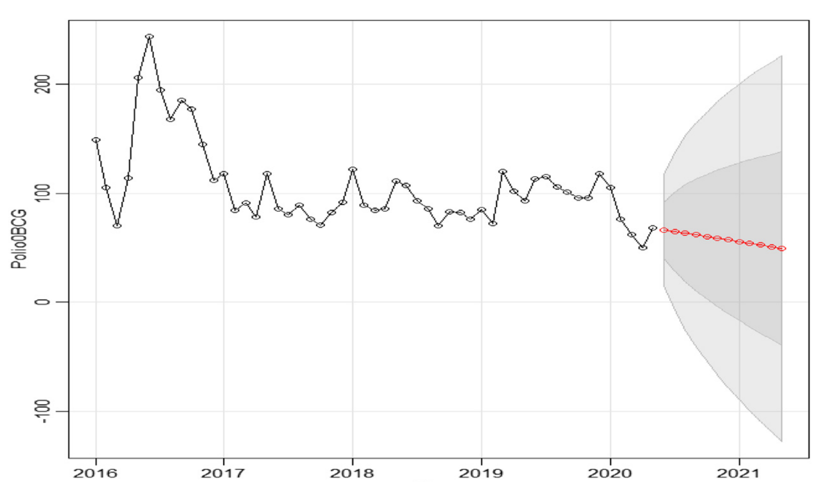

Fig. 9. A 12-month prediction with predictive intervals of monthly number of children who received polio 0 and bacillus Calmette–Guérin (BCG) vaccines from June 2020 to May 2021 using the seasonal ARIMA(0,1,1) × $(0,0,1)_{12}$ model.

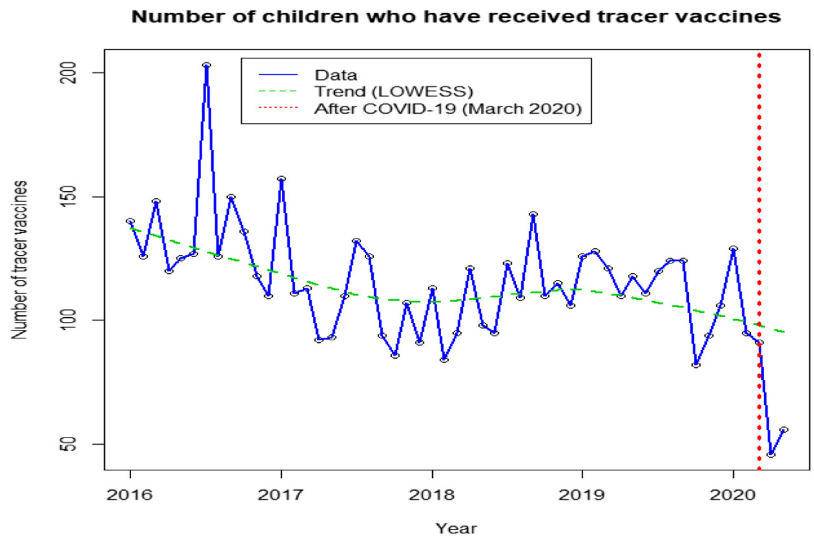

Fig. 10. Progression of the monthly number of children who received tracer vaccines over time with the trend estimated by locally weighted scatterplot smoothing (LOWESS) between January 2016 and May 2020.

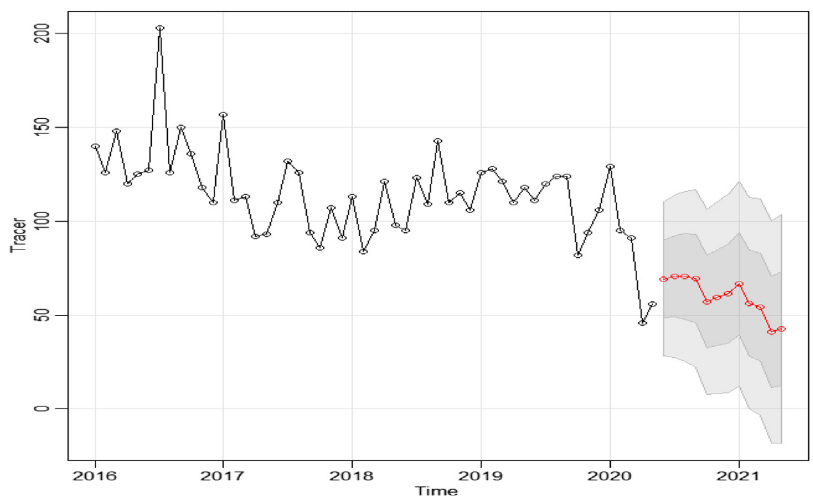

Fig. 11. A 12-month prediction with predictive intervals of monthly number of children who received tracer vaccines from June 2020 to May 2021 using the seasonal ARIMA(0,1,1) $\times$ $(1,0,0)_{12}$ model.

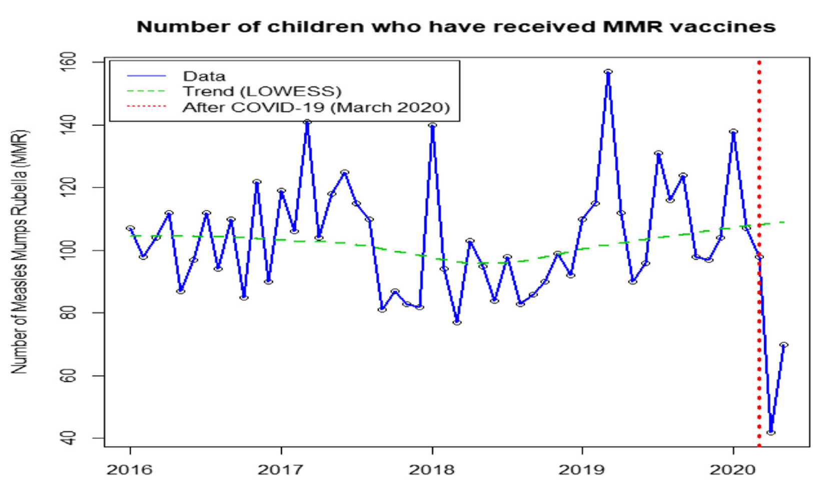

Fig. 12. Progression of the monthly number of children who received MMR vaccines over time with the trend estimated by locally weighted scatterplot smoothing (LOWESS) between January 2016 and May 2020.

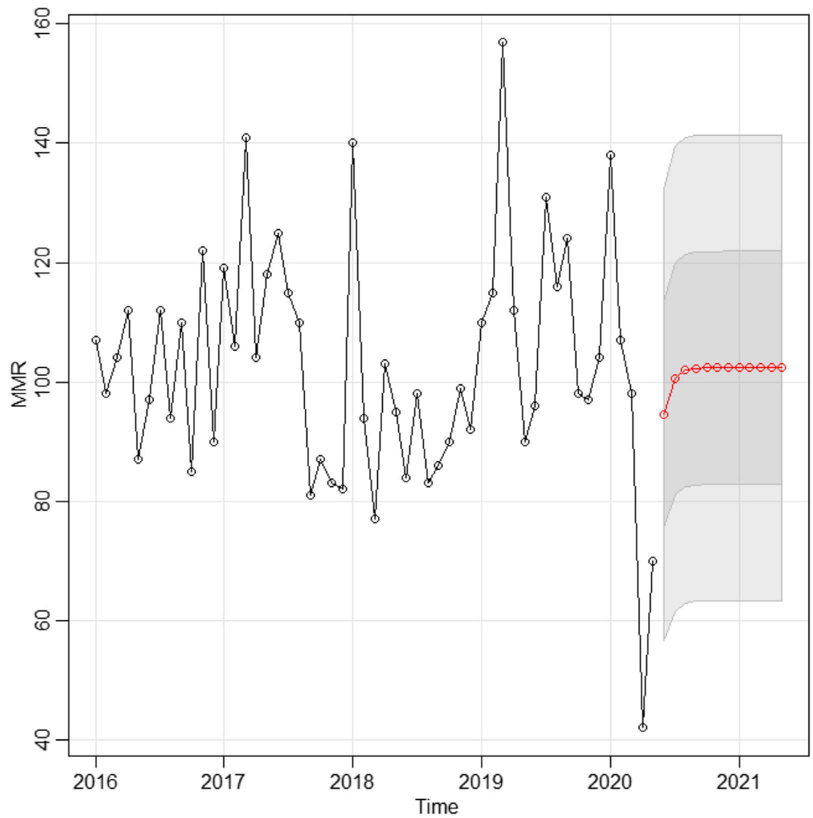

Fig. 13. A 12-month prediction with predictive intervals of monthly number of children who received MMR vaccines from June 2020 to May 2021 using the seasonal ARIMA(1,0,0) × $(0,0,0)_{12}$ model.

the start of the COVID-19 pandemic. All vaccines were affected. We noted, nonetheless, that this decrease was less important for the first vaccines (BCG and polio 0) than for the other vaccines of the expanded program of immunization.

The negative impact of the pandemic on vaccination has already been reported [7,22,23]. There are fears of a resurgence of vaccine-preventable diseases in the coming months. Vaccines for pregnant women have followed the same trend, putting future babies at an increased risk of neonatal tetanus.

Projections of hospital attendance into the coming months increase our concern since most hospital staff are paid from the revenue generated by paid services. At this rate, the hospital would not be able to pay its staff and this could have a negative impact on hospital performance [24]. There was also clearly an impact on hospitalizations and mortality during that period; details can be found in the publication by Chelo et al. [25].

A major public awareness campaign using all available means of communication is therefore important. This will reassure the population of their safety in hospitals. In addition, it will remind them of the importance of vaccination in the prevention of certain childhood diseases. The campaign should rely not only on healthcare providers, but also on opinion leaders, religious authorities, and even popular artists. This campaign could be accompanied by attractive measures such as reducing consultation fees and additional examinations for a specific period.

The retrospective nature of this study limits its scope, because we could not collect all the necessary information from patients. Our database did not allow us to analyze patient subgroups (emergencies, outpatient consultations) as we would have liked. We also limited ourselves to a period of 2.5 months after the start of the pandemic. Furthermore, since the epidemic had been declared less than 3 months earlier, this duration was not long enough to measure the size of the change in various outcomes as is common practice in interrupted time series analysis [26].

In addition, our study focused on a single hospital, which makes it difficult to generalize our findings to all health facilities in the country. Such a study should be undertaken in several hospitals of different levels and over a long period after the start of the COVID-19 pandemic.

5. Conclusion

This study illustrates the negative impact of the COVID-19 pandemic on the uptake of preventive and curative care services in a referral pediatric hospital in Cameroon, in this case consultations and vaccination. There is a risk of an upsurge in vaccine-preventable diseases in the coming months, especially since predictions point to a drastic drop in the demand for vaccination services between June 2020 and May 2021. To anticipate these poor forecasts, it is important that strong actions be taken to restore the relationship of trust between clients (population) and health services. This is an emergency, because apart from the quality care offered to the population, the survival of the hospital depends in part on the income from the payment for care to ensure its functioning.

Disclosure of interest

The authors declare that they have no competing interest.

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