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Attendance and vaccination at immunization clinics in rural Gambia before and during the COVID-19 pandemic



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ABSTRACT

Introduction: The COVID-19 pandemic has affected the delivery of essential health services, such as routine immunization. We assessed the impact of the pandemic on the uptake of routine immunization in rural Gambia.

Methods: We collected real-time vaccine administration data in the Basse and Fuladu West Health & Demographic Surveillance Systems from September 01, 2019, to December 31, 2020. We assessed the monthly number of Expanded Program on Immunization (EPI) clinic attendances and vaccines administered, comparing data during the baseline period (September 01, 2019–March 31, 2020), COVID-19 interruption period (April 01–June 30, 2020), initial recovery period (Jul 01–September 30, 2020) and the late recovery period (October 01–December 31, 2020).

Results: Compared to the baseline period, there was an overall average monthly decline of 13.4% in EPI attendance and 38.3% reduction in average monthly immunizations during the interruption period. This decrease was particularly noticeable for Bacille Calmette-Guérin (BCG) (47.2%), birth dose hepatitis B (Hep B) (46.9%), 1st dose pentavalent (Penta1) (43.1%), 1st dose pneumococcal conjugate vaccine (PCV1) (42.4%), and measles vaccines (15.5%). Comparing the late recovery to baseline period, average monthly EPI attendance was 5.3% higher, with 1.9% increase in average monthly immunizations. Monthly immunizations for BCG were 3.0% greater, 2.5% greater for Hep B, 22.7% greater for oral polio vaccine (OPV1), 2.0% less for Penta1, 19.2% less for Penta2, and 2.6% less for PCV1.

Conclusion: The reduced EPI attendance during the pandemic interruption period lasted only 3 months. Significant recovery in EPI attendance occurred during the late recovery period, while rates of monthly immunization returned to pre-pandemic levels for most antigens. EPI programmes should implement strategies to deliver missed antigens when infants do present to EPI clinics, aware that missed doses may be age dependent.

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Abbreviations: BCG, Bacillus Calmette-Guérin; COVID-19, Coronavirus Disease; DTP, Diphtheria, Tetanus, Pertussis; EPI, Expanded Program on Immunization; Hep B, birth dose Hepatitis B; IPV, Inactivated Poliovirus Vaccine; MenA, Conjugate Meningococcal A Vaccine; OPV, Oral Polio Vaccine; Penta, Diphtheria, Tetanus, Pertussis, Haemophilus influenzae type B, Hep B; PCV, Pneumococcal Conjugate Vaccine; RCH, Reproductive-Child-Health; Rota, Rotavirus vaccine; RVS, Real-time electronic vaccination recording system.

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1. Background

The ongoing Coronavirus disease-2019 (COVID-19) pandemic has been described as one of the worst in history [1]. As of March 12, 2022, a total of 452,201,564 cases of COVID-19 had been confirmed globally with 6,029,852 deaths [2]. The impact of the pandemic has been far-reaching, affecting every facet of human activity. Critically, the delivery of essential health services, such as routine immunization, has been significantly impacted. In May 2020, a joint report by the World Health Organization (WHO), Glo-

bal Alliance for Vaccine Initiative (GAVI), and the United Nations International Children's Emergency Fund (UNICEF) warned that over 80 million children less than 12 months of age were at risk of childhood vaccine-preventable diseases such as polio, measles, diphtheria, pertussis, hepatitis B, pneumococcus, and rotavirus infections due to pandemic-related disruption to routine immunization services in over 68 countries [3]. This development has far-reaching consequences, with the potential to erode gains made in the control of vaccine-preventable diseases in many countries, especially in low- and middle-income countries (LMICs) many of which have weak healthcare systems.

According to a WHO report, an additional 1.3 million African children missed their Bacille Calmette-Guérin (BCG) vaccine, and an additional 1.32 million children less than 12 months of age missed their first dose of measles vaccine between January and August 2020, in comparison to the same period in 2019 [4]. Deployment of staff involved in immunization activities to COVID-19 response activities, reallocation of immunization resources to COVID-19 response, vaccine shortages due to closure of air borders and disruption of logistics, lack of personal protective equipment (PPE) for staff, restrictions of movement, parents refusal or unwillingness to attend Expanded Programme on Immunization (EPI) clinics due to fear of contracting COVID-19 and rumours of immunization centres being used to deploy COVID-19 vaccine trials, especially in African countries, have been cited as factors responsible for the disruption of immunization services [5–8].

In this report, we assess the impact of the pandemic on the uptake of routine immunization services in the Central and Upper River Regions in The Gambia using data from a real-time electronic vaccination data collection system (RVS).

2. Methods

2.1. Population

The Gambia is a small country in West Africa with a population of 2.4 million. The Central River Region (CRR) and Upper River Region (URR) are located in the eastern part of the country. The Medical Research Council Unit The Gambia at London School of Hygiene & Tropical Medicine (MRCG @ LSHTM) operates the Basse and Fuladu West Health and Demographic Surveillance Systems (BHDSS and FWHDS) in URR and CRR respectively (Fig. 1). The BHDSS population is 202,081 (224 villages) with 114,506 in the FWHDS (217 villages); 19 % of the population is aged <5 years. The annual birth cohort is approximately 10,000; BHDSS (66 %) and FWHDS (34 %).

2.2. Immunization and vaccination schedule

There are 68 geographically separate locations at which EPI services are provided, 40 in the BHDSS and 28 in the FWHDS (Fig. 1). Immunization is undertaken at each of 11 fixed health centres in

the area on at least one day each week and at 57 other geographically separate outreach sites visited by Reproductive-Child-Health (RCH) teams at least once per month. The Government of The Gambia has made a major investment in the supply of immunization antigens, recruitment of an adequate number of vaccinators, and provides a comprehensive series of infant immunizations including BCG, diphtheria/pertussis/tetanus (DPT), oral polio (OPV), injectable polio (IPV), hepatitis B (Hep B), *H. influenzae* type b (Hib), Pentavalent (Penta, a combination of DPT/Hep B/Hib), rotavirus (Rota), pneumococcal (PCV), measles/rubella (MR), yellow fever (YF) and meningococcal group A conjugate vaccine (MenA). The vaccine schedule currently recommended is shown in Table 1.

2.3. Data source

A real-time electronic vaccination recording system (RVS) has been used since 2011 to collect vaccination data at RCH clinics in the BHDSS and FWHDS. The RVS is used by MRCG @ LSHTM research projects and runs in parallel with the Ministry of Health (MoH) data system, although the MoH also uses RVS data when needed. The RVS is a bespoke standalone application. It was designed and developed by MRCG @ LSHTM developers. The application is set up on encrypted laptop devices. The application uses C# win forms as the front end and MS Access database as a back-end. At the end of every week, data from all local devices are synchronized to a MRCG @ LSHTM Basse field station central SQL server database. Data are collected electronically using this application and there is no paper record collection. To verify captured vaccine records, field workers do a tally check and compare recorded vaccination information with the MoH logbook at the end of every RCH clinic. Any identified discrepancies are resolved immediately and updated accordingly in the RVS. Additionally, child Infant Welfare Cards (IWCs) are photographed at registration and during the 9-month visit. Later, after data have been synchronized to a central server, a field worker is assigned to verify vaccination records between IWCs and RVS data. Discrepancies are resolved and updated in the RVS. The RVS is the only source of data used for this analysis. The RVS is also used to record data on migration status at every RCH visit. Trained staff visit every EPI clinic and record real-time immunization data for all infants after confirming their identity and residential status. We extracted vaccination records of vaccine antigens administered from September 1, 2019, to December 31, 2020.

2.4. The Gambian government COVID-19 response measures

The Gambia recorded its first COVID-19 case on March 17, 2020, and as of March 12, 2022, the country had recorded 11,963 total cases with 365 deaths [9]. Universities were closed on March 17, 2020, and a ban on all social gatherings and closure of all schools came into effect on March 18, 2020. Air, land, and sea borders were closed on March 23, 2020, and a state of emergency was declared

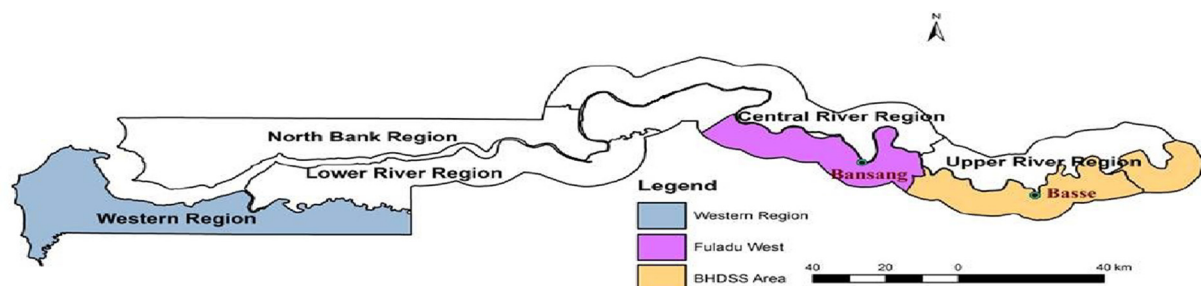


Fig. 1. Map of the Gambia highlighting the Fuladu West and Basse Health and Demographic Surveillance Systems in Central and Upper River Regions.

Table 1
Vaccination schedule of the Gambian Expanded Programme on Immunization.

Age	Vaccine Antigens			
At birth or soon after	BCG	OPV 0	Hep B 1	
Two months	Penta 1	OPV 1	PCV 1	Rota 1
Three months	Penta 2	OPV 2	PCV 2	Rota 2
Four months	Penta 3	OPV3	PCV 3	IPV
Nine months	Measles/Rubella	Yellow fever	OPV 4	
Twelve months	MenA	DTP booster		
Eighteen months	Measles/Rubella	OPV 5		

on March 27, 2020, with the prohibition of gatherings at places of religious worship and the banning of gatherings of more than 10 people. On July 1, 2020, a 21-day partial lockdown was imposed in the main cosmopolitan districts which were further extended for another week. Mandatory wearing of face masks came into effect on July 24, 2020. There was low compliance with the control measures such as wearing of a mask and social distancing in the URR and CRR. COVID-19 cases and related deaths increased sharply from June to July and peaked in August 2020 (Fig. 2) with 2,465 new cases and 87 deaths recorded respectively at that time. There was initial uncertainty regarding policy guidance on the continuity or otherwise of essential services such as EPI activities. However, a communique from the Ministry of Health detailing guidance based on UNICEF and WHO guidance was disseminated across all regions on March 31, 2020, emphasising the continuity of basic health services with enhanced community sensitization as part of the COVID-19 response. However, activities such as child weight measurement, updating of daily antigens administered records in log-books, and infant screening was suspended by RCH staff to decrease waiting time and avoid overcrowding at RCH clinics and was restarted in November 2020. However, updating vaccination information on the infant welfare card was not suspended. In April, May, and June 2020, there was a dramatic reduction in child EPI attendance primarily related to the announcement of a state of emergency, fear of the pandemic, rumours, and messages to reduce social interaction (see Fig. 3).

2.5. Procedure

During the pandemic interruption period, real-time entry of vaccination records at RCH clinics was suspended on March 27, 2020. In the first week of July 2020, we restarted recording individual level vaccination dates in real-time, and vaccination dates from infant welfare cards from the previous 3 months at RCH clinics. Data on the type of antigen received, date of administration, and attendance at EPI clinics was extracted from the RVS. We analysed vaccination data recorded in our RVS from September 01, 2019, to December 31, 2020. We assessed the monthly number of child EPI clinic attendances in the study area and types of vaccines administered in all EPI clinics, comparing data during the baseline period (September 01, 2019–March 31, 2020), the COVID-19 interruption period (April 01–June 30, 2020), the initial recovery period (July 01–September 30, 2020) and the late recovery period (October 01–December 31, 2020). The state of emergency was declared by the Gambia government on March 27, 2020, and on the same day, guidance from the MRCG @ LSHTM led to the pausing of real-time vaccine data collection at RCH clinics. We selected the 7 months from (September 01, 2019–March 31, 2020) before the declaration of the state of emergency as the baseline period as this was the data available and this period included balanced time for the temporal confounding factors of wet and dry season and seasons of higher and lower birth rate. We defined the period April 01–June 30, 2020, as the COVID-19 interruption period as child EPI attendance was most affected during this time, primarily related to the announcement of a state of emergency, fear of the pandemic, rumours, and messages to reduce social interaction. July

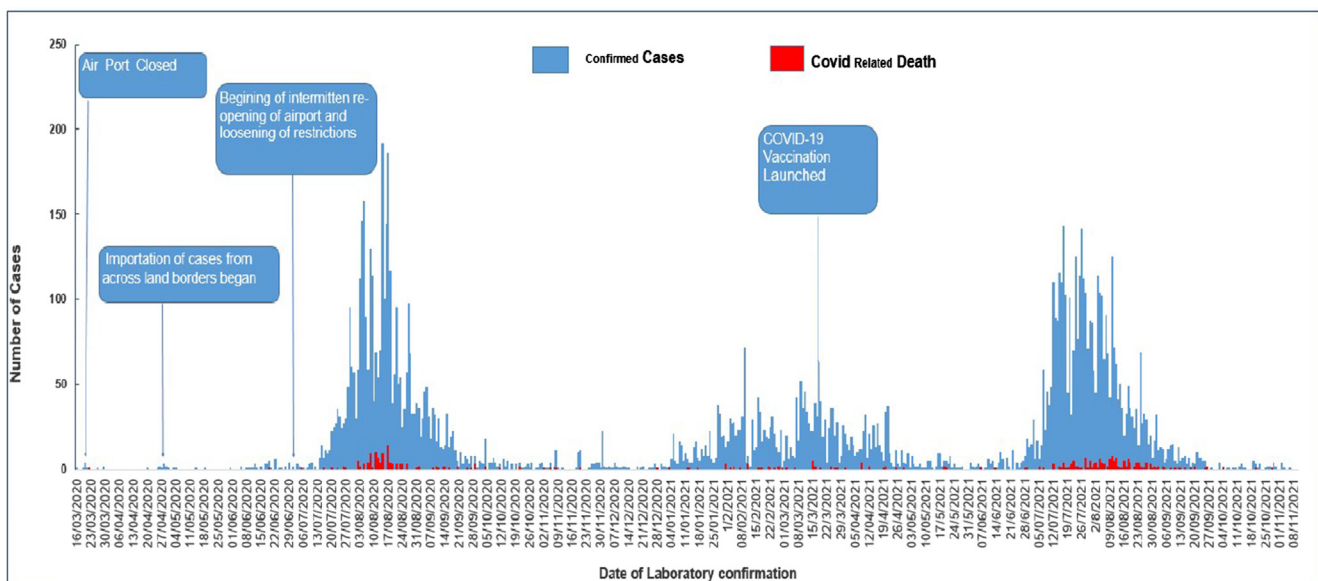


Fig. 2. Epidemic Curve of Laboratory-Confirmed Cases Reported daily, COVID-19 Pandemic, The Gambia, Mar 16, 2020–Nov 08, 2021. Source: The Gambia Covid-19 Outbreak Situational Report # 398.

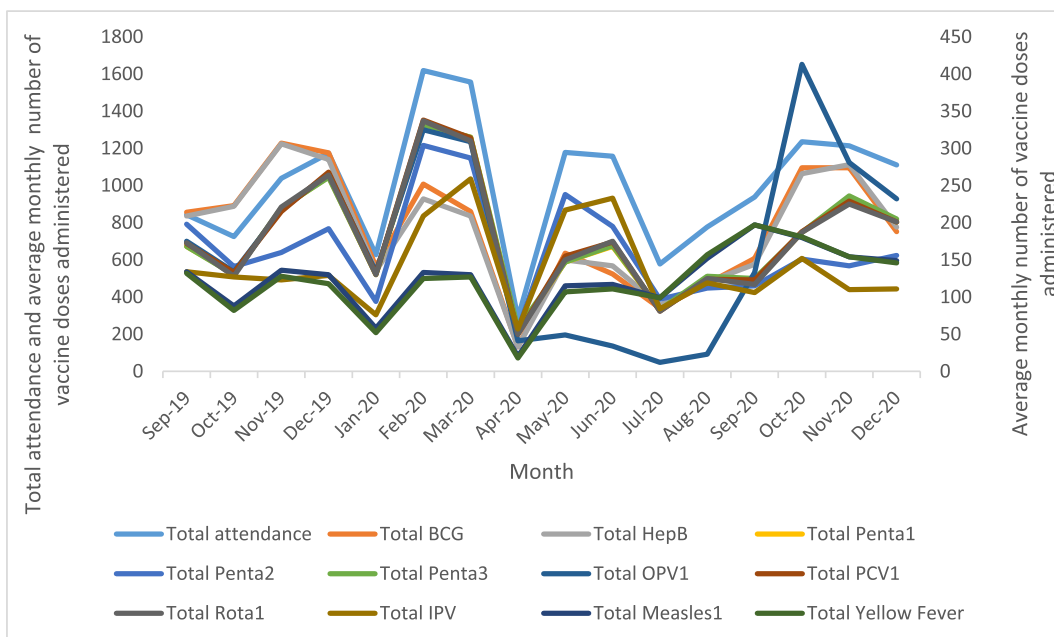


Fig. 3. Monthly attendance and number of vaccine doses administered to children aged 0–23 months attending *EPI* clinics in BHDSS and FWHSS from Sep 1, 2019 to Dec 31, 2020.

01–December 31, 2020, was chosen as the recovery period as child *EPI* attendance began to increase during this period. The comparison periods were structured in this way to best show the extent of the reduced attendance and vaccination with the onset of pandemic disruption and the timing and extent of the subsequent increase in attendance and vaccination.

2.6. Ethical consideration

The procedure for vaccination data collection is part of an ongoing Pneumococcal Vaccine Schedule study which has been approved by the Gambia Government/MRC Joint Ethics Committee (SCC No: 1577).

3. Results

A total of 65,044 child attendances at *EPI* clinics were recorded in the BHDSS and FWHSS from September 01, 2019, to December 31, 2020, which is an average of 4,065 attendances per month. HDSS records reported similar birth rates, of 1,018 compared to 971 per month in the baseline and recovery periods. During the baseline period (September 1, 2019–March 31, 2020), we recorded a total of 28,610 child attendances at *EPI* clinics with an average of 4,087 attendances per month (Table 2). Compared to the baseline period, there was a moderate reduction in *EPI* attendance during the interruption period (April 01–June 30, 2020) with attendance rates down to 3,538 per month and an overall average reduction of 13.4% (Table 2). Compared to baseline attendance, the reduction in *EPI* attendance during the interruption period was 20% in April, 12% in May, and 8% in June. Compared to baseline, *EPI* attendance from July to December 2020, was increased by 5.3%, suggesting some recovery in attendance compared to pre-pandemic attendance rates (Fig. 4).

A total of 118,258 antigens comprising BCG, birth dose Hep B, Penta1, Penta2, Penta3, OPV1, PCV1, Rota1, IPV, Measles1, and Yellow Fever were administered from September 1, 2019, to December 31, 2020. Of these, 57,280 antigens were administered before the pandemic interruption period with an average of 8,182 per

month (see Supplementary Table S1). The rate of vaccine administration during the interruption period was 5,048 per month, a decline of 38.3% compared to baseline (Table 2). This decrease was particularly noticeable for antigens administered at the early stages of the *EPI* schedule, such as BCG (47.2% reduction), birth dose Hep B (46.9% reduction), Penta1 (43.1% reduction), OPV1 (83.6% reduction), PCV1 (42.4% reduction), and Rota1 (43.4% reduction). The greatest percentage drop was seen in the administration of OPV1 which was out of stock nationally from April to July 2020. *EPI* attendance throughout the initial and late recovery period was 5.3% higher than the baseline rate. During the initial recovery period, a total of 20,831 antigens were administered, an average of 6,944 per month, which was 15.1% lower than during the baseline period. Though most antigens showed appreciable improvement in uptake when comparing the difference in reduction between the interruption and initial recovery periods to the baseline, the levels had not yet reached the pre-pandemic rates. The monthly number of BCG doses administered in the initial recovery compared to the baseline period was reduced by 20%, Hep B birth dose by 20%, Penta1 by 33%, OPV1 by 34%, PCV1 by 33%, and Rota1 by 34%. Of note, the percentage positive change in the administration of Measles (79.5%) and Yellow Fever (88.9%) vaccines during the initial recovery period indicates substantial catch-up of doses missed during the interruption period. During the late recovery period, an average of 8,334 antigens per month were administered, which was 1.9% higher than the baseline rate. Compared to the baseline period, the rate of administration of most antigens in the late recovery period had largely returned to pre-pandemic levels; BCG (3.0% greater), Hep B (2.5% greater), OPV1 (22.7% greater), Penta1 (2.0% lower), PCV1 (2.6% lower), Rota1 (2.6% lower) (Table 2, Fig. 4).

4. Discussion

This report provides insight into the impact of the COVID-19 pandemic on the uptake of immunization services in the rural Gambia. Overall, there was a modest 13.4% decline in average monthly child attendance at immunization clinics during a 3-

Table 2

Average monthly attendance and number of vaccine doses administered to children aged 0–23 months attending EPI clinics in the Basse and Fuladu West Health & Demographic Surveillance Systems before and during the COVID-19 pandemic.

Indicators (per month)	Baseline before COVID-19 interruption (Sep 1, 2019–Mar 31, 2020)	COVID-19 interruption period (Apr 01–Jun 30, 2020)	Initial recovery period (Jul 01–Sep 30, 2020)	Late recovery period (Oct 01–Dec 31, 2020)	Difference in COVID-19 interruption period vs baseline (%)	Difference in initial recovery period vs baseline (%)	Difference in late recovery period vs baseline (%)
BCG	880	465	699	906	−47.2	−20.6	3.0
Hep B birth dose	877	466	697	899	−46.9	−20.5	2.5
Penta1	843	480	563	826	−43.1	−33.2	−2.0
Penta 2	731	641	580	591	−12.3	−20.7	−19.2
Penta 3	843	484	569	838	−42.6	−32.5	−0.6
*OPV1	843	138	555	1034	−83.6	−34.2	22.7
PCV1	850	490	567	828	−42.4	−33.3	−2.6
Rota1	846	479	556	824	−43.4	−34.3	−2.6
IPV	580	645	518	472	10.0	−10.7	−18.6
Measles1	459	388	824	557	−15.5	79.5	21.4
Yellow Fever	432	372	816	560	−13.9	88.9	29.6
Antigens administered	8182	5048	6944	8334	−38.3	−15.1	1.9
EPI clinic attendance	4087	3538	4303	4303	−13.4	5.3	5.3

*OPV was out of stock from April to July 2020, which coincided with the covid-interruption period. Due to the unavailability of OPV during the covid-interruption period, active efforts were made to vaccinate all children due for IPV and this resulted in an average increase in IPV administration.

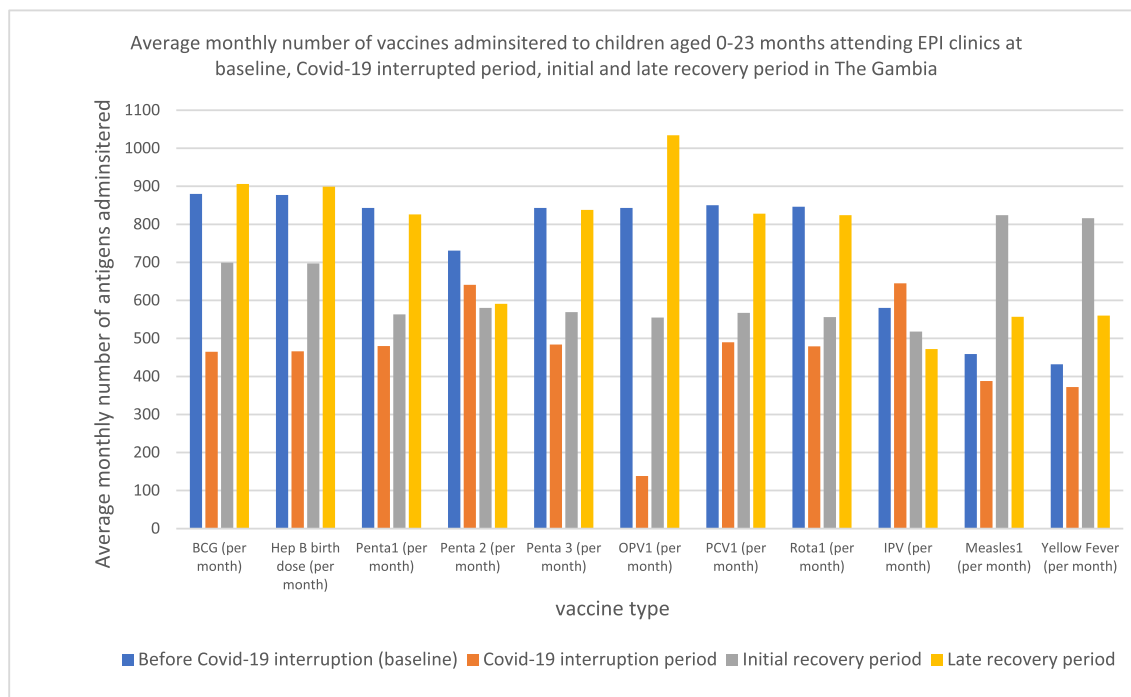


Fig. 4. Attendance and average monthly number of vaccines administered to children aged 0–23 months attending EPI clinics at baseline, COVID-19 interrupted period, initial, and late recovery period from Sep 01, 2019, to Dec 31, 2020, in The Gambia.

month COVID-19 interruption period compared to data recorded before the COVID-19 interruption. There was a 38.3 % reduction in average monthly vaccine antigen administration in the COVID-19 interruption period as compared to the pre-COVID-19 baseline period. The reduction in average monthly immunizations during the COVID-19 interruption period was particularly prominent among vaccines given early in infancy such as BCG, birth dose Hep B, Penta1, OPV1, and PCV1. This indicates that most of the children who missed their vaccinations during this period were newborns who had not had any prior visits to EPI clinics. However, during the initial recovery period, there was evidence of ‘catch-

up’ administration of measles and yellow fever vaccine doses. Throughout the recovery period, the average monthly child attendance at EPI clinics exceeded pre-pandemic levels. During the late recovery period, there was increased administration of early schedule antigens such as BCG, Hep B, and OPV1. These findings indicate that the relatively short period of interrupted services with some catch-up of missed doses would likely result in only a limited effect on population-level vaccination coverage and only a limited increase in the risk of re-emergence of vaccine-preventable diseases,

Several factors explain our findings. In April 2020, several unsubstantiated claims and rumours circulated on many social media platforms, especially on WhatsApp with voice notes warning mothers not to visit *EPI* clinics as their babies would be vaccinated with new Western-developed COVID-19 vaccines. These rumours were widespread in the populations living in the BHDSS and FWHSS and resulted in a moderate decrease in child *EPI* attendance. Furthermore, many parents avoided bringing their children, especially newborns, to *EPI* clinics for fear of themselves or their children contracting COVID-19 at the immunization clinics [10]. Though there was no imposition of lockdown in the study area, it is important to note that the state of emergency raised alarm in the community and some restriction of movement was in place, with many people fearing contracting COVID-19 and so avoided accessing essential health services and seeking healthcare at government facilities as they deemed these places potential settings to contract COVID-19. As part of measures to control overcrowding at *EPI* clinics, some activities such as child weighing at the immunization centres were stopped and mothers were encouraged to bring only children who were due for vaccination to the clinics. Though this might in part explain the reason for the decrease in child *EPI* attendance, the pronounced decrease in antigen administration during this period indicates that this is not a major reason for the decrease in *EPI* attendance. It is also important to note that from April to July 2020, the oral polio vaccine (OPV) was out of stock in The Gambia, and supply was restored in August 2020. This explains the large reduction in OPV1 administered doses in the COVID-19 interruption period as observed in our findings. Due to the lack of OPV, vaccinators made active efforts to administer Inactivated Poliovirus Vaccine (IPV) to children who were due for a vaccination. This resulted in a 10 % increase in the uptake of IPV from April to June 2020.

Though average monthly child attendance returned to pre-pandemic levels in the initial recovery period, antigen administration did not return to pre-pandemic rates for the antigens administered in early infancy, but measles and yellow fever administration at 9 months of age increased above pre-pandemic rates. Child weight measurement, which was stopped during the COVID-19 interruption period, was restarted in November 2020. Thus, the recovery of *EPI* attendance may relate to visits for purposes other than immunization. The lower than baseline administration of antigens such as BCG, birth dose Hep B, PCV1, Penta1, and Rota1 recorded during the initial recovery period may relate to mothers feeling more comfortable to start attending *EPI* clinics with older than younger infants, resulting in the attendance of older infants increasing more quickly than for newborns. This likely explains the significant increase in the administration of early infant antigens such as BCG, Hep B, OPV1, and PCV1 during the late recovery period. A seasonally lower number of births in the recovery compared to the baseline period explains little of the lower administration of early schedule antigens in the initial recovery period.

In July 2020, there was intense community sensitization carried out by public health officers. Radio programs were held, and communities were visited to dispel rumours and provide answers to questions from community members regarding COVID-19. These measures yielded positive results as attendance at *EPI* clinics began to improve in July 2020. Our findings are consistent with other studies which have equally shown a decrease in *EPI* attendance and immunization uptake during the COVID-19 interruption period.

The decline of 13.4 % in child *EPI* attendance in our study was lower compared to a reported decline of 52.8 % in Pakistan [6], a 49.9–71.9 % drop in vaccination visits in Saudi Arabia [11,12], and a 45.6 % decrease in *EPI* attendance reported in northern Ghana [13]. However, studies conducted in the United Kingdom [14], the

Netherlands [15], and South Korea [16] showed a lower decline in vaccination visits compared to our findings. The 38.3 % reduction in average monthly immunizations during the COVID-19 interruption period in our study was lower compared to the 50–85 % decline in vaccine administration in Sierra Leone [17], 52.5 % in Pakistan [6], and 80.0 % in Saudi Arabia [18]. Studies in Canada [19], Turkey [20], Lebanon [5], and India [21] reported a lower reduction in average monthly immunization compared to our findings.

The population in the BHDSS and FWHSS is mainly rural with a weak healthcare system and the initial decline in vaccination attendance during the COVID-19 interruption period was followed by a considerable recovery in attendance and antigen administration to pre-pandemic levels. The relatively brief interruption period and substantial recovery mean that the number of unimmunized infants would have increased by only a limited degree and that population coverage of immunization would have changed little, with a limited overall impact on the risk of vaccine-preventable diseases in the population. Whilst the available evidence shows children are less directly affected by COVID-19 infection as compared to the elderly [22], the indirect impacts of the COVID-19 pandemic could lead to an increase in morbidity and mortality among children. A recent study showed that by sustaining routine immunization activities during the COVID-19 pandemic, for every COVID-19-related death acquired during immunization clinic visits in LMICs in Africa, 84 deaths from vaccine-preventable diseases could be prevented [23]. Every child who missed a vaccine must be tracked and vaccinated. This can be achieved by generating a defaulter list, conducting catch-up campaigns in the most affected communities, and monitoring vaccine stock-outs to ensure a constant and sustainable vaccine supply. Surveillance at health facilities in the BHDSS and FWHSS must be enhanced to enable early detection of vaccine-preventable cases or deaths.

Our report has some limitations. Our analysis did not use the same calendar period in 2019 as the baseline for comparison, but rather the 7 months preceding the detection of the first case of COVID-19 in The Gambia and so our findings may be affected by seasonal changes in the birth rate. The birth rate was only slightly decreased during the recovery period (July–December 2020) and does not explain the lower number of antigens administered in the initial recovery period compared to the baseline period. Given that the rate of administration in the initial recovery period was substantially lower for antigens scheduled in early infancy (BCG, birth dose Hep B, Penta1, OPV1, PCV1, and Rota1) than for measles or yellow fever it appears that the recovery of attendance was more rapid for older infants than newborns. We used aggregated, deidentified data and thus were unable to measure the number of missed children who eventually got vaccinated during the recovery period. Despite suspended data collection during the 3-month interruption period, our data collection system and presence at every immunization clinic during the baseline and recovery periods enabled us to record in retrospect, the vaccines administered during the interruption period, and provide insight into the impact of the COVID-19 pandemic on uptake of immunization services in the rural Gambia.

In conclusion, notwithstanding the limitations mentioned, our report highlights a modest decline in child *EPI* attendance and decreased average monthly immunizations during the COVID-19 interruption period in rural Gambia. Though the decline in child *EPI* attendance seems lower compared to other countries, the number of unvaccinated children who were eventually vaccinated remains unknown. There is an urgent need to generate defaulter lists to track and vaccinate every child who missed a vaccine. Finally, *EPI* programs need to assess strategies to deliver doses that were missed during interruption periods, be it raising the awareness of vaccinators to administer missed doses opportunistically

at scheduled visits at 9, 12, 15, or 18 months of age or conducting supplementary immunization activities.

Author contributions

IO and GAM conceived and designed the study. GS, IH, KS, BB, LC, and ES supervised the collection of demographic and vaccination data. GS and IH extracted the data. IO and GAM did all statistical analyses and interpreted the data. IO wrote the paper while GAM contributed to the discussion. GS, IH, KS, LC, BB, ES, and GAM reviewed drafts and provided input. All authors approved the final version of the manuscript.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2022.09.031>.

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