

COVID-19 pandemic impact on primary immunization uptake

Khalid Alhusayn, Thamer Alsulaiman, Ahmed Abdulkarim, Habiba Sultana, Hussam Jnaid, Yaser Alendijani, Abdullah Alkhenizan

Department of Family Medicine and Polyclinics, King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia

ABSTRACT

Purpose/Background: Pediatricians across the world are seeing a steep drop in the number of children coming in for appointments due to COVID-19 pandemic. To prevent outbreaks of serious diseases that pose an even greater threat to children than COVID-19, it is important that children not skip their routine vaccines. The aim of this study was to determine the impact of COVID-19 pandemic on primary immunization activities in Saudi Arabia. **Settings and Design:** Cross-sectional design. **Methods and Material:** The study was conducted at a community pediatric clinic. All parents of preschool-age children who visited the community pediatric clinics were asked to complete a self-administrated questionnaire on primary immunization uptake during the pandemic. **Statistical Analysis Used:** The Chi-square and Fisher's exact test were performed to examine the demographic differences between participants who missed vaccination during the pandemic and reasons for missing the vaccination. **Results:** Three hundred study participants completed our questionnaire. In total, 90.6% of respondents were up to date with their vaccinations prior to the pandemic, and most respondents believed that children should be immunized at an appropriate age, it is essential for children to be fully immunized, vaccination is effective in preventing serious disease, and childhood immunization is essential during the pandemic (98.3%, 98.7%, 97.3%, and 93.7%, respectively). In total, 72.4% of respondents did not miss their vaccinations during the pandemic, while 26.6% missed vaccinations. The most common reason for missing vaccinations during the pandemic was transportation difficulty and curfew, followed by fear of contracting COVID-19 infection (40.9% and 35.5%, respectively). Those who did not believe that childhood immunization was necessary during the pandemic were more likely to miss vaccinations during the pandemic ($P < 0.001$). In addition, those who did not have a family member with COVID-19 infection were more likely not to miss the vaccine ($P < 0.001$). Moreover, those who thought taking vaccinations in a primary care setting or hospital is safe were more likely not to miss the vaccination during the pandemic ($P < 0.027$) and ($P < 0.001$). **Conclusions:** Significant portion of the population was affected and missed immunizations during the pandemic. The perceptions on the importance of immunization and having a family member affected with COVID-19 during the pandemic were important factors in missing immunizations. Moreover, transportation and fear of contracting COVID-19 during the curfew were also common reasons for missing immunizations during the pandemic.

Keywords: COVID-19, impact, pandemic, primary immunization, Saudi Arabia, uptake

Introduction

It was December 2019 when the Covid-19 pandemic started in China and then the pandemic was declared by the WHO on

Address for correspondence: Dr. Khalid Alhusayn,

King Faisal Specialist Hospital and Research Centre, MBC 62,

PO Box 3354, Riyadh - 11211, Saudi Arabia.

E-mail: khalhusayn@kfshrc.edu.sa

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March 2020.^[1] March 9, 2020 was the time when the first public health emergency was declared in Saudi Arabia. At the same time, public health restrictions were first implemented in the country.^[2] The National Committee on Immunization identified that infant and toddler vaccines should be prioritized particularly the primary immunization services series, with of course some modifications to immunization service provision. For instance, shorter appointments will focus only on immunization, so the public health nurses will not be implementing their usual screening and

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developmental testing. Personal protective equipment was in use, and social distancing was implemented.^[3,4] For school-age vaccine, the recommendation is that routine school-age vaccines could be deferred until school reopened or full health services were available to start catching kids up. It was also highlighted that the vaccine series does not need to be restarted if it is interrupted for this routine vaccines, and the children who are eligible for vaccination would continue to be eligible even if they aged out of the program.^[4]

The important role of routine vaccine programs should not be forgotten in the middle of this pandemic. It protected the public from many serious diseases over the years. There is a strong possibility that outbreaks of some of the vaccine-preventable diseases (VPDs) will occur soon.^[5]

Coverage levels for many of these vaccines were barely high enough to maintain community protection before the pandemic, so any drop in coverage due to the pandemic when combined with the removal of public health restrictions and return of the international travel post pandemic could result in the importation and spread of any number of infectious diseases.^[6]

Because of the pandemic, 80 million children in 68 countries are missing routine immunization programs.^[7,8] The reason for this includes fear of being infected, shortage of staff who can give the vaccines, and shortage in protective equipment, which resulted in fewer appointments available for vaccination visits.^[9] Travel restrictions also play a role. A recent study has shown that the vaccine-ordering rate has dropped dramatically, which resulted in a decrease in vaccine coverage.^[10]

The primary objective of this study is to measure the impact of COVID-19 pandemic on the primary immunization program in Saudi Arabia. The secondary objective is to identify the reasons behind the drop in primary immunization uptake during the COVID-19 pandemic.

Materials and Methods

All Saudi parents who came to the Family Medicine department, KFSH and RC, were invited to participate in this study from October 2020 to April 2021, according to the eligibility criteria. The criterion for inclusion was being parents of preschool-age children. The exclusion criteria were being parents of non-preschool-age children. A totally anonymous, culturally sensitive, and specially designed questionnaire was administered using an interview-based model. The questionnaire will include questions that will assess parent's attitude about primary immunization, percentage of children who missed immunization during the pandemic, and reasons for missing the vaccines. The questionnaire also included the sociodemographic data, number of vaccines that were missed, and method of getting immunization that was more popular among parents.

This study was approved by the ethics committee at KFSH and RC. A study-specific verbal informed consent was obtained from each participant before enrolment in the study. The Institutional Review Board (IRB) exempted this study from written consent for less than minimal risk. Participants' consent was documented according to the IRB guidelines.

The data collection questionnaire was validated using face validity, which was developed and performed by a group of experts in the field. The questionnaire was distributed by the treating physicians in the Family Medicine Pediatric clinics of KFSH and RC, Riyadh, Saudi Arabia. Participants answered coded questions. Anonymity and confidentiality were maintained. The study included 300 participants of varying ages and the level of education.

Statistical analysis

The sample size was estimated to be 300 using a 95% confidence interval (CI) and a 5% margin of error. All data were analyzed using the software package SPSS version 20, by BMI. Descriptive statistics for the continuous variables were reported as mean \pm standard deviation, while categorical variables were summarized in frequency and percentage. The level of significance for all variables was set at 0.05 with 95% CI. Participants were divided into groups based on different demographic variables (age, gender, nationality, employee status, education, social status). The Chi-square and Fisher's exact test were performed to examine the demographic differences between participants who missed vaccination during the pandemic and reasons for missing the vaccination.

Results

Demographics

During the study period, a total of 300 parents completed our questionnaire. Of them, 94.9% were Saudis and 80.6% of them had higher education and above – Table 1. In total, 90.6% of respondents stated that their children were up to date with their vaccinations prior to the pandemic.

Attitudes, behaviors, and perceptions

The majority of respondents believed that children should be immunized at an appropriate age, it is essential for children to be fully immunized, vaccination is effective in preventing serious disease, and childhood immunization is essential during the pandemic (98.3%, 98.7%, 97.3%, and 93.7%, respectively) – Table 2.

In total, 58% of respondents thought that it is safe to take vaccines in a primary health care setting, while 78% thought that it is safe to take vaccines in a hospital setting. Moreover, 58.6% of respondents preferred to take the vaccination in a hospital setting, while 26.6% preferred to have it during home visit – Graph 1.

In total, 72.4% of respondents' children did not miss their vaccinations during the pandemic, while 26.6% had missed

Table 1: Demographics

	Options	Frequency	Percentage
Relationship to child	Mother	160	53.5
	Father	136	45.5
	Grandparent	0	0
	Other	3	1.0
Age	20–30	84	28.1
	31–40	163	54.5
	41–50	42	14.0
	>50	10	3.3
Gender	Male	138	46.0
	Female	162	54.0
Nationality	Saudi	281	94.9
	Non-Saudi	15	5.1
Level of education	Primary education	1	0.3
	Intermediate education	2	0.7
	Secondary education	55	18.5
	Higher education (Bachelor)	165	55.4
	Postgraduate education (Master-Doctoral)	75	25.2
Employment	Employee	227	76.2
	Dependent	38	12.8
	Other	33	11.1
Social status	Married	298	99.7
	Divorced	1	0.3
	Widowed	0	0

vaccinations. Of those who missed vaccination during the pandemic, 37.4% missed two or more vaccinations – Graph 2.

The most common reason for missing vaccinations during the pandemic was transportation difficulty and curfew, followed by fear of contracting COVID-19 infection (40.9% and 35.5%, respectively) – Graph 3.

Correlation between missing vaccinations during the pandemic and demographics

No statistically significant association was found between missing vaccination during the pandemic and demographics – Table 3.

Correlation between missing vaccinations during the pandemic and attitudes, behaviors, and perceptions

Missing vaccinations during the COVID-19 pandemic was significantly associated with the perception that immunization is important during the pandemic. Those who did not believe that childhood immunization was necessary during the pandemic were more likely to miss on vaccinations during the pandemic ($P < 0.001$). Moreover, those who did not have a family member with COVID-19 infection were more likely not to miss the vaccine ($P < 0.001$). Also, those who thought taking vaccinations in a primary care setting or hospital is safe were more likely not to miss the vaccination during the pandemic ($P < 0.027$) and ($P < 0.001$), respectively – Table 3.

The number of missed vaccination throughout the childhood immunization schedule is shown in Table 4.

Table 2: Attitudes, behaviours and perceptions towards vaccination during the pandemic

	Options	Frequency	Percentage
Prior to the pandemic, were your child up to date with the vaccination?	Yes	261	90.6
	No	10	3.5
	I don't know	17	5.9
Do you think children should be immunized at an appropriate age?	Yes	295	98.3
	No	3	1.0
	I don't know	2	0.7
Do you think it's essential for a child to be fully immunized?	Yes	296	98.7
	No	2	0.7
	I don't know	2	0.7
Do you think that vaccination is effective in preventing serious diseases?	Yes	292	97.3
	No	2	0.7
	I don't know	6	2.0
Do you think childhood immunization is necessary during the pandemic?	Yes	281	93.7
	No	6	2.0
	I don't know	13	4.3
Do you think COVID-19 is more serious in children than in adults?	Yes	85	28.3
	No	142	47.3
	I don't know	73	24.3
Did anybody in your family have COVID-19?	Yes	132	44.0
	No	168	56.0
	I don't know	0	0
During the pandemic, do you think taking vaccines in primary health care safe?	Yes	176	58.7
	No	77	25.7
	I don't know	47	15.7
During the pandemic, do you think taking vaccines in the hospital safe?	Yes	236	78.9
	No	43	14.4
	I don't know	20	6.7
During the pandemic, do you prefer taking vaccines in (more than one choice)	Government	180	58.6
	Hospital		
	Private hospital	14	4.6
	Primary health care centers	31	10.1
	Home visits	82	26.7
Did your child miss any vaccine during the pandemic?	Yes	79	26.6
	No	215	72.4
	I don't know	3	1.0
If yes, how many vaccines did he/she miss?	One	52	62.7
	Two	20	24.1
	>Two	11	13.3
If yes, which vaccines did he/she miss? (more than one choice)	2 months	11	9.6
	4 months	22	19.3
	6 months	21	18.4
	9 months	20	17.5
	12 months	10	8.8
	18 months	12	10.5
	2 years	14	12.3
4–6 years	4	3.5	
What was the reason for missing the vaccines? (more than one choice)	Afraid of being infected with coronavirus (you or your child)	33	35.5
	Transportation difficulties/ curfew	38	40.9
	Having high-risk patients at home	1	1.1
	The child was sick	4	4.3
	I thought delaying the vaccine is ok	17	18.3

Table 3: Correlation between missing vaccination during the pandemic and various variables. *after removing “I don’t know” responses

	Options	Did your child miss any vaccine during the pandemic?						P
		Yes		No		Total		
		#	%	#	%	#	%	
Relationship to child	Mother	38	24.4	118	75.6	156	100	0.37
	Father	41	30.6	93	69.4	134	100	
	Grandparent	0	0	0	0	0	0	
	Other	0	0	3	100	3	100	
	Total	79	27	214	73	293	100	
Age	20–30	18	21.7	65	78.3	83	100	0.61
	31–40	47	29.4	113	70.6	160	100	
	41–50	10	25	30	75	40	100	
	>50	3	30	7	70	10	100	
	Total	78	26.6	215	73.4	293	100	
Gender	Male	41	30.1	95	69.9	136	100	0.24
	Female	38	24.1	120	75.9	158	100	
	Total	79	26.9	215	73.1	294	100	
Nationality	Saudi	74	26.8	202	73.2	276	100	0.77
	Non-Saudi	3	21.4	11	78.6	14	100	
	Total	77	26.6	213	73.4	290	100	
Level of education	Primary education	0	0	1	100	1	100	0.09
	Intermediate education	1	50	1	50	2	100	
	Secondary education	18	32.7	37	67.3	55	100	
	Higher education (Bachelor)	47	29.4	113	70.6	160	100	
	Postgraduate education (Master-Doctoral)	12	16.2	62	83.8	74	100	
	Total	78	26.7	214	73.3	292	100	
Are you	Employee	61	27.6	160	72.4	221	100	0.88
	Dependent	9	23.7	29	76.3	38	100	
	Other	9	27.3	24	72.7	33	100	
	Total	79	27.1	213	72.9	292	100	
	Social status	Married	79	27.1	213	72.9	292	
Divorced	0	0	1	100	1	100		
Widowed	0	0	0	0	0	0		
Total	79	27	214	73	293	100		
Prior to the pandemic, were your child up to date with the vaccination?	Yes	70	27	189	73	259	100	0.99
	No	3	30	7	70	10	100	
	Total	77	27.1	206	72.9	269	100	
Do you think children should be immunized at an appropriate age?	Yes	77	26.6	212	73.4	289	100	0.99
	No	1	33.3	2	66.7	3	100	
	Total	78	26.7	214	73.3	292	100	
Do you think it is essential for a child to be fully immunized?	Yes	79	27.2	211	72.8	290	100	0.99
	No	0	0	2	100	2	100	
	Total	79	27.1	213	72.9	292	100	
Do you think that vaccination is effective in preventing serious diseases?	Yes	78	27.2	209	72.8	287	100	0.99
	No	0	0	2	100	2	100	
	Total	78	27	211	73	289	100	

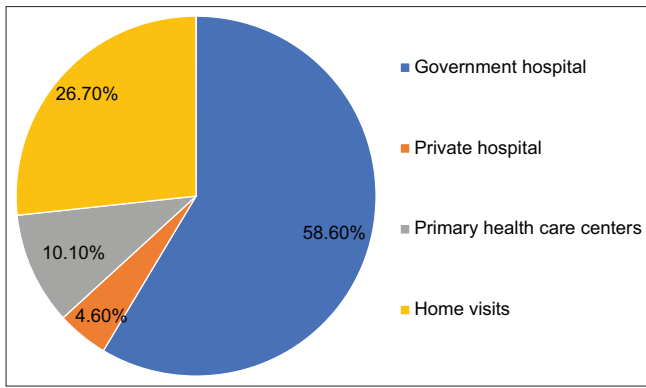
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Table 3: Contd...

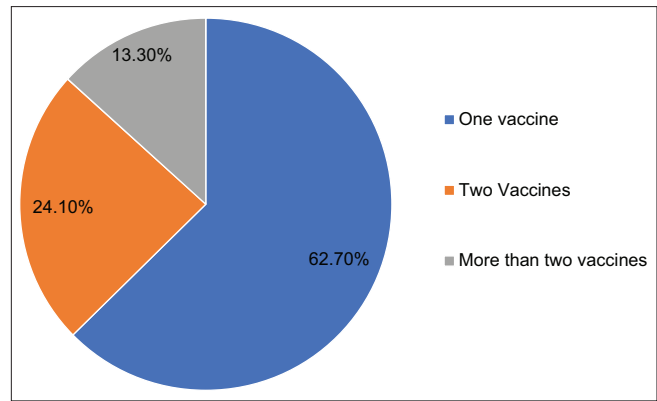
Options	Did your child miss any vaccine during the pandemic?						P	
	Yes		No		Total			
	#	%	#	%	#	%		
Do you think immunization is necessary during the pandemic?	Yes	66	23.9	210	76.1	276	100	0.035*
	No	4	66.4	2	33.3	6	100	
	Total	70	24.8	212	75.2	282	100	
Do you think COVID-19 is more serious in children than in adults?	Yes	28	32.9	57	67.1	85	100	0.33
	No	37	26.8	101	73.2	138	100	
	Total	65	29.1	158	70.9	223	100	
Did anybody in your family have COVID-19?	Yes	45	34.6	85	65.4	130	100	0.008*
	No	34	20.7	130	79.3	164	100	
	Total	79	26.9	215	73.1	294	100	
During the pandemic, do you think taking primary health care safe?	Yes	37	21.4	136	78.6	173	100	0.027*
	No	26	34.7	49	65.3	75	100	
	Total	63	25.4	185	74.6	248	100	
During the pandemic, do you think taking vaccines in the hospital safe?	Yes	51	22	181	78	232	100	0.001*
	No	19	45.2	23	54.8	42	100	
	Total	70	25.5	204	74.5	274	100	
During the pandemic, do you prefer taking vaccines in (more than one choice)	Government hospital	43	24.2	135	75.8	178	100	0.19
	Private hospital	4	30.8	9	69.2	13	100	
	Primary health care centers	9	30	21	70	30	100	
	Home visits	26	32.9	53	67.1	79	100	
	# responses	82	-	218	-	300	-	
	Total	78	95.1	4	4.9	82	100	
If yes, how many vaccines did he/she miss?	One	50	96.2	2	3.8	52	100	0.12
	Two	19	100	0	0	19	100	
	>Two	9	81.8	2	18.2	11	100	
	Total	78	95.1	4	4.9	82	100	
What was the reason for missing the vaccines?	Afraid of being infected with coronavirus (you or your child)	29	90.6	3	9.4	32	100	0.130
	Transportation difficulties/curfew	32	86.5	5	13.5	37	100	
	Having high-risk patients at home	0	0	1	100	1	100	
	The child was sick	4	100	0	0	4	100	
	I thought delaying the vaccine is ok	11	73.3	4	26.7	15	100	
	Total	76	85.4	13	14.6	89	100	

Discussion

The COVID-19 pandemic has had a devastating impact on several aspects of life globally, both directly and indirectly. Healthcare facilities and healthcare workers were overburdened while handling the enormous number of critically ill patients and fatalities. The swift response of the authorities in



Graph 1: Preference on location of having vaccinations during pandemic



Graph 2: Number of vaccinations missed during pandemic

Table 4: Number of missed vaccines

Vaccination	Number of missed vaccines	
	#	%
2 months	11	9.6
4 months	22	19.3
6 months	21	18.4
9 months	20	17.5
12 months	10	8.8
18 months	12	10.5
2 years	14	12.3
4–6 years	4	3.5
Total number of missed vaccines	114	

implementing lockdowns, curfews, and travel restrictions was essential to contain the spread of the disease. This resultant wave sent ripples down the chain of essential health care services; most notably, preventive health care services and immunization programs witnessed a steep decline all over the world.

To date, several studies have reported a decline in vaccine administration during the pandemic. WHO has reported that globally at least 68 countries have reported disruptions in primary immunization programs and has affected more than 80 million children worldwide.^[7] In the US, several states witnessed a sharp decline in vaccine ordering and administration.^[11,12] In Karachi, Pakistan, the mean number of daily immunization visits decreased by 52.8% during the COVID-19 pandemic lockdown compared with baseline.^[9] In sub-Saharan Africa, child health care services and immunization were heavily impacted.^[13] In Saudi Arabia, several studies reported a drop of more than 25% during the pandemic.^[14,15]

Disruption in primary vaccination in children will result in the re-emergence of potentially life-threatening childhood illnesses. This would thwart the efforts taken so far in preventing these VPDs. Based on a benefit-risk analysis study done in Africa, deaths prevented by supporting routine childhood immunizations clearly outweigh the excess risk of deaths from COVID-19 due to exposure at vaccination clinics. Approximately 84 deaths in children could be prevented by sustaining routine childhood immunization

for every COVID-19 death attributable to COVID-19 infection acquired during a routine visit to the clinic for vaccination.^[16]

Vaccine delays have been reported in prior pandemics, like the Swine Flu pandemic (2009–2010) and Zika Virus outbreak (2015–2016). Increased fear of the pandemic and concern for the loved one’s health were the most reported concerns.

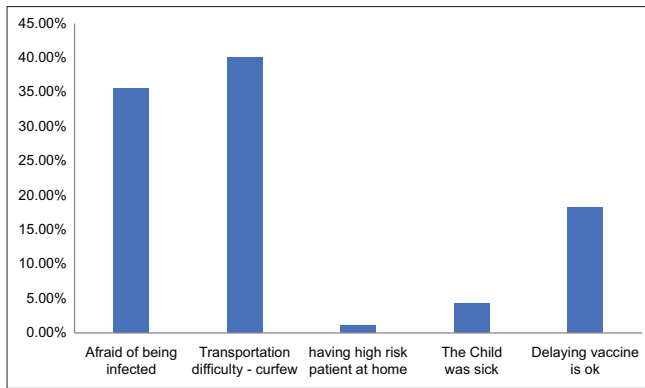
In light of this important study, WHO issued guidelines in March 2020, emphasizing that routine childhood vaccination should continue despite outbreaks and pandemics.^[17]

Prior to the pandemic, among the parents who completed the questionnaire, 90% of the children were up to date on all their vaccines. During the pandemic, about 26.6% of children between the ages of 0–6 years missed one or more vaccines. Of these, 37.4% of children missed two or more vaccines. This number is similar to the number in prior studies in Saudi Arabia. Globally, it is comparable to the decline in the vaccination rates in some high-income countries and far better than most low to middle-income countries.

The next important highlight of this study is the attitude of the parents toward immunizing their children. More than 98% of the parents believe that vaccines are essential in children, that vaccines prevent serious illness in children, and that it is essential for the children to be fully immunized.

In total, 93% believed that vaccination is essential and should be carried out even during the pandemic. This is very encouraging and accounts for Saudi Arabia being in the topmost countries with highest immunization rates regardless of the pandemic. The efforts of the public health authorities and government in implementing this initiative are highly commendable.

The study further highlights the characteristics of the parents who missed vaccines. Those parents who believed that vaccines were not essential during the pandemic were more likely to miss vaccines. Those who had a family member with COVID infection were more likely to miss the vaccines. This could be due to fear of contracting or spreading the illness or limitations from quarantines, or due to limited transportation availability.



Graph 3: Reasons for missing vaccination during Pandemic

The youngest children were more likely to miss the vaccines, possibly due to fear that this is the most vulnerable population and uncertainty of the disease course in young children earlier in the pandemic. The 4-month, 6-month, 9-month, 12-month, and 24-month children were more likely to miss the vaccines than the 4–6-year-old children.

Our study also evaluated the parent preference for receipt of the vaccines. In Saudi Arabia, both hospitals and free-standing primary health care centers offer immunization services. During the pandemic, several hospitals also began to offer home health services for vaccinations. Based on our study, approximately half of the parents preferred to take the vaccines in a hospital setting, and more than a quarter (28%) preferred to take the vaccines in the home setting, while less than a quarter preferred to take them in the primary health care centers. This could be because the study population evaluated parents whose children were already receiving the vaccines in the hospital setting.

Identifying the reasons for the delay in vaccinations during the pandemic is essential for future planning and devising strategies that can be implemented for any future pandemics or emergency situations. Our study evaluated these causes of an interruption in vaccine uptake.

The most common reason cited was transportation difficulty (40%). This could be due to lock downs and curfews imposed during the pandemic, restricting intercity movement. It could also be due to delays in vaccine procurement and delivery, especially applicable in areas with mass vaccination campaigns. In the future, ways to reduce this barrier for essential preventive services should be given priority by issuing passes, etc., or increasing home care services.

The next common reason cited was fear of contracting the illness. In total, 35% of the parents missed vaccines as they feared; their children or adults could contract the illness. While this holds true in the setting of the pandemic, parent awareness regarding the seriousness of other VPDs is essential to instill confidence and compliance in the primary immunization programs.

Only 13% of parents believed that missing vaccines were okay and delayed the vaccines in their children. Other reasons like having a sick adult at home or the child being sick were insignificant.

Routine child and adolescent vaccination are the cornerstones of public health practice in preventing morbidity and mortality in children. It is essential that immunizations be carried out without disruptions to maintain a certain level of herd immunity. Any decline, even transiently, can result in outbreaks of VPD. This is evident from the 2018–2019 Measles outbreak in Rockland County, New York. Measles vaccination coverage in affected areas was only 77%, far below the 93% coverage needed to sustain herd immunity. Outbreaks of VPD could potentially derail the efforts to reopen schools and adversely affect education.

This study has investigated the aspect of the COVID-19 pandemic's impacts on the primary immunization program in a primary care setting in Riyadh, Saudi Arabia. A representative sample size was calculated to allow generalizability among populations with similar settings in the local region. Although causality cannot be established due to the nature of the study design, several significant findings were reported that could guide future research.

Continuation of childhood vaccination programs is essential to the child's health and must be prioritized and sustained even during pandemics. A comprehensive effort is needed on the part of the health care providers to resume timely catch-up vaccines to ensure that all children are up to date. These studies reiterate the need to develop an integrated strategic plan by public health authorities involving various departments to safeguard the public and mitigate the direct and indirect negative impacts of pandemics in the future.

Conclusions

Our study described the demographics, attitudes, and perceptions on vaccinations during the covid-19 pandemic in a primary care setting. Respondents' perceptions and attitudes influenced vaccination uptake during the pandemic, while transportation difficulties and fear of contracting disease were common reasons for missing vaccinations during the COVID-19 pandemic. Understanding reasons for missing vaccinations and removing obstacles (e.g. curfew regulations) may help in reducing missed vaccinations in the future. Moreover, education on vaccine safety and importance remains an ongoing task to reduce numbers of missed vaccines.

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Conflicts of interest

There are no conflicts of interest.

References

1. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed* 2020;91:157-60.
2. Algaissi AA, Alharbi NK, Hassanain M, Hashem AM. Preparedness and response to COVID-19 in Saudi Arabia: Building on MERS experience. *J Infect Public Health* 2020;13:834-8.
3. MacDonald NE, Comeau JL, Dubé È, Bucci LM. COVID-19 and missed routine immunizations: Designing for effective catch-up in Canada. *Can J Public Health* 2020;111:469-72.
4. Ontario Ministry of Health. Guidance for immunization service providers during COVID-19. 2021.
5. Moreno-Montoya J, Ballesteros SM, Rojas Sotelo JC, Bocanegra Cervera CL, Barrera-López P, De la Hoz-Valle JA. Impact of the COVID-19 pandemic on routine childhood immunisation in Colombia. *Arch Dis Child* 2022;107:e4.
6. World Health Organization. Regional Office for the Western Pacific. Routine immunization services during the COVID-19 pandemic. Guidance note. 2020.
7. World Health Organization. At least 80 million children under one at risk of diseases such as diphtheria, measles and polio as COVID-19 disrupts routine vaccination efforts, warn Gavi, WHO and UNICEF. WHO News release. 2020. Available from: <https://www.who.int/news/item/22-05-2020-at-least-80-million-children-under-one-at-risk-of-diseases-such-as-diphtheria-measles-and-polio-as-covid-19-disrupts-routine-vaccination-efforts-warn-gavi-who-and-unicef>.
8. Lassi ZS, Naseem R, Salam RA, Siddiqui F, Das JK. The impact of the COVID-19 pandemic on immunization campaigns and programs: A systematic review. *Int J Environ Res Public Health* 2021;18:988.
9. Chandir S, Siddiqi DA, Setayesh H, Khan AJ. Impact of COVID-19 lockdown on routine immunisation in Karachi, Pakistan. *Lancet Glob Health* 2020;8:e1118-20. doi: 10.1016/S2214-109X (20) 30290-4.
10. Hoffman J. Vaccine rates drop dangerously as parents avoid doctor's visits. *The New York Times*. 2020. Available from: <https://www.nytimes.com/2020/04/23/health/coronavirus-measles-vaccines.html>.
11. Santoli JM, Lindley MC, DeSilva MB, Kharbanda EO, Daley MF, Galloway L, *et al.* Effects of the COVID-19 pandemic on routine pediatric vaccine ordering and administration-United States, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:591-3.
12. Patel Murthy B, Zell E, Kirtland K, Jones-Jack N, Harris L, Sprague C, *et al.* Impact of the COVID-19 pandemic on administration of selected routine childhood and adolescent vaccinations-10 U.S. jurisdictions, March-September 2020. *MMWR Morb Mortal Wkly Rep* 2021;70:840-5.
13. Buonsenso D, Cinicola B, Kallon MN, Iodice F. Child healthcare and immunizations in Sub-Saharan Africa during the COVID-19 pandemic. *Front Pediatr* 2020;8:517.
14. Alrabiaah AA, Alshaer AH, Estrella SMC, Inclan KAS, Aljammaz HA, Almoosa KM, *et al.* Effects of the coronavirus disease 2019 pandemic on routine pediatric immunization coverage rates at the main University Hospital in Saudi Arabia. *Saudi Med J* 2020;41:1197-203.
15. Alsuhaibani M, Alaqeel A. Impact of the COVID-19 pandemic on routine childhood immunization in Saudi Arabia. *Vaccines (Basel)* 2020;8:581.
16. Abbas K, Procter SR, van Zandvoort K, Clark A, Funk S, Mengistu T, *et al.* Routine childhood immunisation during the COVID-19 pandemic in Africa: A benefit-risk analysis of health benefits versus excess risk of SARS-CoV-2 infection. *Lancet Glob Health* 2020;8:e1264-72.
17. World Health Organization. Guiding principles for immunization activities during the COVID-19 pandemic: Interim guidance. World Health Organization; 2020.