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Percentage of Unvaccinated children and factors associated with Immunization among children presenting to pediatric hospitals in Khartoum state, Sudan, 2020.

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Abstract

Introduction: Vaccination prevents two to three million deaths annually, nevertheless, in 2018; 20 million children missed out on lifesaving measles, diphtheria, and tetanus vaccines. In 2019, in Sudan, approximately 39000 children missed those vaccines too. The aim of this study is to determine the percentage of unvaccinated children in three major pediatrics hospitals in Khartoum state and to assess the possible factors associated with the vaccination status.

Methods: We conducted an analytic cross-sectional study from 9/12/2020 to 16/12/2020 period in the selected hospitals. The study population was all children admitted to the chosen hospitals. Total coverage method was used for sampling. The questionnaire targeted assessment of the vaccination status and the potential factors associated with it. Descriptive statistics were applied to analyze the demographic characteristics while Chi-Square and Fisher's exact tests were used to assess the factors associated with vaccination.

Results: A total of 111 patients were included, of which 29 (26.1%) were unvaccinated. We found a statistically significant association between the child vaccination status and: Residence (P value<0.001), with higher percentage of unvaccinated children in rural areas; Mother's level of education (P value <0.001) and, mother's access to Antenatal care (P value = 0.018). We also found a significant association between the vaccination status and the possession of a vaccination card (P value<0.001), with 88.8% of the children having a vaccination card being fully vaccinated compared to 13.6% among those who don't. An additional significant association was found between the vaccination status and the proximity of the vaccination center (P value<0.001) with those living near a vaccination center having a higher percentage of vaccination (79.6%) compared to 30.8% among those who need to travel to get vaccinated.

Conclusion: Our study showed that a considerable portion of the participants were not fully vaccinated, the most important factors associated with unvaccination including the residence, mother's education, and the possession of a vaccination card, and finally, the proximity of the vaccination center, indicating that financial and infrastructural factors may also play a role in preventing vaccination.

Recommendations: Further nation-wide studies are needed to study the vaccination coverage in Sudan, and to further explore additional factors that are associated with vaccination in order to target them specifically and hopefully reach the goal of full vaccination coverage in Sudan.

Introduction:

Vaccination is one of the greatest human accomplishments in terms of diseases prevention. It's defined as the introduction of immunity to certain infectious diseases by administering various types of substances. Unlike a lot of other preventive methods, vaccination proved its efficacy by almost eradicating some infectious diseases (polio) and being cost-effective in doing so (1,2). Currently vaccination prevents two to three million deaths annually (3), but despite all of its success, in 2018, 20 million children missed out on lifesaving measles, diphtheria, and tetanus vaccines (4).

In order to increase the percentage of vaccinated children worldwide, multiple studies were conducted to identify factors that affect vaccination coverage. According to the World Health Organization (WHO), these factors are clustered into four main groups: Immunization System, Communication and Information, Family Characteristics and Parental Attitudes and Knowledge(5).

According to the United Nations Children's Fund (UNICEF), in 2019, in Sudan, approximately 39000 children were unvaccinated by Diphtheria, Pertussis, and Tetanus (DPT) vaccine (which is used as an indicator for the efficiency of immunization coverage of countries) (6), given this, nowadays in clinical practice it's not uncommon to encounter a child presenting with what is considered a rare, nearly-eradicated infection or to find accidentally

that he/she is not vaccinated.

Un-vaccination remains among the major contributors to child morbidity and mortality,
As

among the 140 million children born annually, 20 million remain unvaccinated, with
Africa

being a major contributor to this number (2). In 2019, 39000 Sudanese children were
unvaccinated by DPT vaccine (6), which explains the possibility of encountering a child
presenting with a vaccine preventable disease in pediatrics hospitals in Sudan
nowadays .

Despite the reduction in child mortality rates globally, Africa has the highest child
mortality

rates (54% of the global child mortality rate), with infectious diseases and vaccine
preventable

infections being on the top leading causes of death in the one year to five years age
group (14).

To our knowledge there is no recent published data from Sudan neither on proportion of
vaccine-preventable diseases and un/under-vaccination among children in pediatric
hospitals nor that examined the association between Un-vaccination and child morbidity
and mortality.

The aim of this study is to determine the percentage of unvaccinated children in
pediatrics

hospitals in Khartoum state and the probable factors associated with immunization.

As under-vaccination (low immunization coverage,) is considered one of the threats to
the

global health, there is a need to study the proportion of un-vaccination, vaccine
preventable

diseases, and to assess the possible factors associated with un/under-vaccination, in
order to

assist in the elimination of this threat.

Objectives:

General:

To determine the percentage of unvaccinated children in the target population and to
describe reasons for non-vaccination in pediatrics hospitals in Khartoum state and
assess the possible factors that are associated to the vaccination status.

Specific:

- 1) To determine the immunization status of children in pediatrics hospitals in target population.
- 2) To assess the potential factors associated with vaccination (geographic location/ socioeconomic status / education/ Gender / cultural beliefs and practices/ knowledge & behavior of parents/guardians on vaccination, etc.)
- 3) To estimate the percentage of vaccine preventable diseases in three major pediatric hospitals in Khartoum state.

Literature Review:

A research conducted by Ozawa S et al, in **2016**, titled: **Return On Investment From Childhood Immunization In Low- And Middle-Income Countries, 2011–20**, Stated that: "Vaccines are the most powerful and cost effective interventions in public health; they prevent 3 million childhood death annually, foster health equity and yield a 44\$ return on investment for every 1\$ spent" (7).

According to **WHO's 2018 assessment of the global vaccine action program**, out of the 140 million children born annually, 20 million children remain under-vaccinated or completely unvaccinated, out of those 20 million, the majority reside in low and middle income countries, with Africa being the most prevalent (2).

According to the **WHO's 2019 global vaccine action plan**: in sub-Saharan African countries, a major contributor to the high child mortality is vaccination preventable diseases, as immunization coverage still remains low (8).

According to **UNICEF**, In **2018**, 20 million children missed out on lifesaving measles, diphtheria, and tetanus vaccines (4).

The **WHO** reported in **2018** that in many countries, vaccination coverage are falling to the level that herd immunity can't be maintained, which might lead to outbreaks (2). An example for recent one is the **2018 measles outbreak** that occurred in **New York City**, the outbreak began when one unvaccinated child returned home from

Israel infected with measles among additional measles importations from Israel and

from parts of Europe to New York City, which ignited what has become the largest measles outbreak in the United States since 1992 (9). Which further emphasized that even single person with measles or other vaccine preventable infection, can lead to a large outbreak when introduced into an area with vaccination coverage below that which would be needed to maintain herd immunity (9). For the up-mentioned reasons, The **WHO** classified vaccine hesitancy among the top ten global health threats for **2019** (10).

A study conducted by Jani JV et al, in **2008**, regarding **risk factors for incomplete immunization in rural Mozambique**, concluded that the reasons for incomplete immunization could be grouped into three main categories: Parental factors (education and beliefs), healthcare system factors (availability of vaccines), and healthcare providers related factors (patient education and activation towards vaccination) (11).

Kyujin Chang et al, in their paper regarding **vaccination hesitancy**, in **2019**, concluded that even when socioeconomic barriers have been sufficiently eliminated (in a developed country), there are still many anti-vaccination groups, and false parents' beliefs which results in a higher percentage of unvaccinated children (12).

According to a study published in **2014** by Ismail Tibin et al, in **Nyala locality, south Darfur, Sudan**, only 63.4% of children under study were fully vaccinated (13).

Methodology:

1. Study Design, Study Area, & Study Period:

This is a hospital based, multi-center, analytic cross-sectional study conducted during the period from 9/12/2020 to 16/12/2020. The study took place in three pediatric hospitals in Khartoum State, which is the capital of Sudan, the most populous, and the most developed medically. Khartoum state is divided into three cities: Omdurman, Bahri, And Khartoum city. The largest (reference) hospital in each city was selected for the study: Jaafar Ibnouf Hospital in Khartoum city, Omdurman Pediatrics Hospital in Omdurman city, Ahmed Gasim Hospital in Bahri city.

2. Study population and sampling:

The study population was all children admitted to the chosen pediatric hospitals and their parents/guardians during the study period.

-Inclusion criteria: All children Admitted to Jaafar Ibnouf Hospital, Omdurman Pediatrics Hospital, or Ahmed Gasim Hospital during the period of the study.

-Exclusion criteria: refusal of participation in the study, Children with known contraindications for vaccination.

3. Sample Size & Sampling Technique:

Total coverage sampling was chosen, where the whole population of interest who was admitted during the data collection period was studied (as inpatient and those admitted to emergency room wards).

4. Study Variables:

-Socio-demographic information.

-Vaccination history (using their vaccination card when available and the mother's recall when it isn't).

-Reasons for non-vaccination

- Access of mother to antenatal care (previous study showed its association to the vaccination of the child (15)).

- Causes of presentation of the child to the hospital

- Causes of admission, if were due to a vaccination preventable disease.

- Past history of a vaccination preventable disease

- Factors associated with vaccination, derived from the "5A's Taxonomy for Determinants of Vaccine Uptake"(16), further explanation of each one is presented in (Appendix-1)

4. Data Collection Method & Tool:

Data Collection Tool included: A Google Form questionnaire & Clinical records (Patient's file). A trained interviewer administered a pretested structured Google Form questionnaire, and the data was collected from the informant of the child (usually the mother) by each interviewer using a mobile phone device. The questionnaire is presented as Appendix-2.

5. Data Analysis:

Data were reviewed, ordered, and coded, then Statistical Package for the Social Sciences (SPSS) version 25 used for data analysis. Children were classified according to the program of immunization classification into two categories:

- 1-Fully vaccinated: children who took all the vaccines according to their current age
- 2-Not fully vaccinated: children who missed one or more vaccines or did not receive any vaccination at all

Descriptive statistics were applied to analyze the demographic characteristics, and the child's cause of presentation. chi- square test and Fisher's exact test were implicated to assess the factors associated with vaccination.

6. Ethical Consideration:

An informed consent will be obtained prior to the administration of questionnaire, and participants will be informed that participation in the study is voluntary, and participants anonymity will be preserved. Ethical approval will be obtained from the Research Ethics Committee of Omdurman Islamic University.

Results:

1. Child's and parent's demographic characteristics:

A total of 111 pediatric patients were included in the study. More than half of the patients (61 patients) were older than 18 months, and most of them were males (66 patients). 78 lived in urban areas and 33 in rural areas. Out of the 111 patients, 100 had siblings, and 86 of those have fully vaccinated siblings. Most mothers aged 18-40 (97), with only 14 over the age of 40 in contrast to fathers whose 50 of them were older than

40. In term of Literacy, 78 (70.3%) of the mothers were literate, with remaining 33 (29.7%) being illiterate. The vast majority of mothers were Housewives (93). 93 of the mothers received Antenatal care, while the remaining 18 did not. (Table 1) shows the demographic characteristics of the children involved in the study and their parents.

2. Child's presentation:

Almost all (97.3%) patients presented due to causes unrelated to vaccination-preventable diseases with only 3 patients (2.7%) presenting with vaccine-preventable diseases. A large proportion (81%) of patients had vaccination cards, while 22 (19%) of them did not. 82 children (73.9%) were vaccinated up to date, with the remaining 29 (26.1%) either not completing their vaccination or being not vaccinated at all. Of those who were not fully vaccinated, parents' ignorance, illness at the dose time and lack of services were the major contributors to the problem. Only 1 child (0.9%) had history of previous presentation with disease preventable by vaccination, namely Pertussis. Table 2 shows the descriptive statistics of the presentation of the children involved in the study.

3. Factors associated with the child's vaccination status:

3.1. Demographic characteristics:

Table 1 shows the demographic characteristics of the children involved in the study and their parents, and its association to the vaccination status of the child. We found a statistically significant association between the child vaccination status and: child's age (P value<0.001), Residence (P value<0.001), siblings vaccination status (P value = 0.019), mother's age (P value = 0.028), Mother's level of education (P value <0.001) and, mother's Antenatal care (P value = 0.018). Majority of the children residing in urban areas (83.3%) were fully vaccinated while only 51.5% of the rural residents were. All (100%) of the mothers aged more than 40 years had their children fully vaccinated with 64.6% of the children whose mothers aged 18-30 did. Only About half (51.5%) of the children of 33 illiterate mothers were fully vaccinated in opposite to the 78 literate mothers whose 83.3% of their children completed their vaccination. Mothers who had Antenatal care were more likely to vaccinate their children (78.5%), on the other hand only 50% of children whose mothers didn't were fully vaccinated.

3.2. Child's presentation:

Chi-square test showed significant association between the child vaccination status

and if he/she had a vaccination card (P value<0.001), 88.8% of the children who had vaccination card were fully vaccinated, while only 13.6% of those who did not were. Further information regarding the child's presentation are illustrated in (Table 2).

3.3. 5 A's Taxonomy for Vaccine Uptake (Access, Affordability, Awareness, Acceptance, and Activation):

Fisher's Exact Test showed a significant association between the child vaccination status and the proximity of the vaccination center to where the child lives (P value<0.001). Of those who have the vaccination center within the same town or city, 79.6% were fully vaccinated, while just 30.8% those who needed a long-distance travel to reach the centers were vaccinated.

Additionally, we found a statistically significant association between the vaccination status and suitability of the vaccination date and time to the parents (P value<0.001). A statistically significant association was found between the child vaccination status and mother's awareness of the type and time of doses on the local vaccination schedule (P value <0.001), with 83.6% of children whose mothers were aware of the schedule were fully vaccinated. Results of the analysis regarding the "5A's Taxonomy for vaccine uptake" and their association to the vaccination status of the participants are shown in (Table 3).

Table 1: Child's and parents' demographic characteristics and their association with the vaccination status of the child (N = 111)

Characteristic	categories	Proportions, n (%)		Total	P-value
		Fully vaccinated	Not fully vaccinated		
Age (months)*	< month	0 (0.0%)	3 (100%)	3	
	1 - 8 (months)	24 (68.6%)	11 (31.4%)	35	
	9 - 18 (months)	4 (33.3%)	8 (66.7%)	12	<0.001
	> 18 months	54 (88.5%)	7 (11.5%)	61	
Gender	Male	48 (72.7%)	18 (27.3%)	66	
	Female	34 (75.6%)	11 (24.4%)	45	0.739
Residence*	Urban	65 (83.3%)	13 (16.7%)	78	
	Rural	17 (51.5%)	16 (48.5%)	33	<0.001
Place of birth	Hospital	50 (79.4%)	13 (20.6%)	63	
	Home	32 (66.7%)	16 (33.3%)	48	0.131
Number of siblings	0			11	
	1			18	

	2		19	
	3 or more		63	
Order among siblings	First	20 (80%)	5 (20%)	25
	Second	13 (68.4%)	6 (31.6%)	19
	Third	13 (72.2%)	5 (27.8%)	18
	Fourth or more	36 (73.5%)	13 (26.5%)	49
Are all of the siblings vaccinated? *	Yes	67 (77.9%)	19 (22.1%)	86
	No	6 (42.9%)	8 (57.1%)	14
Mothers age*	18-30	31 (64.6%)	17 (35.4%)	48
	31-40	37 (75.5%)	12 (24.5%)	49
	More than 40	14 (100%)	0 (0.0%)	14
Mothers level of education*	Illiterate	17 (51.5%)	16 (48.5%)	33
	Literate	65 (83.3%)	13 (16.7%)	78
Marital state	married	78 (74.3%)	27 (25.7%)	105
	Widowed	4 (66.7%)	2 (33.3%)	6
Fathers age	18-30	11 (68.8%)	5 (31.3%)	16
	31-40	28 (70%)	12 (30%)	40

	More than 40	40 (80%)	10 (20%)	50	
Fathers education	Illiterate	20 (62.5%)	12 (37.5%)	32	0.062
	Literate	59 (79.7%)	15 (20.3%)	74	
Mothers occupation	Housewife	70 (76.1%)	22 (23.9%)	92	
	Part time job	8 (61.5%)	5 (38.5%)	13	0.496
	Full time job	4 (66.7%)	2 (33.3%)	6	
Did the mother have ANC*	Yes	73 (78.5%)	20 (21.5%)	93	0.018
	No	9 (50%)	9 (50%)	18	
Subjective Family income Level	Low	34 (66.7 %)	17 (33.3%)	51	
	Middle	47 (79.7%)	12 (20.3%)	59	0.233
	High	1 (100%)	0 (0.0%)	1	

ANC: Antenatal Care * P<0.05; ** P<.001.

Table 2: Descriptive statistics of the presentation of participants and their association to the vaccination status of the child (N = 111)

Characteristic	categories	Proportions, n (%)		Total	P-value
		Fully vaccinated	Not fully vaccinated		
did the child present with a vaccination-preventable disease	Yes	2 (66.7%)	1 (33.3%)	3	1
	No	80 (74.1%)	28 (25.9%)	108	
does the child have a vaccination card? *	Yes	79 (88.8%)	10 (11.2%)	89	<0.001
	No	3 (13.6%)	19 (86.4%)	22	
Is the child fully vaccinated	Yes	82 (73.9%)		82	
	no		29 (26.1%)	29	
If the child is not vaccinated, what is the reason for it	Fear of complications		1 (3.4%)		
	Internal travelling		1 (3.4%)		

	Lack of services	6 (20.7%)		
	Home birth	2 (6.9%)		
	Illness at the dose time	9 (31%)		
	Parents ignorance	10 (34.5%)		
Past History of disease preventable by vaccination	Yes	0 (0.0%)	1 (100%)	1
	No	82 (74.5%)	28 (25.5%)	110
				0.261

* P<0.05; ** P<0.001.

Table 3: The “5 A's taxonomy for determinants of vaccine uptake” and their association to the vaccination status of the participants. (N = 111)

Is the date and time of vaccination suitable for you? *	Yes	81 (78.6%)	22 (21.4%)	103	<0.001
	No	1 (12.5%)	7 (87.5%)	8	

Awareness

Do you think immunization is essential for the safety of your child?	Yes	78 (73.6%)	28 (26.4%)	106	1
	Don't know	4 (80%)	1 (20%)	5	

If the answer is don't know what do you think the reason is?	Lack of informative communication from health care providers	3 (75%)	1 (25%)	4	1
	Others	1 (100%)	0 (0.0%)	1	

Are you aware of your child vaccination schedule (type and time)? *	Yes	61 (83.6%)	12 (16.4%)	73	<0.001
	No	21 (55.3%)	17 (44.7%)	38	

Acceptance

Do you think vaccines are safe (side effects more harmful than the disease itself)?	Yes	75 (75.8%)	24 (24.2%)	99	0.25
	No	3 (50%)	3 (50%)	6	3
	Don't know	4 (66.7%)	2 (33.3%)	6	

If the answer is don't know what do you think the reason is?	Lack of informative communication from health care providers	4 (66.7%)	2 (33.3%)	6

Do you think vaccines are	Yes	79	27 (25.5%)	106	0.60

		(74.5%)			
effective?	Don't know	3 (60%)	2 (40%)	5	4
If the answer is don't know what do you think the reason is?	Lack of informative communication from health care providers	3 (60%)	2 (40%)	5	
Do you think diseases prevented by vaccinations are severe?	Yes	72 (77.4%)	21 (22.6%)	93	0.08
	No	1 (100%)	0 (0.0%)	1	5
	Don't know	9 (52.9%)	8 (47.1%)	17	
If the answer is don't know what do you think the reason is?	Lack of informative communication from health care providers	9 (52.9%)	8 (47.1%)	17	
Do you trust the information provided by healthcare workers and government toward vaccination?	Yes	78 (75.7%)	25 (24.3%)	103	0.20
	No	4 (50%)	4 (50%)	8	3
Do you think vaccination is a social responsibility (you need to vaccinate your child in order to protect other children)?	Yes	63 (77.8%)	18 (22.2%)	81	0.12
	Don't know	19 (63.3%)	11 (36.7%)	30	4
If the answer is don't know what do you think the reason is?	Lack of informative communication from health care providers	19 (63.3%)	11 (36.7%)	30	

Have you been discouraged from vaccinating your child by a peer or family member?	Yes	21 (87.5%)	3 (12.5%)	24	.086
	No	61 (70.1%)	26 (29.9%)	87	

Activation

Do you get notified by any mean when the next vaccination is due (e.g. calls, SMS)?	Yes	3 (75%)	1 (25%)	4	1
	No	79 (73.8%)	28 (26.2%)	107	

* P<0.05; ** P<0.001.

Discussion:

Out of total of 111 pediatric patients, 29 (26.1%) were not fully vaccinated. The Child's and parents' demographics had the most pronounced impact on the child's vaccination status. We found a significant association of age of the child to the vaccination status of the child, and this association was also demonstrated by Ibn Ouf et al in his study conducted in Sudan in 2007 (17), in our study all of those aged less than one month were not fully vaccinated, and in all of these cases it was due to neonatal illness that led the mothers to hesitate vaccinating their newborns out of fear of complications (they thought that vaccinations might worsen the health).

condition of their children). On the other hand, 88.5% of children older than 18 months were fully vaccinated. There was no significant association between the child's gender and status of vaccination, and according to our knowledge no previous study concluded to found any (18), lastly, children whose siblings were fully vaccinated tend to be fully vaccinated (77.9%) compared to only 42.9% of those with not fully vaccinated siblings, this could be due to the parent's personal beliefs and attitude towards vaccination, so parents who vaccinate their first child will continue to do so with the after coming siblings.

Vaccination status was found to be strongly affected by residence, and this finding is consistent with findings of a similar study conducted in Sudan (17). With 83.3% of those living in urban areas completed their vaccination with the percentage dropping to 51.5% in those living in rural areas. This finding might be due to lack of services and education in rural areas as compared to urban areas in Sudan, furthermore, the proximity of vaccination centers proved to have an association with vaccination status of the child, and this finding is also consistent with the findings of the up-mentioned study (17). Those who needed a long-distance travel to vaccinate their children were less likely vaccinate their children, with only 30.8% of the children being fully vaccinated. This might be the result of financial or infrastructural unavailability of a transportation method, or alternatively due to lack of awareness of vaccination importance. This factor may also explain the lower vaccination coverage in rural areas.

In consistence with our findings, a similar study found that maternal age and education also affected the child's vaccination (17), with the percentage of vaccinated children increasing alongside the increase of their mothers' age and literate mothers being more likely to have a fully vaccinated child. This may be explained as the older and literate mothers are more aware of their children's vaccination schedule and vaccination's importance. Also, we found

that mother's access to antenatal care (ANC) was also associated to the vaccination status of the child, in those who had ANC, 78.5% of them were found to fully vaccinate their children while only 50% of children whose mothers had no antenatal care were vaccinated. This result is on the same line with what Dixit and colleagues found (19). This might suggest that information provided by healthcare providers to pregnant women regarding their children immunization during the ANC visits may increase the likelihood of them vaccinating their children later on. Also, awareness of mothers to their children vaccination schedule (type and time) appears to affects their probability to vaccinate their children, with 83.6% and 55.3% fully-vaccinated children among mothers who were aware and those who were not respectively. This can be attributed to the possible relation between awareness and mothers' attention and concern about their children's immunization and its significance.

Possession of vaccination card for children aged 18-month-old and younger (or during the same period for older children) have a great association with vaccination status, as 88.8% of those who did have a vaccination card were fully vaccinated with surprisingly low numbers (13.6%) in those who did not. A possible reason is that the vaccination card could act as a reminder for the parents regarding the vaccination schedule of the child, in addition the information presented in the vaccination card regarding the importance of vaccination and the lethality of the diseases it prevents may act as a stimulant for parents to vaccinate their children.

A study done by Francis et al. in 2019, concluded that there was no significant association between convenience of vaccination timing and vaccination uptake, on the other hand, our study showed a significant association, as we found the percentage of fully vaccinated children to be 78.6% of those who find the date and time of vaccination sessions suitable for

them, while among those who do not find the time and date of vaccination schedule convenient, only 12.5% of their children fully vaccinated. This difference may be due to that in low income countries such as Sudan, inconvenience is more or less a reflection of inability of the child's caregiver to reach the vaccination centers at all, or to do so at the appropriate time.

Limitations:

The major limitation in our study was the sample size, the COVID-19 Pandemic affected the performance of every hospital in Khartoum state including pediatric hospitals and this led to a pronounced decrease in the number of patients presenting to hospitals either directly due to fear of getting infected with the virus or indirectly by the effect of the virus on the whole aspects of people's life including mobilization and transportation. Other important factor is that the study was conducted at the time of medical Registrars strike, including pediatric registrars, which in addition to COVID-19, significantly affected the number of inpatients in the targeted hospitals, but in spite of the up-mentioned factors we managed to obtain a convenient sample of 111 children. We could not access other major pediatric hospitals located in Khartoum.

Conclusion:

Our study showed that (26.1%) of the participants were not fully vaccinated, among the sociodemographic characteristics age of child and residence were found to be

significantly associated with the vaccination status of the child, also the vaccination status of the siblings was associated with vaccination status of child. Mother's education, age, and access to antenatal care were also major associates with vaccination status, where mothers that are educated, older, and had access to antenatal care having a higher percentage of fully vaccinated children. Being aware of the vaccination schedule and having a vaccination card for the child were also associated to the vaccination status of child, highlighting the role of mother's awareness in vaccination. The proximity of the vaccination center and the suitability of the date and time of vaccination were found to be associated with vaccination status of the child, indicating that financial and infrastructural factors may also play role in preventing vaccination.

Recommendations:

The findings of this research are expected to benefit the Ministry of Health in planning for routine schedule and as well as massive immunization campaigns in the rural areas where they need to travel long distances in order to get access to vaccination. We advise the use of Televisions and Radio channels to educate parents regarding vaccination and its importance for the safety and well-being of their children, we also advise healthcare providers (especially obstetricians and pediatricians) to provide health education regarding vaccination. Further nation-wide studies are needed to study the vaccination coverage in Sudan, and to further explore additional factors that are associated with vaccination in order to target them specifically and hopefully reach the goal of full vaccination coverage in Sudan.

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Conflict of Interest

The authors report no conflict of interest.

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Appendix (1):

5 A's Taxonomy for Vaccine Uptake

Root Cause	Definition
Access	Ability to reach or to be reached by the recommended vaccine.
Affordability	The financial and non-financial (time) ability of the individual to obtain the vaccine.
Awareness	The degree of knowledge regarding the need for vaccines, their availability, and the recommended vaccines.
Acceptance	The degree to which individuals question, accept, or refuse vaccination.
Activation	The degree to which individuals are stimulated towards vaccine uptake

Appendix (2):

The Questionnaire:

Do you agree to participate in the study: Yes No

Hospital:

Omdurman Pediatrics Hospital Ahmed Ghasim Hospital Jaafar Ibnouf hospital

A-SOCIODEMOGRAPHIC CHARACTERISTICS

I. of the Child:

- Age:

- Gender: Male Female

- Residence: Rural Urban

-Place of birth: Home 0 Hospital 0

-Number of siblings:

-Order among siblings: First 0 Second 0 Third 0 Fourth or more
0

Are all of them fully vaccinated: Yes 0 No 0

II. of the Parents:

Mother's level of education: illiterate 0 Literate 0

Mother's age: less than 18 0 18 -30 0 31-40 0 40> 0

Marital state: Married 0 divorced 0 widowed 0

Father's level of education: illiterate 0 Literate 0

- Father's age: 18< 0 18-30 0 31-40 0 40> 0

Mother's occupation: House wife 0 Full-time job 0 Part-time job 0

Did the mother have ANC: Yes 0 No 0

Subjective Family income level: high 0 Middle 0 Low 0

B-CHILD'S PRESENTATION:

-did the child present with a vaccination-preventable disease?

Yes 0 No 0

-does the child have a vaccination card?

Yes 0 No 0

-Is the child fully vaccinated?

Yes 0 No 0

-If the child is not vaccinated, what is the reason for it?

-Past History of disease preventable by vaccination:

Yes 0: No 0

C-FACTORS CONTRIBUTING TO VACCINE UPTAKE: (5 A's taxonomy for determinants of vaccine uptake):

1-Access:

-What's the proximity of vaccination center?

within the same town/city 0 Requires long-distance travel 0

-Are there any vaccination campaigns arranged to where you live?

Yes 0 No 0

1. Affordability:

-Is the date and time of vaccination suitable for you?

Yes 0 No 0

2. Awareness:

-Do you think immunization is essential for the safety of your child?

Yes 0 No 0 Don't know 0

- If the answer is don't know what do you think the reason is?

Lack of informative communication from health care providers 0 Others 0

-Are you aware of your child vaccination schedule (type & time)?

Yes 0 No 0

3. Acceptance:

• Vaccine:

-Do you think vaccines are safe (side effects are more harmful than the disease itself)?

Yes 0 No 0 Don't know 0

•If the answer is don't know what do you think the reason is?

Lack of informative communication from health care providers 0 Others 0

-Do you think vaccines are effective?

Yes 0 No 0 Don't know 0

- If the answer is don't know what do you think the reason is?

Lack of informative communication from health care providers 0 Others 0

•Disease:

-Do you think diseases prevented by vaccination are severe?

Yes 0 No 0 Don't know 0

•If the answer is don't know what do you think the reason is?

•Individual Characteristics:

-Do you trust the information provided by health care workers and government towards vaccination?

Yes O No O

- **Social Context:**

-Do you think that vaccination is a social responsibility (you need to vaccinate your child in order to protect other children)?

Yes 0 No 0 Don't know 0

- If the answer is don't know what do you think the reason is?

Lack of informative communication from health care providers 0 Others 0

-Have you been discouraged from vaccinating your child by a peer or a family member?

Yes 0 No 0

4. Activation:

-Do you get notified by any mean when the next vaccination date is due?

Yes 0 No 0