Article published online: 2022-10-11

Missed Opportunities: A Cross-Sectional Descriptive Study on Reasons for Nonadherence to the South African Expanded Program on Immunization

Roberta Edwin[1] Cheryl Mackay[1] Siyazi Mda[2]

[1] Faculty of Health Sciences, Walter Sisulu University, Eastern Cape, South Africa
[2] Faculty of Health Sciences, Nelson Mandela University, Eastern Cape, South Africa

Address for correspondence Roberta Edwin, MBChB (UCT), FCPaed (SA), Dip HIV Man (SA), Faculty of Health Sciences, Walter Sisulu University, Gqeberha Campus, Eastern Cape, South Africa (e-mail: robertaedwin@gmail.com).

J Pediatr Infect Dis 2022;17:282–288.

Abstract

Objective Our objective was to identify factors which underline nonadherence to childhood immunizations provided by the Department of Health and outlined in the Expanded Program on Immunizations in South Africa.

Methods A cross-sectional descriptive study was conducted at Dora Nginza Hospital, a regional hospital in the Eastern Cape Province, which provides free health care in resource-limited settings. It included patients under the age of 5 years and their primary caregivers. A piloted questionnaire was used to collect data, and comparisons were made between children under the age of 5 years who missed one or more immunizations and those with complete immunizations. Data on maternal/caregiver and health system-related characteristics were also collected, and comparisons were made between the two groups.

Results Of the 200 participants enrolled in the study, 47 (23.5%) had incomplete immunizations. Prematurity (odds ratio [OR] = 0.33, $p = 0.001$), vaccine shortages (OR = 0.22, $p < 0.005$), and a low maternal/caregiver level of education (OR = 0.32, $p = 0.002$) were significantly associated with incomplete immunization status.

Conclusion Strategies to improve supply chain management of vaccines and to optimize follow-up care of high-risk children, specifically those born prematurely and those born to women of lower education level, need to be identified and implemented to reduce vaccine-preventable diseases.

Keywords
- vaccine-preventable diseases
- immunizations
- missed opportunities
- South Africa

Introduction

Globally, under-5 mortality was reported as 38 per 1,000 live births in 2019; in South Africa that rate is 34.5 per 1,000 live births.[1] Vaccine-preventable diseases (VPDs) contribute considerably to these child mortality rates.[2] The South African Expanded Program on Immunizations (EPI-SA) was introduced in 1995 with the purpose of preventing VPDs.[3] The immunization schedule outlined by EPI-SA is in line with recommendations by the World Health Organization and forms part of a comprehensive primary health care system. Since its introduction, EPI-SA has expanded and now targets 11 VPDs, with a significant reduction in morbidity and mortality. For instance, there has been more than a 40%

received
March 29, 2022
accepted after revision
August 3, 2022
published online
October 11, 2022

DOI https://doi.org/10.1055/s-0042-1756710.
ISSN 1305-7707.

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

decrease in pneumococcal diseases in children, 40% reduction in the hospitalization of children with diarrhea, and 60% reduction in hospitalizations from diarrhea caused by rotavirus.[3]

The target set by the Global Vaccine Action Plan 2011 to 2020 and endorsed by the World Health Assembly was that by 2020, all countries would have reached at least 90% national coverage for all vaccines in the country's immunization schedule.[4] In South Africa, coverage was reported to be as low as 54% for the second dose of the measles vaccine and 73% for the rotavirus vaccine.[5] Reasons for the suboptimal coverage are multiple. Studies show an association between incomplete immunization and certain socioeconomic, parental demographic and health system-related factors. These include low income, low level of parental education, and difficulties accessing vaccines.[6,7]

The South African health care system is highly unequal, with the underresourced state-funded public sector catering for 71% of the population, and a private sector largely funded by individual contributions to various health insurance schemes.[8] The Eastern Cape Province is geographically the second largest in the country but also the poorest of the nine provinces. Approximately, 12.7% of households in the province live in poverty.[9] The largest city in this province is Gqeberha, formerly known as Port Elizabeth. Dora Nginza Hospital (DNH), a regional hospital in Gqeberha, provides free health care to the Nelson Mandela Bay (NMB) Municipality. There are 39 primary health care facilities in NMB that refer sick children directly to DNH. Most of the people who access health care from DNH come from low-income households and live in periurban communities and have been historically economically disadvantaged.

There are numerous studies in low- and middle-income countries investigating the factors associated with incomplete immunizations in children. In Nigeria, Kenya, Bangladesh, India, and Indonesia, certain socioeconomic characteristics have been consistently shown to be associated with incomplete immunizations.[10–14] These include low-income households, children living in rural communities, children of mothers with no formal education, children of mothers with poor knowledge of immunizations, and children of mothers who do not receive antenatal or postnatal care.[10–14]

Studies focused on the issue of nonadherence to the EPI-SA immunization schedule are limited in South Africa, especially in the Eastern Cape Province. We, therefore, sought to investigate the factors which underline incomplete immunizations in children under the age of 5 years admitted to DNH.

Methods

We conducted a cross-sectional descriptive study from 1 August 2020 to 7 October 2020. We enrolled parent/child pairs. The children were all under the age of 5 years and had been admitted to the general pediatric wards at DNH. The pediatric department at DNH offers regional and tertiary level services to all children $\leq$12 years in the NMB and Sarah Baartman Districts of the Eastern cape Province of South Africa. The two general pediatric wards accommodate children admitted to the hospital, excluding inborn neonates and children with surgical conditions. These two wards have a combined capacity of 90 beds and are staffed by full-time doctors including specialist pediatricians, medical officers, and pediatric registrars. They provide the same in-patient general medical care.

All children under the age of 5 years admitted to the two general pediatric wards at DNH who were in possession of a Road-To-Health-Booklet (RTHB) at the time of admission, and whose parents or caregivers provided informed consent, were enrolled by the primary investigator/researcher. The RTHBs are booklets provided freely by the Department of Health to every child born in the country, whether in a private or public facility. These booklets contain important information on the well-being of the child and mother, and any routine childhood immunization administered is formally documented in the RTHBs. They usually accompany the child when he/she is presented to a health facility by the parent or guardian. These booklets are, therefore, a quick and reliable way to confirm administered vaccines.

We made comparisons between those who were up-to-date with their immunizations as indicated in their RTHBs and those who had missed one or more immunizations.

To assess immunization uptake among study participants, sample size calculation was based on the formula below[15]:

$$n = Z^2 \times P\,(1-P)/d^2$$

where n is the sample size, $Z = 1.96$ for 95% confidence interval, P is the prevalence of 0.9 based on the assumption that 100% immunization coverage is ideal, and $< 90\%$ is suboptimal, based on the target set by the Global Vaccine Action Plan 2011 to 2020,[4] and $d =$ level of significance of 0.05.

The prevalence of 90% stated above was used as there is a paucity of statistics on vaccine uptake in the Eastern Cape province of South Africa. Based on this calculation, a minimum of 138 participants were required; however, we ultimately enrolled and included 200 participants.

We used a piloted interviewer-administered and self-developed questionnaire to collect data. Data were collected from the mothers/caregivers. The questions developed were based on findings from studies in low- and middle-income countries which have shown the effects of socioeconomic factors such as household income, maternal factors such as education level, and health-system factors such as proximity to health facility, on immunization status. Questions included, therefore, sought to determine if similar factors played a role in immunization status in the study population. We first piloted the questionnaire among 10 participants. The immunization statuses of the enrolled children were assessed by scrutinizing their RTHBs, and the prevalence of incomplete immunization was calculated. We used the questionnaire to obtain information on child and maternal/caregiver and health system-related characteristics that were likely contributors to nonadherence to the immunization schedule. Maternal/caregiver characteristics included the income

level. A household income of less than R1,000 per month was considered low, as this is below the 2020 poverty line value of R1,268 per person, per month, as revised by Statistics South Africa.[16] Participants were recruited after receiving their informed consent.

Ethics approval was granted by Walter Sisulu University (ref. no. 014/2020), Eastern Cape Health Research Committee (EC_202005_006), and the DNH hospital management. Microsoft Excel and Statistica version 13 were used to analyze data. The continuous variable of age was described using mean and standard deviation, and categorical variables were analyzed using frequency distributions with percentages. Hypothesis testing was performed using the Student's *t*-test for continuous variables, and the chi-square test for categorical variables. For effect measures, a p-value < 0.05 and a 95% confidence interval which did not include the null value of one were considered statically significant.

Results

Five hundred and sixty-two children were admitted to the two general pediatric wards during the course of the study. Out of this number, 243 were below the age of 5 years and 213 of them where in possession of an RTHB on admission. We enrolled a total of 200 children and their parents/guardians. Forty-seven (23.5%) children had an incomplete immunization status. Of 200 children, 57.0% were male, 68.5% identified as black , and 30.0% as colored; most (56.5%) were aged under 12 months. The median age was 8 months (interquartile range [IQR] = 2–24), and the median birth order was the second (IQR 1–3). A majority of 66.5% had no past hospital admissions and 76.5% had no history of a chronic illness. In addition, 76.0% had no history of prematurity and only 8.0% reported a history of significant infections in the neonatal period. A comparison of child characteristics between those with complete and incomplete immunization status is summarized in ►**Table 1**. Prematurity was the only child characteristic found to be associated with incomplete immunization status (odds ratio [OR] = 0.33, $p = 0.001$).

Regarding maternal/caregiver characteristics, 6.5% of the mothers/caregivers had an income of less than R1,000 per month. Of the 200 participants, 72.5% lived in formal housing, 48.0% had less than three children in the household, and 91.0% reported more than two maternal antenatal clinic visits in the last pregnancy. A majority of 97.5% perceived immunizations to be important and 99% were in favor of immunizations. Also, 95.0% had no beliefs that prevented them from immunizing their child/guardian.

Table 1 Comparison of child characteristics between children with complete and incomplete immunization status ($n = 200$)

Variable	Complete immunizations ($n = 153$) No. (%)	Incomplete immunizations ($n = 47$) No. (%)	Total ($n = 200$)	Odd ratio	95% Confidence interval	*p*-Value
Sex						
Male	84 (74.0)	30 (26.0)	114	0.7	0.4–1.45	0.280
Female	69 (80.0)	17 (20.0)	86			
Ethnicity						
Black	109 (80.0)	28 (20.0)	137	0.6	0.3–1.0	0.144
Colored	42 (70.0)	18 (30.0)	60			
Birth order						
First	56 (80.0)	14 (20.0)	70	0.7	0.4–1.5	0.390
Second–seventh	97 (75.0)	33 (25.0)	130			
Age (months)						
0–11	28 (25.0)	85 (75.0)	113	1. 2	0.6–2.3	0.670
12–59	68 (78.0)	19 (22.0)	87			
Chronic illness(es)						
Yes	32 (68.0)	15 (32.0)	47	0.6	0.3–1. 2	0.120
No	121 (79.0)	32 (21.0)	153			
Previous admission(s)						
None	106 (80.0)	27 (20.0)	133	0.6	0.3–1. 2	0.133
One–eight	47 (70.0)	20 (30.0)	67			
Prematurity						
Yes	28 (58.0)	20 (42.0)	48	0.3	0.6–0.9	**0.001**
No	125 (82.0)	27 (18.0)	152			

Note: The bold font indicates *p*-values which were less than 0.005.

Table 2 Comparison of maternal/caregiver characteristics between children with complete and incomplete immunization status ($n = 200$)

Variable	Complete immunizations ($n = 153$) No. (%)	Incomplete immunizations ($n = 47$) No. (%)	Total ($n = 200$)	Odd ratio	95% Confidence interval	P-value
Age (years)						
< 26	52 (75.0)	17 (25.0)	69	1.1	0.6–2. 2	0.783
26 +	101 (77.0)	30 (23.0)	131			
Marital status						
Single, separated, divorced, widowed	90 (78.0)	25 (220)	115	0.8	0.4–1.5	0.470
Living together, married	63 (74.0)	22 (26.0)	85			
Education level						
< Grade 12	78 (68.0)	36 (32.0)	114	0.3	1.5–6.6	**0.002**
Grade 12+	75 (87.0)	11(13.0)	86			
Employment status						
Unemployed	110 (74.0)	38 (26.0)	148	1.7	0.7–3.7	0.221
Employed	43 (83.0)	9 (17.0)	52			
Housing type						
Informal	39 (71.0)	16 (29.0)	55	1.5	0.8–3.1	0.251
Formal	114 (79.0)	31 (21.0)	145			
Income/month						
< R3 500	88 (73.0)	32 (27.0)	120	1.6	0.8–3.2	0.196
R3 500+	65 (81.0)	15 (19.0)	80			
Family size						
< 3	68 (71.0)	28 (29.0)	96	1.8	1.0–3.6	0.069
> 3	85 (82.0)	19 (18.0)	104			
Alternative medicine use						
No	129 (75.0)	42 (25.0)	171	1.6	0.6–4.4	0.740
Yes	24 (83.0)	5 (17.0)	29			

Note: The bold font indicates *p*-values which were less than 0.005.

A comparison of maternal/caregiver characteristics between children with complete and incomplete immunization status is summarized in ►**Table 2**. A low level of education was associated with an incomplete immunization status (OR = 0.32, $p = 0.002$; ►**Table 2**).

Primary health facility-related characteristics in children with complete and incomplete immunization status are compared in ►**Table 3**. The only significant association with immunization status was a history of past incidents of vaccine shortages at the participant's primary health facility. The odds of complete immunization if there was such history was 0.2 times the odds for the group without such history (►**Table 3**).

A majority (75.0%) of participants lived within walking distance of their preferred primary health facility, and 69% participants had never experienced incidents of vaccine shortages there. Almost half (48.5%) of participants rated the attitude of the staff at their primary health facility as good, and 88.0% were satisfied with they care received.

Discussion

Factors which affect childhood immunization status were analyzed among children under the age of 5 years admitted to a regional public hospital in South Africa. We identified prematurity, vaccine shortages, and low level of education of the primary caregiver as factors associated with incomplete immunization status.

The association of prematurity with incomplete immunization is not a new finding. Studies have shown that delayed immunizations of premature infants by health care staff are common, despite adequate data supporting early immunization without correction for gestational age in stable premature infants.[17–19] In this study, possible reasons for incomplete immunizations in children with a history of prematurity may include prolonged in-hospital stay during the neonatal and immediate postneonatal period and missed opportunities for immunization while in hospital. This may be due to misconceptions by medical staff regarding

Table 3 Comparison of the primary health facility-related characteristics between children with complete and incomplete immunization status ($n = 200$)

Variable	Complete immunizations ($n = 153$) No (%)	Incomplete immunizations ($n = 47$) No (%)	Total ($n = 200$) No (%)	Odd ratio	95% confidence interval	*p*-Value
Proximity of residence to primary health facility						
Within walking distance	115 (77)	35 (23)	150	0.96	0.45–2.04	0.923
Not within walking distance	38 (76)	12 (24)	50			
Past incidents of vaccine shortages						
No	118 (86)	20 (14)	138	0.22	0.11–0.44	$<$ **0.005**
Yes	35 (56)	27 (44)	62			
Trust in staff at primary health facility						
No	51 (74)	18 (26)	69	1.24	0.63–2.44	0.531
Yes	102 (78)	29 (22)	131			
Attitude of staff at primary health facility	50 (79)	13 (21)	63	0.79	0.38–1.62	0.535
Poor/Fair Good/Excellent	103 (75)	34 (25)	137			
Staff perceived to have adequate knowledge of immunizations						
No/Not sure	31 (74)	11 (26)	42	1.20	0.55–2.63	0.644
Yes	122 (77)	36 (23)	158			
Satisfied with care received at primary health facility						
No	21 (88)	3 (12.5)	24	0.43	0.12–1.51	0.175
Yes	132 (75)	44 (25)	176			

Note: The bold font indicates *p*-values which were less than 0.005.

immunization of the premature infant, such as the need to correct for gestational age and to wait for the infant to grow and mature before immunization, as well as immunizations being deemed unsafe in the premature infant. These misconceptions and the incorrectly perceived contraindications to immunization of the premature infant need further investigation and may be addressed with appropriate staff education and training.

A low maternal/caregiver level of education was also shown to have a negative effect on immunization status. In low-income countries, it is well documented that incomplete immunization in children is associated with mothers who have had no formal education.[20,21] A low level of maternal education may be an indicator of low socioeconomic status, and in many low- to middle-income countries inequalities in full immunization coverage have been shown to differ according to wealth, with prorich inequalities existing.[20] These findings, however, contrast with a prospective cohort study in the United Kingdom where a higher proportion of mothers of unimmunized infants were educated to the degree level or above.[22] In high socioeconomic populations, there appears to be parental vaccine refusal due to vaccine-related concerns regarding side effects and dosing.[23]

The only health system-related characteristic associated with incomplete immunization was that of an experience of vaccine shortages at one's primary health facility. Vaccine shortages result in an unreliable supply of needed vaccines to children, contributing to the issue of incomplete immunizations. In this study, 31% of participants reported having experienced vaccine shortages. The odds of complete immunizations in the group of patients without a history of vaccine shortages is 4.55 times greater than that of the group with a history of vaccine shortages at their primary health facility. To address the problem of vaccine shortages, technology and real-time alerts can be used to project vaccine needs and availability, monitor vaccine uptake and predict, prevent, or at least minimize vaccine shortages.

We found no statistically significant effects of sex, age, birth order, or a history of previous admissions or chronic illness on immunization status. There was also no statistically significant effect of children's ethnicity on immunization status. However, 69 and 30% of the participants in the study identified as "black" and "colored," respectively, meaning that the study population is not representative of the general South African population; this mut be borne in mind when considering the results of this study.

Maternal/caregiver age, marital status, monthly income, housing type, and family size also had no effect on immunization status. However, study participants were predominantly from low-income families, which may account for the lack of a significant effect of socioeconomic factors on the completeness of immunizations.

In low- and middle-income populations, there is well-documented research on the issue of service inaccessibility

as a major obstacle to immunization.[7] Interestingly, no statistically significant effect was shown in the current study between immunization status and proximity to health facilities or other health system characteristics described. This may be the result of the majority of the study participants living within walking distance of their primary health facility with easy access to immunization services.

This study identified three significant factors associated with incomplete immunizations in children under 5 years of age including a history of prematurity, a low maternal/caregiver education level, and an experience of vaccine shortages at the local primary health facility. To reduce mortality from VPDs, high-risk children need to be identified and closely followed up, in-patient immunization of premature infants needs to be stepped up, supply chain and other issues related to vaccine shortages need to be identified and resolved, and the broader social issue of improving basic education for girls requires urgent attention.

Despite generating useful information, the study had several limitations. First, due to limited resources and consequent logistical difficulties, the study was conducted only on in-patients at DNH. It may not, therefore, be representative of the population of children in the Eastern Cape Province as a whole since healthy children, and children attending clinics and private health facilities were excluded. Moreover, data were collected using a self-developed questionnaire due to the lack of availability of validated questionnaires in similar studies in the country and region.

Calculating the sample size using a formula for prevalence studies may have resulted in the study being underpowered for some of the correlations tested, but this means that we can be certain that the significant correlations found were correct. A Cochrane review evaluating interventions which can improve vaccine uptake in low- and middle-income countries showed that providing information on immunization to the community, integrating immunization with other services, providing incentives, and redesigning reminder cards are all strategies which may improve vaccine uptake.[24]

Also, there was the limitation of participant recall bias which was difficult to avoid due to the nature of the study. Lastly, because it was important to assess immunization status formally, and the RTHB is an important tool for documenting administered vaccines, children without RTHBs were excluded. This may have introduced bias because vaccine uptake may differ between the groups of children. There is, however, no known prior research investigating potential differences between the two groups, and this was not an objective of this study.

Conclusion

VPDs contribute significantly to under-5 mortality globally and in South Africa. An understanding of the factors underlining nonadherence to the childhood immunization schedule outlined by EPI-SA is paramount to addressing the issue of incomplete immunizations. The factors identified in the current study include prematurity, a low level of maternal/caregiver education, and previous vaccine shortages at one's primary health facility. These findings present an opportunity for the health district to develop strategies for high-risk children. Intersectoral collaborative efforts are needed to improve maternal education and to resolve administrative and health systems issues, such as vaccine shortages.

Conflict of Interest
None declared.

References

1 United Nations International Children's Emergency Fund. Under-five mortality – UNICEF Data. New York: United Nations International Children's Emergency Fund; 2020. . Published December 2021. Accessed January 2022, at: https://data.unicef.org/topic/child-survival/under-five-mortality/
2 Bamford LJ, McKerrow NH, Barron P, Aung Y. Child mortality in South Africa: fewer deaths, but better data are needed. S Afr Med J 2018;108(03):25–32. Accessed November 17, 2020, at http://www.samj.org.za/index.php/samj/article/view/12238
3 Dlamini NR, Maja P. The expanded programme on immunisation in South Africa: a story yet to be told. S Afr Med J 2016;106(07):675–677. Accessed November172020, at: http://www.samj.org.za/index.php/samj/article/view/10956
4 VanderEnde K, Gacic-Dobo M, Diallo MS, Conklin LM, Wallace AS. Global routine vaccination coverage—2017. MMWR Morb Mortal Wkly Rep 2018;67(45):1261–1264
5 World Health Organization. South Africa: WHO and UNICEF estimates of immunization coverage. Geneva: World Health Organization; 2020. Published June 2020. Accessed February 4, 2021, at: https://www.who.int/immunization/monitoring_surveillance/data/zaf.pdf
6 Adedokun ST, Uthman OA, Adekanmbi VT, Wiysonge CS. Incomplete childhood immunization in Nigeria: a multilevel analysis of individual and contextual factors. BMC Public Health 2017;17(01):236. Accessed January 20, 2021, at: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-017-4137-7
7 Favin M, Steinglass R, Fields R, Banerjee K, Sawhney M. Why children are not vaccinated: a review of the grey literature. Int Health 2012;4(04):229–238. Accessed January 20, 2021, at: https://academic.oup.com/inthealth/article/4/4/229/672421
8 Rensburg R. Healthcare in South Africa: how inequity is contributing to inefficiency. July 6, 2021. Accessed May 17, 2022, at: https://theconversation.com/healthcare-in-south-africa-how-inequity-is-contributing-to-inefficiency-163753
9 Statistics South Africa. Subjective poverty in South Africa. Findings from the general household survey 2019. Pretoria; 2022. Published 2022. Accessed May 17, 2022, at: http://www.statssa.gov.za/publications/03-10-25/03-10-252019.pdf
10 Herliana P, Douiri A. Determinants of immunisation coverage of children aged 12-59 months in Indonesia: a cross-sectional study. BMJ Open 2017;7(12):e015790
11 Srivastava S, Fledderjohann J, Upadhyay AK. Explaining socioeconomic inequalities in immunisation coverage in India: new insights from the fourth National Family Health Survey (2015-16). BMC Pediatr 2020;20(01):295
12 Allan S, Adetifa IMO, Abbas K. Inequities in childhood immunisation coverage associated with socioeconomic, geographic, maternal, child, and place of birth characteristics in Kenya. BMC Infect Dis 2021;21(01):553
13 Eze P, Agu UJ, Aniebo CL, Agu SA, Lawani LO, Acharya Y. Factors associated with incomplete immunisation in children aged 12-23 months at subnational level, Nigeria: a cross-sectional study. BMJ Open 2021;11(06):e047445

14 Sarker AR, Akram R, Ali N, Sultana M. Coverage and factors associated with full immunisation among children aged 12-59 months in Bangladesh: insights from the nationwide cross-sectional demographic and health survey. BMJ Open 2019; 9(07):e028020
15 Pourhoseingholi MA, Vahedi M, Rahimzadeh M. Sample size calculation in medical studies. Gastroenterol Hepatol Bed Bench 2013;6(01):14–17
16 Africa SS. National Poverty Lines 2020. Pretoria; 2020. Published August 2020. Accessed November 17, 2021, at: http://www.statssa.gov.za/publications/P03101/P031012020.pdf
17 Bonhoeffer J, Siegrist CA, Heath PT. Immunisation of premature infants. Arch Dis Child 2006;91(11):929–935
18 Ji C, Li M, Zeng Y, et al. Vaccination deferral among children with seizures in Zhejiang: influence, recommendation, safety and implications. Expert Rev Vaccines 2021;20(12):1667–1675
19 Lyanda LN. Prevalence and factors associated with immunization delays among low-birth weight infants at Kenyatta National Hospital. [Master's Thesis]. Kenya: University of Nairobi; 2019
20 Mugada V, Chandrabhotla S, Kaja DS, Machara SGK. Knowledge towards childhood immunization among mothers & reasons for incomplete immunization. J Appl Pharm Sci 2017;7(10):157–161
21 Forshaw J, Gerver SM, Gill M, Cooper E, Manikam L, Ward H. The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis. BMC Infect Dis 2017;17(01):801. Accessed November17, 2021, at: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-017-2890-y
22 Restrepo-Méndez MC, Barros AJ, Wong KL, et al. Inequalities in full immunization coverage: trends in low- and middle-income countries. Bull World Health Organ 2016;94(11):794–805B. Accessed November 17, 2021, at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5096343/
23 Samad L, Tate AR, Dezateux C, Peckham C, Butler N, Bedford H. Differences in risk factors for partial and no immunisation in the first year of life: prospective cohort study. BMJ 2006;332(7553):1312–1313
24 Oyo-Ita A, Wiysonge CS, Oringanje C, Nwachukwu CE, Oduwole O, Meremikwu MM. Interventions for improving coverage of childhood immunisation in low- and middle-income countries. Cochrane Database Syst Rev 2016;7:CD008145