

Potential of improving full vaccination status of children in Niamey, Niger; a randomized cluster survey

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Abstract

Background and Objectives: Economically-disadvantaged Sub-Saharan African children are not fully protected from vaccine-preventable diseases. Maternal education is a promoting factor associated with child vaccination. However, both socio-economic status and maternal education factors are not easily modifiable. This study aimed to identify factors associated with full vaccination status of children in Niamey, Niger.

Methods: A cross-sectional, multi-stage randomized cluster survey was conducted in Niamey's five health districts. Data on vaccination coverage and socio-economic household characteristics were collected. Logistic regression analysis was conducted with data on 445 pairs of mothers and their children aged 12-23 months.

Results: Of 445 children, 38% were fully vaccinated. Mothers who were satisfied with their health worker's attitude and had correct vaccination calendar knowledge (AOR 5.32, 95% CI 2.05-13.82) were more likely to have fully vaccinated children. Mothers who had completed secondary school (AOR 2.04, 95% CI 1.17-3.55) were also associated with fully vaccinated children.

Conclusions: Low coverage of full vaccination could be improved through modifiable factors in resource-limited settings such as Niger. Communication interventions may be effective, including improving mothers' knowledge about vaccination timing and intervals between appointments. Health workers' attitudes should also be improved with better interpersonal communication with the mothers.

Introduction

Vaccination has played a central role in narrowing global health inequity. Full child vaccination was originally defined as receiving eight vaccine doses over five visits before a child's first birthday. Fully vaccinated children received one dose of BCG vaccine at birth, three doses of polio and DTP vaccines at six, 10 and 14 weeks after birth, and one dose of measles vaccine at nine months (1). The proportion of children who are fully vaccinated has risen in the past decade (1) as service availability, accessibility and acceptability have improved (2). However, when mothers are of lower economic status, are less educated and/or live in rural areas(1), they are not always able to take full advantage of vaccines and services being offered for their children. As a result, more than half a million Sub-Saharan Africa children are not fully protected from vaccine-preventable diseases (3).

Vaccination service availability is monitored through vaccination coverage. Vaccination coverage is the percentage of those in a target age group who received the recommended vaccines according to the vaccination calendar. The numerator for child vaccination is the number of children vaccinated. The denominator is the estimated number of children eligible for vaccination under the Expanded Programme on Immunization (EPI) (4). However, denominators are difficult to predict timely and correctly. The reasons cited are rapid population growth, population mobility and rapid urbanization. Administrative

data quality becomes doubtful. Therefore whenever possible, cross-sectional vaccination coverage surveys are conducted and triangulated with administrative vaccination coverage estimates.

Increasingly, vaccination coverage and population health surveys collect data on socio-economic factors related to vaccination. These factors inhibit adequate vaccination coverage (5, 6), or improve vaccination coverage. More specifically, factors that are said to have a statistically significant association with vaccination coverage are; maternal education and health literacy levels (7–11), socio-economic status or wealth quintiles (7–10, 12), possession of a maternal and child health handbook(11, 13–15), health workers attitudes (16–20), as well as discussion about vaccination with friends and family (18, 21–23).

In Niger, initial access to vaccination is relatively high. For example, results from the 2012 Demographic Health Survey (DHS)(24) show 80% BCG and DTP 1 vaccination coverage for children aged 12–23 months. For DTP 2, coverage falls by 10%. For DTP 3, coverage falls by another 10%. Only 58% of children receive measles vaccination before they turn one-year-old. Of the 2275 children surveyed in 2012, full vaccination coverage was estimated at 44% with 6% of children never having received any vaccination. When the data was disaggregated, the poorest quintile children compared to the richest quintile, were disadvantaged by 30% to be fully vaccinated (1). Children whose mothers were not educated were 20% disadvantaged in being fully vaccinated, compared to those whose mothers received secondary education. Children in rural areas were 20% less likely to be fully vaccinated than children in urban areas. A pattern of economic-related, education-related and place of residence inequality is observed.

Vaccination status becomes more equitable when interventions are carried out to eliminate poverty or to improve maternal education levels. However, such interventions require time to take effect. As low-income countries including Niger have low human capital and limited resources, they cannot afford to wait. These countries need to identify interventions which would have a more immediate and equitable effect.

In this context, this study aimed to identify rapidly modifiable factors associated with full vaccination status of children in Niamey, Niger.

Methods

Study Area

The Republic of Niger has an estimated population of over 20 million people (25, 26). The country has one of the world's highest birth rates. As a consequence, Niger has one of the fastest growing populations in the world. Nearly half of the population (44.1% in 2016) lives below the poverty line of US 1.9 dollars per day. The country ranked second to last on the Human Development Index in 2016 (26). In the Human Capital Index announced in 2018 (27), Niger ranked 155 out of 157 countries. The capital, Niamey, has an estimated population of over a million people. The average annual urban population growth rate was 5.1% over 2010–2015 (28). The health of the capital's population is overseen by a regional directorate

and its five health district offices. This study was conducted in all of the five health districts under the authority of the Niamey regional health directorate.

Study design

A cross-sectional study was conducted in October 2016. A multi-stage randomized cluster design was used, following first the WHO cluster survey 2005 guidelines (29). As the study was being implemented, WHO cluster survey 2015 draft working guidelines (30) were announced. The sample size for the stratified five health districts was calculated based on a 85% likely coverage for DTP 3 from 2014 administrative data (31). In addition, the following parameters applied; 95% confidence interval, 90% power and an intra-cluster correlation of 0.042 (or a design effect of 1.38 which means that there is very little variation in coverage). After stratifying on health district, 46 clusters were randomly selected from a cluster list. This cluster list was constructed for the 2012 Census by the National Institute of Statistics (NIS) of Niger.

Study questions were drafted based on the 2012 Niger Demographic Health Survey (DHS) questionnaire (24) and WHO cluster survey 2015 draft working guidelines (30). MKK, MLM and the NIS statistician reviewed the questions for cultural appropriateness. The above-mentioned three researchers then pretested the questions during training of 22 surveyors. Of the 22, four supervisors were selected during training to oversee the remaining 18 surveyors. The four supervisors were supervised by MKK, MLM and the NIS statistician.

Participants

Mothers of children aged 12–23 months were identified within each cluster. If mothers had more than two children between the ages of 12–23 months, only data of the youngest child was collected.

Variables

The dependent variable was the fully vaccinated child verified by the child's vaccination record in the maternal and child health handbook. This study did not collect information on vaccination based on the mother's memory. Full vaccination status was coded "1" if the child had received BCG, three DTP, three times oral polio vaccine drops and measles vaccines. If the child had missed any of the above-mentioned vaccines, the child's vaccination status was coded "0".

For the dependent variable of a fully vaccinated child, independent variables derived from the literature were selected. Specifically, socio-economic independent variables included maternal education level (7–11), socio-economic status based on wealth quintile (7–10, 12), mother's and father's age (as continuous variables), mother's employment status (19) and the child's birth order (33, 34). Independent variables included in the analysis were: discussion about vaccination with family (18, 21–23), satisfaction with the

attitudes of the health workers (16–20), and maternal vaccination calendar knowledge. All independent variables were binary.

This study's wealth quintile was constructed using principal component analysis (PCA) of household assets. Questions were asked on electricity, water source, home and vehicle ownership, livestock ownership, as well as TV, refrigerator and air conditioner ownership. Typical DHS questions regarding housing materials were not included, as roofing and flooring materials in Niamey are similar.

Binary response questions were asked on satisfaction with the attitudes of health workers, and whether the women discussed vaccination with friends and discussion with family. Responses were coded in binary form: i.e. "1" for "yes" and "0" for "no".

Maternal vaccination calendar knowledge was assessed through the question "How many times should you take your child (to the vaccination center) so that he/she is fully vaccinated?". If the mother correctly replied "five" to the question, her response was coded "1" for "has knowledge". If the mother gave another number or was unable to answer, her response was coded "0" for "does not have knowledge".

Data collection and analysis

On the NIS maps, MKK randomly marked the first household to start from. Cluster boundaries were confirmed on the ground. Surveyors then canvassed each cluster, going in a predetermined direction. Surveyors continued until they had interviewed ten mothers. The same procedure was repeated in each of the 46 clusters. For clusters which were markets or bus terminals, surveyors randomly approached mothers carrying babies on their backs. Mothers were interviewed with a structured questionnaire.

Mother-child pairs were nested within their neighborhoods. Usually when data is nested, a multilevel regression is run. However, the intraclass correlation coefficient (ICC) was negligible (ICC 0.02, standard error 0.03) when an empty model was run for the dependent variable of a fully vaccinated child. This was interpreted as minimal variation of the dependent variable from one neighborhood to another. Therefore data was analyzed at mother-child level without taking neighborhood clustering into account. A single level logistic regression analysis was run. All statistical analyses were performed using Stata software, version 13.1 (StataCorp, Lakeway Drive, College Station, TX, USA).

Results

Study population characteristics

A total of 460 mothers of children ages 12–23 months were recruited. Data of 15 children were removed before data analysis as they did not meet the age inclusion criteria.

Table 1 shows the descriptive characteristics of the 445 mothers. Of 146 mothers who were not able to read and write, 101 (36.9%) did not have a fully vaccinated child. Of 182 mothers who had completed

both primary and secondary schools, 86 (50.3%) had a fully vaccinated child. Of 445 mothers, 436 were divided into quintiles according to their socio-economic status. The poorest quintile had the lowest percentage (11.8%) while the middle class had the highest percentage (25.4%) of fully vaccinated children. The richest quintile also had a high percentage (22.5%) of fully vaccinated children, just slightly lower than the middle quintile.

Table 2 shows modifiable factors of the 445 mothers. When mothers were asked “Are you satisfied with the attitude of your health worker?”, 384 of 433 mothers (88.7%) replied positively. Of 433 mothers who were asked the maternal vaccination calendar knowledge question, 208 (48.0%) responded correctly. Of these 208 mothers, 101 (48.6%) had a fully vaccinated child.

Socio-economic and modifiable factors associated with a fully vaccinated child

Of 445 children, 171 children (38%) were fully vaccinated. Table 3 shows the result of multivariable logistic regression on the association between the independent variables and the dependent variable of a fully vaccinated child. Given the relatively small sample size in this study, selected socio-economic variables were included in the logistic regression analysis (35, 36). Mothers classified to the middle wealth quintile (AOR 4.05, 95% CI 1.90–8.66) and the rich wealth quintile (AOR 2.67, 95% CI 1.28–5.58) were more likely to have fully vaccinated children. Mothers who had completed primary and secondary schools (AOR 2.04, 95% CI 1.17–3.55) were more likely to have fully vaccinated children. Mothers satisfied with their health worker’s attitude and having correct vaccination calendar knowledge (AOR 5.32, 95% CI 2.05–13.82) were also more likely to have fully vaccinated children.

Discussion

This study identified modifiable and less modifiable factors that were associated with full vaccination of children. Modifiable factors were mothers’ satisfaction with their health worker’s attitude and their vaccination calendar knowledge. Financial status and education level were considered as less modifiable factors.

Maternal vaccination calendar knowledge and satisfaction with health worker’s attitude

In this study, when mothers knew that they needed to bring their children to the health center five times, they were more likely to have a fully vaccinated child. Maternal education and health literacy levels are commonly associated with higher vaccination coverage (7–11). However, measuring health literacy level measurement can not only be complicated but also inconsistent (37). In this study, maternal vaccination calendar knowledge was assessed through a simple and direct question with a binary response. Such a question can easily be added to household and vaccination coverage surveys. In this way, maternal

knowledge of the vaccination calendar could predict whether the mother will bring back her child for further vaccination. If knowledge is insufficient, communication interventions could be made to rapidly modify this independent variable. Communication could improve correct knowledge of the vaccination schedule, such as the time intervals between appointments. Mothers might be nudged to come for timely vaccination.

Children were more likely to be fully vaccinated, when mothers had knowledge and were satisfied with health worker attitudes. Health worker attitudes and knowledge may be interconnected. In fact, health worker attitudes are critical when a mother is looking for information on vaccination (38, 39, 40). If health worker attitudes are acceptable, mothers are more likely to trust vaccination and vaccines. Trusting mothers may be more willing to attend vaccination sessions. Through these visits, mothers might acquire correct knowledge of the vaccination schedule compared to those women who come less often.

Socio-economic status and healthcare utilization

In this study, the poorest and poorer mothers were less likely to have a fully vaccinated child. Similar findings have reported on the association between lower socio-economic status and the lesser likelihood of a fully vaccinated child (8, 12, 41, 42). One explanation was that poorer mothers had less time or “multiple livelihood activities which deter clinic attendance” (43). Previous literature has also found that poor mothers felt poorly treated by health workers (43). Health worker attitudes may influence healthcare utilization more than previously acknowledged. Therefore, modifying health worker attitudes may be key to improving healthcare utilization experience of poor mothers. More economically disadvantaged children could be fully vaccinated if sympathetic health workers communicated with mothers better.

Economically disadvantaged children could also be protected from vaccine-preventable infectious diseases through reinforced community or herd immunity. Community immunity can be raised if a critical mass has been vaccinated, through routine vaccination and vaccination campaigns (44). In addition, community immunity can be kicked-off with correct maternal vaccination calendar knowledge and helpful health workers, both shorter-term modifiable factors.

Study Limitations

This cross-sectional study did not record received vaccination antigens if mothers who did not possess their child’s vaccination record or a maternal child health handbook. Recall bias, a problem flagged by prominent researchers in this field (45, 46), was therefore minimized. Selection bias is possible as the surveyors might have selected mothers who were able to show their child’s vaccination record. Chance responses, to the question determining maternal vaccination calendar knowledge, could not be controlled for. In any case, a binary response question was the most direct way to measure maternal vaccination calendar knowledge. For the wealth index quintiles, cautious interpretation is necessary. This study’s wealth quintiles were constructed from urban household assets unweighted to a national scale. Results could be skewed, as this study’s urban inhabitants fall in the top two quintiles of the national wealth

index. As a cross-sectional study, the cause-effect relationship between modifiable factors and full vaccination status could not be assessed. For example, mothers could have acquired vaccination calendar knowledge through the process of getting their child fully vaccinated. Or, mothers could have learned correct vaccination calendar through frequent contact with health workers. Finally, ethnographic and other qualitative methods could have furthered understanding on urban specificities and access to health services.

Conclusions

Based on proof of vaccination recorded in the maternal and child health handbook, only 38% of children were fully vaccinated. More fully vaccinated children could be achieved by modifiable factors. These modifiable factors include, mothers' satisfaction with health workers' attitudes and vaccination calendar knowledge. One way to modify would be through communication interventions. Specifically, mothers could act on specific information on time intervals between appointments. Maternal satisfaction with health workers' attitudes could be improved through better health worker interpersonal communication with mothers. In this way, communication interventions may be effective in improving low vaccination coverage.

List Of Abbreviations

AOR: Adjusted Odds Ratio, BCG: Bacillus Calmette–Guérin vaccine, CI: Confidence Interval, DHS: Demographic Health Survey, DTP: Diphtheria, Tetanus, and Pertussis vaccine, EPI: Expanded Programme on Immunization, KAP: Knowledge, Attitude and Practice, NIS: National Institute of Statistics of Niger (INS in French), WHO: World Health Organization

Declarations

Ethics Approval

The Research Ethics Committee of the Graduate School of Medicine in the University of Tokyo approved the protocol for this study (serial number 11218). The National Ethics Committee of Niger authorized study execution (no. 03660/MSP/SG/DEP/DER). Consent in the form of a signature or thumbprint was obtained from all mothers. Participation was strictly voluntary with no incentive given. Measures were taken to ensure the confidentiality of the mothers so that individuals could not be identified. The Institutional Review Board of Harvard University approved a follow-up research proposal (IRB17–1451) using the same dataset.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MKK designed the study, field survey and led the data collection and data analysis of the survey. MKK designed the study, field survey and led the data collection and data analysis of the survey. MLM contributed to the study design and supervised the acquisition of data. AS assisted with data analysis. MKK drafted the manuscript with critical contributions from AS and MJ. All authors read and approved the final manuscript.

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Authors' information

MKK is a former UNICEF Communication for Development Specialist responsible for monitoring polio and routine immunization in West and Central Africa. During this time, MKK supported several external EPI reviews in the region from 2010 to 2014. Previous to this, MKK was health project formulation advisor with Japan International Cooperation Agency (JICA) in Niger. MLM was Regional Director for Public Health in Maradi Region, Niger from 2008 to 2012.

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Tables

Table 1: Study population characteristics

(n=445, of which not fully vaccinated n=274, fully vaccinated n=171)

Variable	Child not fully vaccinated		Child fully vaccinated		p-value
	N	(%)	N	(%)	
Mother's education level	n=445				0.030
Unable to read and write	101	(69.2)	45	(30.8)	
Able to read and write	19	(67.9)	9	(32.1)	
Primary and Secondary	96	(52.8)	86	(47.3)	
Post-Secondary	16	(61.5)	10	(38.5)	
Koranic	42	(66.7)	21	(33.3)	
Socio-economic status (measured by constructed wealth index)	n=436				0.003
Poorest	65	(76.5)	20	(23.5)	
Poorer	60	(67.4)	29	(32.6)	
Middle	44	(50.6)	43	(49.4)	
Richer	48	(55.2)	39	(44.8)	
Richest	50	(56.8)	38	(43.2)	
Mother's age group	n=443				0.721
15-19 years old	19	(59.4)	13	(40.6)	
20-24 years old	63	(61.2)	40	(38.8)	
25-29 years old	86	(65.2)	46	(34.9)	
30-34 years old	50	(62.5)	30	(37.5)	
35-39 years old	43	(58.9)	30	(41.1)	
40 years old or more	11	(47.8)	12	(52.2)	
Father's age group	n=437				0.038
20-29 years old	28	(63.6)	16	(36.4)	
30-34 years old	46	(54.8)	38	(45.2)	
35-39 years old	69	(71.9)	27	(28.1)	
40-44 years old	60	(65.9)	31	(34.2)	
45-49 years old	40	(58.0)	29	(42.0)	
50 years old or more	25	(47.2)	28	(52.8)	
Mother's employment status	n=445				0.651
At-home mother	208	(61.0)	133	(39.0)	
Working mother	66	(63.5)	38	(36.5)	
Child's birth order	n=444				0.689
1 st child	53	(57.6)	39	(42.4)	
2 nd child	52	(61.9)	32	(38.1)	
3 rd child	49	(56.3)	38	(43.7)	
4 th child	37	(67.3)	18	(32.7)	
5 th -6 th child	47	(64.4)	26	(35.6)	
7 th -11 th child	35	(66.0)	18	(34.0)	

Table 2: Study population behaviors

(n=445, of which not fully vaccinated n=274, fully vaccinated n=171)

Variable	Child not fully vaccinated		Child fully vaccinated		p-value
	n	(%)	n	(%)	
Mother's possession of maternal and child health handbook (n=445)					0.001
No	18	(100.0)	0	(0.0)	
Yes	256	(60.0)	171	(40.0)	
Mother's discussion about vaccination with family (n=434)					0.019
No	83	(69.8)	36	(30.3)	
Yes	181	(57.5)	134	(42.5)	
Mother's satisfaction with health worker's attitude (n=433)					0.025
No	37	(75.5)	12	(24.5)	
Yes	226	(58.9)	158	(41.2)	
Maternal vaccination calendar knowledge (n=433)					<0.001
No	156	(69.3)	69	(30.7)	
Yes	107	(51.4)	101	(48.6)	