Original article

Determinants of full valid vaccine dose administration among 12-32 months children in Ethiopia: Evidence from the Ethiopian 2012 national immunization coverage survey

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Abstract

Introduction: According to the 2012 national immunization coverage survey report of Ethiopia, EPI coverage by antigen is 79.6% for BCG, 80.0% for DPT-HepB-Hib1 90.1% for OPV1 65.7%; for adjusted DPT-HepB-Hib 3; 65.7 % for OPV3 and 68.2% for Measles. Similarly, the prevalence of full vaccination was 50%. However, the prevalence of valid vaccination dose for all vaccines is 18.6 %. Therefore, the aim of this study is to identify factors that determine the administration of full valid vaccines dose to set effective interventions.

Methods: Data was obtained from the 2012 Immunization Coverage survey of Ethiopia, a cross- sectional study administered at the household level. Data were analyzed using SPSS version 20. Binary and multivariate logistic regression with 95% CI was done to assess factors associated with getting full valid vaccination dose.

Results: As documented from the 2012 national immunization coverage survey, the coverage of full valid vaccination dose were very low as compared to full immunization coverage that is 18.6% Vs 50%, respectively. Urban residence 2.6 (95% CI: 2.50, 2.68), mothers with age groups of 21-34 and >35 were 1.26 (95% CI: 1.22, 1.29) and 2.4 (95% CI: 2.3, 2.44); children with caretakers with primary, secondary, and higher level of education were 1.6 (95% CI: 1.22, 1.29), 2.8 (95% CI: 2.76, 2.92), and 2.2 (95% CI: 2.13, 2.27) times more likely to get valid vaccination dose.

Conclusion: The rich wealth quintile, rural place of residence, living more than 5km proximity to nearest health facility, having more than six sibling, having teenage (<20years old) mother, having mother with no formal education, having mother/ care giver with no card or family folder which state children vaccination status sources, and having mother who did not heard a message about importance of vaccine were found to be the independent determinants of low valid dose immunization. The efforts at all level to increase full valid vaccination coverage by targeting activities to socio-economic, socio-demographic, organizational, and related determinants. [*Ethiop. J. Health Dev.* 2016;30(3):135-141]

Key words: Valid dose, vaccination, Ethiopia

Introduction

Immunization is the process by which a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine (1). A vaccine is a non-pathogenic antigen that stimulates the body's own immune system to produce antibody to protect the person against later infection or disease. It is the most cost effective public health intervention that can control and eliminate life-threatening infectious disease. Worldwide it averts an estimated 2 to 3 million deaths each year (1).

Vaccines are recommended for members of the youngest age group at risk for experiencing the disease for which efficacy and safety have been demonstrated. WHO set the minimum age at first dose and the minimum interval between doses for each vaccine for production of optimal protection (2, 3). Certain products, including inactivated vaccines, toxoids, recombinant subunit vaccines, polysaccharide conjugate vaccines, and live vaccines, require ≥2 doses to elicit an adequate antibody response (2, 3). Even though optimal response to a vaccine depends on multiple factors such as type of vaccine, age of the recipient, and immune status of the recipient, timely adherence to vaccination schedule also has an effect on it. (2, 3).

According to the recommendations of the Advisory Committee on Immunization Practices (ACIP), invalid vaccine dose defined as any dose of a vaccine administered ≥5 days earlier than the minimum interval or age (3). The invalid dose should be repeated and spaced after the invalid dose by the recommended minimum interval (ACPI) (3). Similarly, based on the national routine EPI schedule, a child is fully vaccinated when s/he receive one dose of BCG, 3 dose of penta, 3 dose of polio other than polio at birth, and one dose of measles vaccine before 12 month of age (4).

Inappropriate timing of vaccination adversely impacts the effectiveness of the country's immunization program through sub-optimal sero-conversion (5-6). Early age immunization might result in the neutralization of vaccine by maternal antibodies result

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with no immune response. On the other hand, delaying vaccination increases the amount of time those children at risk of acquiring this infection (7-8). When interval between doses is reached at the recommended level; the sero-conversion (development of detectable antibody level) would be faster. (5-8).

The optimal timing of vaccines to be given is an important question in order to optimize the benefit and minimize the risks of vaccines. A study has demonstrated the association of vaccination delay and development of side effects. Another study conducted to examine the potential modifying effect of age on the risk of developing fever and seizures following immunization with measles-containing vaccines showed that the relative risk of post immunization fever and seizures were significantly greater among older children than younger ones (6). Generally, high vaccination coverage and timeliness of vaccination are very important points to prevent disease outbreaks, providing protection for children and reduce the need to repeat doses (9-12).

Several studies conducted by different scholars showed that socio- demographic and behavioral characteristics of mothers/ care givers substantially affect health seeking behaviors. These factors also affect timely adherence to vaccination schedule. Mothers or care givers education play significant role in timely adherence to vaccination schedule. Studies conducted in Pakistan and Iraq showed that children whose care giver or a mother had low educational attainment were less likely to get timely vaccination (13, 14).

There was always a difference in health service utilization among regions and between urban and rural people. The presence of these disparities affects timely adherence to vaccination schedules (15). The result of study done in Burkina Faso showed that area of residence was significantly associated with failure of timely adherence to the vaccination schedule. Children living in rural areas were more likely to fail to have timely vaccination than urban children (16). Distance from health facility also affects timely immunization. Study conducted in China showed that Children who live in the nearby health facility were more likely to get timely vaccination than their counterparts (17).

Studies done in Belgium and Korea showed that first borne children were more likely to get on time vaccination than children who have older siblings (18, 15). Another study conducted in Uganda revealed that children who had families of better economic status were more likely to get timely vaccination than their counterparts (19).

Significance of the study: Both high coverage and timely administration of vaccination is useful to attain the full benefits of immunization. Vaccination schedule is not set arbitrarily. Timely administration of vaccines is very important to optimize the benefit and minimize the risks of vaccines. As understood from the 2012 national immunization coverage survey, the coverage of full valid vaccination dose were very low as compared to full immunization coverage that is 18.6% Vs 50%, respectively. However, the national EPI coverage by antigen is 79.6% for BCG, 80.0% for DPT-HepB-Hib1 90.1% for OPV1 65.7%; for adjusted DPT-HepB-Hib 3; 65.7 % for OPV3 and 68.2% for Measles.

What factors determine the low utilization of valid vaccination dose is not well understood and the availability of literature is very scarce. Therefore, the aim of this study is to identify factors that determine the administration of full course of valid vaccines dose based on data from national immunization coverage survey of 2012 in Ethiopia to fill the literature gap. Similarly, health development stakeholders to implement effective intervention for the improvement of valid vaccination dose will use the study result. Finally, the study finding can be used as an input to improve quality of immunization service delivery to achieve the goal of HSTP 1.

Methods

Study setting: Ethiopia is the oldest independent and second populous country in Africa. The country occupies an area of 1.1 million square kilometer with geographical diversity ranging from 4,620m above sea level at Ras Dashen Mountain and down to Danakil (Dallol) Depression of 148m below sea level. Projections from the 2007 population and housing census estimate the total population for the year 2015 to be 90 million.

Data source: Ethiopian national immunization coverage survey was carried out in 2012. The study covered urban and rural areas of the entire regions. This national level data was obtained from the Ethiopian Public Health Institute.

Inclusion and exclusion criteria

Exclusion criteria

Data set which have incomplete information for the intended variable were excluded from the analysis.

Operational definitions

Valid dose: any vaccine dose administered after a minimum age or interval but before 12 months of age.

Receiving full course of valid dose vaccination: If a child get one valid dose of BCG + three valid dose polio excluding polio given at birth, + three valid dose of pentavalent + one valid dose of measles.

***Invalid dose*:** a dose of vaccine considered as invalid if it is administered before minimum age, or if it administered less than 28 days between two subsequent doses, or a dose administered after 12 months of age.

Variables of the study:

Dependent variable: Children with full course of valid vaccine dose.

Independent variables: maternal age, residence, region, level of education, wealth index, birth order,

distance from enumeration area to health facility, having vaccination card or family folder, ever heard message about importance of vaccination from any sources, ever refused to vaccinate their child, and ever decide not to take their child to get vaccine.

Data management and analysis: After getting the data, the desired data was extracted carefully based on the study objectives. The new data set consists of dependent and independent variables which was created by recoding. The extracted data was checked for its completeness. Then it was transformed, edited and recoded using SPSS data editor command.

Whether the vaccine was administered at the right time or not, the time of administration for each vaccine and child's age at the time of vaccination were critically reviewed and the numbers of days between each dose of vaccination were calculated. If a child get one dose of BCG before two weeks of age + three dose polio excluding polio given at birth, + three dose of pentavalent + one dose of measles vaccine provided after the recommended age or interval but completed before 12 months of life were recorded as receiving full course of valid vaccination dose. Whereas a dose of vaccine administered out of the recommended age or interval or after12 months of the vaccine were recorded as in valid dose vaccination. Bi-variate analysis with 95% confidence interval was done to assess the association of dependent and independent variables. All variables which had association at P-value < 0.2 were entered at Multivariate analysis. Multivariate logistic regression analysis was performed to assess the independent effect of each explanatory variable on the dependent variable by controlling other independent variables for the identification of determinant factors.

Ethical consideration: The national EPI of 2012 coverage survey got an ethical approval from the Ethiopian Public Health Institute (EPHI), scientific and ethical review board. This assessment was a further analysis, which used secondary data and did not involve any human subject for interview.

Result

This study encompassed 3762 children and 3762 mothers or primary caretakers to assess factors associated with valid dose vaccination.

According to the 2012 EPI coverage report, of the children surveyed, 52.3% were male and 47.7% were female. Nationally, among the children's mothers/care givers, in terms of level of education 75.6% of them were less than primary level, 17.8% primary school, 4.6% secondary school and 2.3% were post-secondary school. The survey results indicated that 85.7% of children were from rural areas and 14.3% live in urban areas. The wealth index showed that 20.7% of them were categorized in 1st quintile (lowest), 20.2% 2nd quintile, 19.6% 3rd quintile, 19.4% 4th quintile and 19.9% 5th quintile (highest).

The result of bivariate analysis showed that all independent variables except residing in Dire Dawa City Administration, other variables were associated with getting full course of valid dose immunization. Infants were less likely to get full valid vaccination dose if they belonged to out the richest wealth quintile, lived in rural settings, and more than 5killo meter (Km) far from nearest health facility (HF), had more than six sibling, had young (<20 years old) or had no formal education. Mother/ care giver no card or family folder which state children vaccination status, caretakers ever refused to vaccinate their child, did not heard a message about the importance of vaccine, and ever decision about not to take their child to be vaccinated (Table 1).

Table 1: **Univariate and multivariate analysis of covariates associated with full valid vaccine dose administration, Ethiopia**

Types of variables	Frequency	COR(95% C.I)	AOR (95% C.I)
Residence			
Rural	2524	1	1
Urban	1238	3.3 (3.24,3.29)	2.6(2.50,2.68)
Region			
ADD	346	1	1
TIG	339	0.29(.28, .292)	0.553(.527, .581)
Afar	344	0.02(.014, .017)	0.000
Amhara	346	0.124(.122, .127)	0.313(.300, .327)
Ben	348	0.112(.110, .115)	0.589(.565, .614)
DIR	345	0.000(.000,)	0.000
GAM	338	0.067 (.06, .07)	0.198(.181, .218)
HARI	321	0.085(.083, .088)	0.330(.316, .344)
OROM	349	0.02(.024,.03)	0.114(.09, .145)
SNN	340	0.125(.115, .136)	0.195(.152, .251)
SOM	346	0.313(.297, .331	0.63(.545, .727)
Parity			
1 child	856	1.46(1.438, 1.474	1.4(1.366, 1.467)
2-3	1215	1.3(1.31, 1.34)	2.6(2.55, 2.7)
4-5	698	1.015(1.003, 1.027)	1.7(1.67, 1.78)
6+	465	1	
Level of education			
No formal education	214	1	
Primary	851	.932(.92, .944)	1.6(1.57, 1.63)
Secondary	395	2.55(2.505, 2.592)	2.84(2.76,2.92)
Higher	176	2.9(2.84, 2.967)	2.2(2.13, 2.27)
Maternal age			
<20 yrs	477	1	
21-34	2364	1.48(1.47,1.5	1.26(1.22, 1.29)
>35	664	1.4(1.38, 1.4)	2.4(2.3, 2.44)
Parity			
1 child	856	1.456(1.438, 1.474	1.42(1.366, 1.467)
2-3	1215	1.324(1.31, 1.34)	2.63(2.55, 2.7)
4-5	698	1.015(1.003, 1.027)	1.7(1.67, 1.78)
6+	465	1	
Wealth index			
Poorest	962	0.139(.137,.14)	0.378 (.365, .392)
Poorer	603	0.196(.194, .199)	0.288(.278, .298)
Middle	545	0.315(.312, .319)	0.218(.210, .225)
Richer	547	0.406(.401, .410	0.308(.299, .318)
Richest	1091	1	1
Distance from EA to HF			
<5 km	908	1.026(1.017, 1.034)	1.6(1.58, 1.63)
>5 km	1299	1	1
Have you ever decided NOT to take your child to get a vaccination?			
Yes	136	1	
No	3601	1.8(1.8, 1.9)	
Do you have card or folder recording child's vaccinations?			
Yes	2629	8.2(8, 8.3)	5.8(5.7, 5.9)
No			
Have you ever refused vaccination for this child?	1100	1	1
Yes	114	1	
No	3638	2.07(2.023, 2.116)	2.4(2.2, 2.6)
Ever heard message about importance of vaccines			
Yes	3106	2.46(2.431, 2.496)	1.5(1.45, 1.55)
No	536	1	1

The result of multivariate analysis revealed that except ever decide not to take their child to get vaccine, living in Afar region and in Dire Dawa city administration, all other independent variables become significantly associated with full course of valid immunization dose.

Residential area was found significant determinant factors for getting valid vaccination dose. Children who resided in urban areas were 2.6 (95% CI: 2.50, 2.68) times more likely to get valid vaccination dose than their rural counterparts. Maternal age was significantly associated with valid vaccination dose.

Compared with children who were born from younger women (<20 years), children who were born from mothers with age groups of 21-34 and >35 were 1.26 (95% CI: 1.22, 1.29) and 2.4 (95% CI: 2.3, 2.44) times more likely to get valid vaccination dose. Similarly, mothers or caretakers level of education positively influences receiving valid vaccination dose. Children who had caretakers attended primary, secondary, and higher level of education were 1.6 (95% CI: 1.57, 1.63), 2.8 (95% CI: 2.76, 2.92), and 2.2 (95% CI: 2.13, 2.27) times more likely to get valid vaccination dose than caretakers with no formal education. Wealth index also determine the likely hood of receiving full course of valid vaccination dose. Children who live in the poorest, poorer, middle, richer wealth index were about 62% (0.38 (95% CI: 0.365, .392), 71% (95% CI: 0.29(.278, .298), 78% (95% CI: 0.22(.210, .225), and 69% (0.31(.299, .318) less likely to get full course of valid vaccination dose compared to richest wealth index, respectively. Moreover, birth order was significantly associated with getting full course of valid vaccination dose. First order child were 42% (1.42(95% CI: 1.37, 1.47), 2-3 children 2.6(95% CI: 2.55, 2.70), 4-5 children 70% (1.7(95% CI: 1.67, 1.78) times more likely to get full valid vaccination dose than 6+ births.

Distance from health facility was found significantly associated with valid vaccination dose. Children who lived with in less than 5Km to the nearest health facility were about 60% (1.6(95% CI: 1.58, 1.63) times more likely to get valid vaccination dose than their counterparts. Having child card or family folder, which tells about children vaccination history, was significantly determined receiving full valid vaccination dose. Caretakers who had card or family folder that state their child vaccination status were 5.8 (95% CI: 5.7, 5.9) times more likely to get valid vaccination dose than caretakers who had no card or family folder. In addition, hearing about importance of vaccination from any source was significantly associated with valid dose immunization. Caretakers who heard about importance of vaccine were about 50% (95% CI: 1.5(1.45, 1.55) times more likely to get their children to full valid dose vaccination than their counterparts. Likewise, ever refusal of caretakers to vaccinate their children significantly determines getting full valid vaccination dose. Caregivers who did not refuse to vaccinate their child were 2.4(95% CI: 2.2, 2.6) times more likely to receive valid vaccination dose than their counterparts.

Discussion

Immunization is the most proven and cost effective mechanisms to avert life treating, but vaccine preventable diseases when the vaccine is administered based on the recommended schedules (1). Timely adherence to a recommended immunization schedules is believed to improve an optimal protection against infections, which are vaccine-preventable, and to avoid unnecessary wastage especially in economically deprived countries like Ethiopia.

The result of multivariate analysis of this study revealed that there were regional as well as urban-rural disparities to receive valid vaccination dose. Children who live in rural settings were less likely to get valid vaccination dose than urban counterparts. This might be due to the presence of difference in availability, accessibility, and functionality of the health facility as well as knowledge, attitude and practice of service users in rural and urban areas. This result was similar with a result of a research conducted in Burkina Faso (16).

It was also found that maternal age also determines getting full valid vaccination dose. Children who had younger mother were less likely to get valid vaccination dose. This might be due to younger mothers (<20Yrs) may got difficulty in managing their children. Or they may not have experience and this may lead to fear to get vaccinated their child. This result was similar with the result of a study done in Belgium (18).

Similarly, maternal education affects getting valid vaccination dose. Children whose guardian or mother had no formal education or lower educational attainment were less likely to receive valid vaccination dose than children whose caretakers fall in higher educational categories. This could be explained by the fact that education and awareness plays a vital role by providing not only better life and economic status but also helping people to accept one thing with reason and logic that can help to combat superstitions and replace such beliefs. This result was concordant with other studies done in Pakistan and Iraq (13, 14).

In addition, the result of this study showed that the numbers of older siblings affect the probability of the youngest children to get valid dose vaccination. Children who had less number of older siblings were more likely to get on time vaccination than children who had large number of older siblings. This result was consistent with study done by different scholars (15, 16).

Ever refuse to get their children vaccinated and ever heard of a message about the importance of vaccination affect receiving valid vaccination dose. Caregivers who refused to get their children vaccinated were less likely to make their children vaccinated as per the recommended time than their counterparts. This might be due to caregiver's refusal to vaccinate their child for any reasons. On the other hand, having heard a message about importance of vaccination increases the likely hood of getting valid vaccination dose. Children who had a mother ever heard of a message about importance of vaccination were more likely to get valid vaccination dose than their counterparts. This might be due to mothers /caregivers who have positive attitude towards a vaccine had a great interest to protect their child from any disease through vaccination.

Conclusion:
In conclusion, as we have seen from the result, full valid vaccination was low. Several factors have been investigated as initiators for low utilization of valid vaccination dose. Socio-demographic & economic variables were identified as main barriers for the coverage. The rich wealth quintile, rural place of residence, living more than 5km proximity to nearest health facility, having more than six sibling, having teenage (<20years old) mother, having mother with no formal education, having mother/ care giver with no card or family folder which state children vaccination status sources, and having mother who did not heard a message about importance of vaccine were found to be the independent determinants of low valid dose immunization. The efforts should be maximized at all level to increase full valid vaccination coverage by targeting activities to socioeconomic, socio demographic, organizational, and related determinants.

Recommendation
Based on the findings, we would like to recommend that it is good to provide integrated immunization education with other maternal and child health services like antenatal care, post-natal care, pediatrics, family planning units. Health education should target young mothers to get their children vaccinated based on the recommended schedules. Educating women to higher educational level is also recommended. Immunization strategies should focus in providing vaccination card or family folder during vaccination. Health education and promotion should be given to women about the importance of full valid vaccination through different routes such as paper based or electronic mass-media, schools, social organization like "Idere" and "Iqub' could Improve the percentage of full valid vaccination at national level. Further study is recommended to assess the burden of each determinates of low valid vaccination coverage.

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Competing interests
The corresponding author declares that there is no financial or non-financial competing interest.

Reference
1. What is immunization? http://www.who.int/topics/immunization/en/ accessed in 1/11/2016.
2. WHO/MSD/MDP. English behavioral science learning modules, behavioral factors in immunization, department of mental health and substance dependence world health organization, Geneva, 2010.
3. CDC. General Recommendations on Immunization Recommendations of the Advisory Committee on Immunization Practices (ACIP), Morbidity and Mortality Weekly Report, Recommendations and Reports / Vol. 60 / No. 2, January 28, 2011.
4. FMOH, EHNRI, CSA, WHO, UNICEF, Bill and Mellenda gets. Ethiopian national immunization coverage survey: Ethiopian Health and Nutrition Research Institute (EHNRI), 2012.
5. Niyi Awofeso, Anu Rammohan and Kazi Iqbal. Age-appropriate vaccination against measles and DPT-3 in India–closing the gaps. BMC Public Health. 2013, 13:358. Open accessed at http://www.biomedcentral.com/1471-2458/13/358, 2013.
6. Elizabeth T. Luman, Lawrence E. Barker, Mary Mason McCauley et al, Timeliness of Childhood Immunizations. PEDIATRICS. 2002; 110 (5), retrieved at pediatrics.aappublications.org, August 7, 2015.
7. T. Jacob John. Chairman, IAP Committee on Immunization and Emeritus Professor, Department of Clinical Virology, Christian Medical College, Vellore 632 004, Tamil Nadu. Indian immunization dialogue, 2012.
8. Steven Novella, Delaying Vaccines Not a Good Idea, Science-Based Medicine.html, June 4, 2014.
9. Simon J. Hambidge, Sophia R. Newcomer, Komal J. Narwaney, et al. Timely Versus Delayed Early Childhood Vaccination and Seizures: PEDIATRICS. 2014; 133, (6) June 2014, retrieved at pediatrics.aappublications.org, accessed on August 14, 2015.
10. Haelle Tara, Scientific American, June 2, 2014. http://www.scientificamerican.com/article/delaying-vaccines-increases-risks-with-no-added-benefits/
11. Ali Rowhani-Rahbar, Bruce Fireman, Edwin Lewis, et al. JAMA Pediatr, Effect of Age on the Risk of Fever and Seizures Following Immunization With Measles-Containing Vaccines in Children FREE,2013
12. Akmatov MK, et al. Evaluation of invalid vaccine doses in 31 countries of the WHO African Region. Vaccine. 2014, http://dx.doi.org/10.1016/j.vaccine. 2014.
13. Nazish Siddiqi, Azfar-e-Alam, Nighat Nisar et al, Mothers knowledge about EPI and its relation with age-appropriate vaccination of infants in peri-urban Karachi, Journal Of Pakistan Medical Association, 2010
14. Kholod D Al- Shemari. Causes of Delay in Age Appropriate Vaccination, THE IRAQI POSTGRADUATE MEDICAL JOURNAL 2006; 5(32:98.
15. Eun-Young K, Moo-Sik L. Related Factors of Age-Appropriate Immunization among Urban-Rural Children Aged 24-35 Months in a 2005 Population-Based Survey in Nonsan, Korea, Yonsei. Med J. 2011; 52(1):104-112, DOI 10.3349/ymj.2011.
16. Research Gate. Socio-demographic determinants of timely adherence to BCG, Penta3, measles, and complete vaccination schedule in Burkina Faso -

Available from: http://www.researchgate.net/publication/258252056_Socio-demographic determinants_of_timelyadherence_to_BCG_ Penta3_measles_and_complete_vaccination_schedule_in_Burkina_Faso [accessed Aug 17, 2015].

17. Research Gate. Completeness and timeliness of vaccination and determinants for low and late uptake among young children in eastern China - Available from: http://www.researchgate.net/publication/260445844_Completeness_and_timeliness_of_vaccination_and_determinants_for_low_and_late_uptake_among_young_children_in_eastern_China [accessed Aug 17, 2015].
18. Tinne Lernout, Heidi Theeten, Niel Hens et al. Timeliness of infant vaccination and factors related with delay in Flanders, Belgium. Vaccine 32 (2014) 284–289.
19. Juliet N. Babirye, Ingunn M. S. Engebretsen, Frederick Makumbi, et al. Timeliness of Childhood Vaccinations in Kampala Uganda: A Community-Based Cross-Sectional Study. PLoS ONE. 2012;7(4). www.plosone.org.