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Assessment of Factors Associated with Low Measles Vaccine Effectiveness in Honkolo-Wabe District, Ethiopia

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Abstract: *Background*:-Measles is an acute illness and the most contagious childhood diseases. Almost all non-immune children contract this respiratory disease if exposed to the virus. The disease characterized by prodarmal fever, conjunctivitis, coryza and presence of Koplik spots. Prior to the introduction of vaccination programs, measles affected almost every child in the world. The expected sero conversion was estimated to 80-85% when 0.5ml live attenuated measles vaccine correctly administered subcutaneously at 9 months and more than 95% after 12months. This study was aimed to describe vaccine effectiveness and assess factors contributing to low measles vaccine effectiveness in Honkolo-Wabe district, Ethiopia. *Methods*:-Community based unmatched case-control study, involving 51 children who had previous measles illness were randomly selected and 153 controls were selected from the community three for each case in July, 2014. Vaccination status and other risk factors for the study children were ascertained through by interviewing mothers /care giver and observing the cold chain management. Epi-info version 7 was used for data analysis. *Results*:-Measles vaccine effectiveness was estimated at 70.9% [95% CI=65-79%]. Age of measles vaccine given, poor health seeking behavior of the community, number of dose and inappropriate vaccine transportation from district health office to health post, administration of reconstituted vaccine after 6hrs by HEW were identified as the contributing factors for low measles vaccine effectiveness in Honkolo-Wabe district. Contacting with laboratory confirmed or epidemiological linked measles cases statically significant regard to measles [OR=23.77, 95% CI=9.17-64.25]. Of the study participants 19.6%, 44.6% and 3.9% were received one, two and three doses of measles vaccine respectively. About 3.9%, 45.1% and 12.3% of the participants were received first dose of measles vaccination before, at 9month and after nine month respectively. However 18.6% of the study participants were not received 2nd does. Only 35.3% of the participants were received their second doses after 12month their birth. *Conclusions*:-Measles vaccine effectiveness was low. Age of children, number of dose, inappropriate vaccine transportation and utilization of reconstituted vaccine after 6hrs were contributing factors for low measles vaccine effectiveness. Regular monitoring and ensure of all birth cohort have received at least 2 doses of measles vaccine at 9month of their birth and above. Improve cold chain management at health post and use reconstituted vaccine within 6 hours.

Keywords: Measles Virus, Vaccine, Ethiopia

1. Introduction

1.1. Background

Measles is contagious disease caused by genus Morbillivirus, a member of the Paramyxoviridae family. It is single-stranded, of negative polarity, antigenically stable and only one serotype exists. The incubation period is approximately 10-12 days from exposure to onset of fever and other nonspecific symptoms and 14 days (with range of 7–18 days) from exposure to onset of rash. The disease characterized by prodarmal fever, conjunctivitis, coryza and presence of Koplik spots. A characteristic maculopapular rash appears on the third to seventh day beginning on the face and

become more generalized. Measles transmitted from four days before and after rash onset. Infectivity is greatest three days before rash onset [1-5]. When measles virus is introduced into a non-immune population, 90–100% of individuals commonly become infected and practically all develop clinical illness. In areas with tropical climates, most cases of measles occur during the dry season, whereas in areas with temperate climates the incidence peaks during late winter and early spring [6, 7, 16].

1.2. Statement of the Problem

Prior to the introduction of vaccination programs, measles affected almost every child in the world. In densely populated areas, measles most commonly affected children aged 3-4 years old. In less crowded urban and rural areas, the highest incidence was among children aged 5-10 years who contracted the disease on entering school [7, 8, 13]. High-risk groups for measles complications include infants and persons suffering from chronic diseases and impaired immunity, or from severe malnutrition, including vitamin A deficiency. The high infectivity of measles virus means that a small percentage of susceptible individuals are sufficient to maintain viral circulation in populations of a few hundred thousand [6, 32].

Between 2000 and 2008, global mortality due to measles was reduced by 78% from an estimated 733, 000 deaths in 2000 to164 000 in 2008. All WHO regions, with the exception of the South-East Asia Region, have achieved the 2010 global goal of reducing measles mortality by 90% compared to estimated levels in 2000 [5, 15, 20, 26]. The expected sero conversion was estimated to 80-85% when 0.5ml live attenuated measles vaccine correctly administered subcutaneously at 9 months and more than 95% after 12months. However, most measles cases were identified during measles outbreak among those children vaccinated and whose ages were 1-4 years [1, 2, 13, 18].

In Oromia region measles outbreak was repeatedly occurred in different zones with the annual cases ranging from 3,700-12,300 among under five populations in the last five years. In 2010/11 a total of 10 zones were affected with measles outbreak and 7,221measles cases were reported from 58 districts. In 2012, seven zones (Arsi, Bale, East and West Shewa, West Wollega, Jimma, and Kellem Wellaga) were affected by measles outbreak. A total of 8,928 measles cases were reported to Oromia Regional Health Bureau from 22 districts. The outbreak was primarily affected under five age population segment. Low-vaccination coverage and non-functional cold storage likely triggered to the outbreak [2012 ORHB unpublished annual report]**.** Of 149 new measles cases were reported from six regions and Addis Ababa during the week ending 16 December 2012; 70% of them were from Oromia Region (i.e. Arsi, Bale, East Hararghe and East Shewa) zones [12, 14].

Arsi zone`s cold chain management system was good. However; the vaccine was transported from district to health posts with vaccine carrier during vaccination which might affected its potency if not appropriately handled or the reconstituted vaccine should be given for the child with 6hrs at 2-8°C, which is not applicable at most health posts during immunization. These all factors may affect the effectiveness of the measles vaccine even though correctly administered after 9 months.

Even though routine measles vaccination coverage of the Honkolo-Wabe district was above 95% in the last three consecutive years; there was a frequent measles cases were reported from different kebeles of the district and a confirmed measles outbreak in 2012. The others factors that affecting the seroconverstion was the presence of maternal antibody during vaccination which may neutralized virus antigen and later worn out after 12 months. It is difficult to detect the presence of IgG antibody during vaccination, but by comparing the correct age of the children at which he/she given the measles vaccine is help full weather the maternal IgG antibody present or not to estimate vaccination failures in the district [30, 33]. Therefore; this study would identify factors associated with low measles vaccine effectiveness in the Honkolo-Wabe district.

1.3. Literature Review

1.3.1. Routine Immunization

Measles vaccination is one of the most effective interventions available. Since measles vaccine was developed in 1958, it has saved the lives of millions of children throughout the world. Measles vaccine is made from a live attenuated virus. The peak antibody response occurs 6 to 8 weeks after infection or vaccination. The effect of measles immunization is generally felt to be long-lasting and most probably lifelong [4, 11]. The National immunization programme in Ethiopia was established in the 1980s, and currently delivers service through static and outreach sites nationwide. The current routine immunization schedule recommends measles vaccination at 9 months of age [21, 22, 23].

1.3.2. Second Opportunity for Vaccination

A second opportunity for vaccination is giving the chance for immunization of measles for the second time to children who may not have got the vaccine or failed to develop protection. Those who are not immune to measles could be identified only by testing measles specific IgG antibody levels; however since tests to detect antibody levels are much more expensive than measles vaccine and measles vaccine is a very safe vaccine, immunization activities to provide second opportunity should be given to all people in the targeted age group. Accordingly, even in regions where routine immunization coverage is high; some children from each birth cohort remain susceptible to measles. When large numbers of susceptible children accumulate over time, periodic outbreaks may occur in well vaccinated woredas [24, 25, 29, 30]. The second opportunity for measles immunization is required to protect those children who have never been vaccinated and those who were vaccinated but did not develop the immunity [31]. The second opportunity can be provided through supplementary immunization activities (SIAs) or through routine immunization [27].

Vaccination coverage of at least 95% for the first dose and 80% for the second opportunity has been listed as one of five indicators of progress towards regional elimination of measles. In addition, the second opportunity for measles

immunization plays an important role in increasing the proportion of the population with lifelong protection against measles, as boosting through natural infection gradually disappears [1, 7, 28].

1.3.3. Vaccine Storage

Measles vaccine, like measles virus, is very stable when stored between –70°C and –20°C. According to WHO requirements, exposure of lyophilized measles vaccine to a temperature of 37°C for at least one week should not reduce the geometric mean virus titre by more than 1 log. The minimum quantity of vaccine virus per human dose is considered to be 1000 viral infective units. Reconstituted measles vaccine loses about 50% of its potency after one hour at 20°C and almost all potency after one hour at 37°C [2, 4]. The vaccine is also very sensitive to sunlight, hence the need to keep it in colored glass vials; following reconstitution, the vaccine must be stored in the dark at 2–8°C and used within 6 hours. Each dose of 0.5 ml contains at least 1000 infective units of the vaccine virus; this is also true when it is combined with mumps and/or rubella vaccines [1, 2, 7, 10].

1.4. Purpose of the Study

Honkolo-Wabe is one of the districts of Arsi Zone with high measles vaccine coverage (i.e. above 95%) in the last five consecutive years. However, the measles cases were reported repeatedly and measles outbreak was occurred in Nov. 2012. During this outbreak most cases were identified among measles vaccinated children in the district. Therefore, the findings of this study help to know major factors associated with low measles vaccine effectiveness in district. The Regional Health Bureau and Arsi zone health department will use this finding for others districts with the similar problems. This finding will also help Federal Ministry of Health (FMOH) to be focused on identified factors to be improved measles vaccine effectiveness in Ethiopia.

2. Objectives

2.1. General Objective

To assess factors associated with low measles vaccine effectiveness in Honkolo-Wabe district in Arsi Zone, Ethiopia.

2.2. Specific Objectives

1) To describe measles vaccine effectiveness in the district
2) To identify factors that associated with the low measles vaccine effectiveness.
3) To assess number of measles vaccine dose given to individual in the district.
4) To describe the age at which measles vaccine given for children in the district.
5) To assess educational level of parents (father, mothers/care giver) of children.

3. Methods and Materials

3.1. Study Area

The study was conducted from June 28 to July12, 2014 in Honkolo-Wabe district of Arsi Zone, Oromia Region, which is located about 255 km away to east of Addis Ababa, the capital of Ethiopia. The 2014 projected population of Honkolo-Wabe district is estimated to be 67,858 (33,945 males and 33,913 females). The proportion of less than five years age population is 10,179 (15%). The district agro-climatically divided in to Dega (91%) and Woinadega (9%). The altitude is greater than 3,500 meters above sea level. The district share boundaries with Lemu-Bilibilo in West and South, Shirka in North and Bale zone in East. The primary health service coverage of district was 72% in 2014. The health delivery system is given to the community by using 5 health centers, 9 health posts and 5 private health units. In the last two years routine measles immunization coverage of district was above 95% (i.e. 96.4% in 2012 and 98.6% in 2013).

3.2. Study Design

Unmatched community based case-control study was conducted on children 6-59 months of age in Honkolo-Wabe district.

3.3. Study Period

The study will be conducted from June 28 to July12, 2014 in Honkolo-Wabe district.

3.4. Source and Study Population

Target population of the study was all children 6-59 months in the district and study population were children 6-59 months with known measles vaccination status. We used cases based on the line lists of the last measles outbreak in the district of children with age of 6-59months then controls were randomly selected from the community.

3.5. Sample Size Calculation

Sample size calculation assumption was based on 95% CI, 80% power, proportion of control exposed 30%, proportion of cases exposed 50% and the number of control to cases ratio of 3:1. However, a total of 204 (51 cases and 153 unmatched community controls) were included in the study.

3.6. Study Variables

3.6.1. Dependent Variable

Children 6-59months of age that has been vaccinated for measles at least one times and developed measles disease so far or during data collection period and living in Honkolo-Wabe district for the last one year.

3.6.2. Independent Variables

1) Socio-economic variable
2) Socio-cultural variables
3) Educational level of the mother/caregiver

4) Number of measles doses
5) Age of child at which measles vaccine given
6) Type of health facility (HC / HPs) where measles vaccination given for the child
7) Cold chain management system

3.7. Inclusion and Exclusion Criteria

3.7.1. Inclusion

Children whose age 6-59 months with known measles vaccination status developed measles disease or not so far or during data collection and living for at least one year in Honkolo-Wabe district.

3.7.2. Exclusion

Children whose mothers/care givers cannot able to communicate or response correctly and not know the vaccination status of child were excluded from the study participants.

3.8. Data Collection and Data Collection Tools

We requited four data collectors who are able to communicate in Afan Oromo and who had been experienced on EPI from district. We trained them prior to data collection for one day on data collection tools and conduct pilot for effective and quality data collection before the actual data collection. The training was cover study objectives, a review of the questionnaire, on the importance of the quality of data and direction as to how to administer the structured questionnaire and ethics during work. Data were collected using a pre-tested structured questionnaire from mothers or caregivers who was avail in the house during data collection period using interview. The cold chain management system records of the last five years were checked at district health office and health facility levels during data collection period.

We used piloted questionnaire for parents (i.e. father, mothers/caregiver) and collected relevant information about child. Observation was also conducted at health facilities on the cold chain management system. We used questionnaire for health professionals on the general immunization program in the district. The questionnaire used in this study was developed for this study by our team.

3.9. Operational Definitions

Immunized:-Any child who receive measles vaccine and protected from measles disease.

Vaccinated:-Child received 0.5ml live attenuated measles vaccine by subcutaneous at 9moths of age and above.

Vaccine effectiveness: The percentage reduction in disease that occurs in vaccinated.

Suspected case:-Any person with fever and maculopapular (non vesicular) generalized rash and cough, coryza or conjunctivitis (red eyes) or any person in whom a clinician suspects measles.

Laboratory confirmed:-Suspected case of measles with positive serum IgM antibody, with no history of measles vaccination in the preceding 4 weeks.

Confirmed by epidemiologic linkage:-Suspected cases of measles who not investigated serologically but has possibility of contact with a laboratory confirmed case whose rash onset was within the preceding 30 days.

Fever:-Any child with history of fever >38.5°C rectal or >38.0°C axillary temperature.

3.10. Data Quality, Data Processing and Analysis

All data was checked at the end of the day for its completeness by princpal investegator, regular supportive suppervision was conducted, on site oreintion was given for data collectors accordingly and final cross- checking was done before data coded, entery and analysis.

Data was entered and analyzed by using Epi-Info version 7 and Microsoft Excel. Both bi variate and multivariate analysis was done. Descriptive statistics was calculated and logistic regression was applied to identify independent factors and to declare statically significance.

4. Results

4.1. Socio-demographic Characteristics of Measles Cases

A total of 51 (25%) cases and 153 (75%) controls were randomly selected from the community to assess factors associated with low measles vaccine effectiveness in Honkolo-Wabe district. Of the total study participants 53.4% are male and 46.6% are female. The majority of the study participants were Orthodox 66.7% in religious followed by Muslim and protestant 25% and 8.3% respectively.

The mean age of cases and controls were 4.3 and 3.9 years respectively; whereas the median age of the participants were 4 years. More than fifty two percent of the participants were from Lemu-Kera Kebele followed by Lemu-Leman and Siltan-01 27.5% and 15.7% respectively.

The educational levels of mothers and fathers those joining formal schooling were 52.9% and 68.6% respectively. Of these total participants about 58.8% for cases and 43.1% for controls mothers were illiterate. Majority of the mothers of the participants were housewife 91.2%. More than 95% of the mothers' marital status were married and followed by single 4.4%.

About 37.3% of the study participants had a contact history with laboratory confirmed or epidemiological linked case (i.e. 44 (86.3%) of the cases and 32 (20.9%) controls) where as 128 (62.7%) of the participants were without contact history (i.e. 7 (51%) and 121 (79.1%) cases and controls respectively.

Of the total study participants 51.5% had history of moderate malnutrition during the occurrence of the measles outbreak in the district. Accordingly 49% of the cases and 52.3% of the controls were registered for malnutrition. All measles cases had a history of rash and fever, 90.2% had conjunctivitis, 92.2% had cough, 66.7% vomiting and 76.6% had running of nose. About 28 (54.9%) of the cases were developed complication due to pneumonia followed by diarrhea. See table 1 for socio-demographic characteristics of the study participants.

Table 1. *Socio-demographic characteristics of the cases and controls selected to assess factors associated with low measles vaccine effectiveness in Honkolo-Wabe district, Ethiopia July, 2014.*

Characteristics	Case № (%)	Control № (%)	Total № (%)
Sex			
Male	30 (58.8)	79 (51.6)	109 (53.4)
Female	21 (41.2)	74 (48.4)	95 (46.6)
Age group in months			
0-12	0 (0)	4 (2.6)	4 (2.0)
13-24	1 (2)	14 (9.2)	15 (7.4)
25-36	7 (13.7)	34 (22.2)	41 (20.1)
37-48	18 (35.7)	39 (25.5)	57 (27.9)
49-59	25 (49.0)	65 (40.5)	87 (42.6)
Resident (Kebele)			
Lemu -Kara	27 (52.9)	81 (52.9)	105 (52.9)
Lemu-Leman	14 (27.5)	42 (27.5)	56 (27.5)
Siltena Chegicha	2 (3.9)	6 (3.9)	8 (3.9)
Siltena 01	8 (15.7)	24 (15.7)	32 (15.7)
Religious			
Orthodox	39 (76.5)	97 (63.4)	136 (66.7)
Muslim	8 (15.7)	43 (28.1)	51 (25)
Protestant	4 (7.8)	13 (8.5)	17 (8.3)
Mother`s educational status			
Schooling	21 (41.2)	87 (56.9)	108 (52.9)
Not schooling	30 (58.8)	66 (43.1)	96 (47.1)
Mother's occupation			
Housewife	46 (90.2)	140 (91.5)	186 (91.2)
Others	5 (9.8)	13 (8.5)	18 (8.8)
Mather`s marrital status			
Married	49 (96.1)	146 (95.4)	195 (95.6)
Single	2 (3.9)	7 (4.6)	9 (4.4)
Contact history			
Yes	44 (86.3)	32 (20.9)	76 (37.3)
No	7 (13.7)	121 (79.1)	128 (62.7)
Malnutrition			
Yes	25 (49)	80 (52.3)	105 (51.5)
No	26 (51)	73 (47.7)	99 (49.5)
Total	51 (100)	153 (100)	204 (100)

Table 2. *Distribution of measles vaccination status of cases and controls study to assess factors associated with low measles vaccine effectiveness in Honkolo-Wabe district, Ethiopia, July, 2014.*

Characteristics	Case № (%)	Control № (%)	Total № (%)
Vaccination status (verbal)			
Vaccinated	28 (54.9)	111 (72.5)	139 (68.2)
Unvaccinated	6 (11.8)	23 (15.1)	29 (14.2)
Unknown	17 (33.3)	19 (12.4)	36 (17.6)
Measles vaccine dose (verbal)			
One	6 (11.8)	34 (22.2)	40 (19.6)
Two	21 (41.2)	70 (45.8)	91 (44.6)
Three and more	1 (1.9)	7 (4.6)	8 (3.9)
Unvaccinated	6 (11.8)	23 (15.0)	29 (14.2)
Unknown	17 (33.3)	19 (12.4)	36 (17.6)
Age of 1st dose measles			
Before 9 months	5 (9.8)	3 (1.9)	8 (3.9)
At 9 months	14 (27.5)	78 (50.9)	92 (45.1)
After 9 months	9 (17.6)	16 (10.5)	25 (12.3)
Unvaccinated	6 (11.8)	23 (15.0)	29 (14.2)
Unknown	17 (33.3)	19 (12.4)	36 (17.6)
Age of 2nd dose measles			
Not take 2nd dose	4 (7.8)	34 (22.2)	38 (18.6)
9 months	1 (1.9)	6 (3.9)	7 (3.4)
12-24 months	1 (1.9)	67 (43.8)	68 (33.3)
>24 months	0 (0.0)	4 (2.6)	4 (2.0)
Unknown	17 (33.3)	19 (12.4)	36 (17.6)
Unvaccinated	6 (11.8)	23 (15.0)	29 (14.2)
Total	51 (100)	153 (100)	204 (100)

4.2. Risk Factors

Of the total study participants 139 (68.2%) had history of measles vaccination (28 cases and 111 controls), 29 (14.2%) not vaccinated and 36 (17.6%) with unknown status. About 9.8% of cases and 1.9% controls had first dose of measles vaccine before nine months of age, 27.5% cases and 50.9% of controls were vaccinated at nine months of age where as 17.6% cases and 10.5% of controls vaccinated after nine months of age. Only 1.9% and 3.9% cases and controls were vaccinated second dose of measles at nine months respectively. Majority of the participants were vaccinated 2nd dose within 12-24 months of age. About 38 (18.6%) (4 cases and 34 controls) had no history for second measles vaccine (see table 2).

There was significant difference between those who had and did not had any contact history with laboratory confirmed or epidemiological linked measles cases with regard to the of measles [OR=23.77, 95% CI=9.17-64.25]. There was no significantly difference among vaccinated and none vaccinated children with regard to the measles (OR=0.97, 95% CI=0.33- 2.94] and also there was no significantly difference among those who had one dose and more doses of measles vaccine children with regard to the measles (OR=1.62, 95% CI=0.56-4.93]. There was no significantly difference among those had 2nd dose of measles vaccine before and after nine months children with regard to the measles (OR=1.01, 95% CI=0.36-2.95].

Table 3. *Identified risk factors for low measles vaccine effectiveness, in Honkolo-Wabe district, Ethiopia, July, 2014.*

Risk factors		Cases	Controls	Total	OR, (95% CI)
Measles Vaccination	Yes	28	111	139	OR=0.97 (0.33-2.94)
	No	6	23	29	
Two and more dose	Yes	22	77	99	OR=1.62 (0.56-4.93)
	No	6	34	40	
1st dose given at 9months +	Yes	23	94	117	OR=0.83 (0.25-2.89)
	No	5	17	22	
2nd dose given after 9 months	Yes	21	83	104	OR=1.01 (0.36-2.95)
	No	7	28	35	
No formal schooling of mother	Yes	30	87	117	OR=1.08 (0.54-2.17)
	No	21	66	87	
Malnutrition	Yes	25	80	105	OR=0.88 (0.44-1.73)
	No	26	73	99	
Contact history with known measles cases	Yes	44	32	76	OR=23.77 (9.17-64.25) P<0.001
	No	7	121	128	
Vaccine by HEW	Yes	21	92	113	OR=0.62 (0.21-1.87)
	No	7	19	26	
Vaccination at HC	Yes	7	19	26	OR=1.52 (0.51-4.47)
	No	21	92	113	
Total vaccinated		28 (100)	111 (100)	139 (100)	

Mother's education status was also assessed as a risk factor for low measles vaccine effectiveness among the cases and controls during this study. There was no significant difference among children's whose mother had and did not had formal schooling with regard to the measles [OR=1.08, 95% CI=0.54-2.17]. In this study more cases and controls had history of malnutrition, however there was no significant difference between those who had and did not had history of malnutrition with regard to the measles [OR=0.88, 95% CI=0.44-1.73]. Majority of the study participants were vaccinated by health extension worker (HEW) and there was no significant difference between those vaccinated and not vaccinated by HEW with regard to measles [OR=0.62, 95% CI=0.21-1.87]. During this study we place of measles vaccine administered was assessed and most children were not vaccinated at health centers, however there was no significance difference between those vaccinated and not vaccinated at health center with regard to the measles [OR=1.52,95% CI=0.51-4.47] see table 3.

4.3. Cold Chain Management

The cold chain management system of zonal health department and district health offices for drug and vaccine storage was well monitored. Even though there was only one trained person on cold chain management system at zone and district levels, temperature monitoring chart for cold chain was done on a regular manner for the last two years. There was a problem during vaccine transportation from DHO to the health posts due in accessibility some health post the HEW sent none health professionals not well oriented on cold chain management system. At health posts reconstituted vaccine was used after 6 hours by health extension workers due to the distance of some remote kebeles (up to 20 kilometers from the cold chain center) and infrastructure/transport problem in this pocket area.

4.4. Measles Vaccination Converge in the District

According to the district health office report, the measles vaccine coverage was 92.6%, 93.8%, 89.4%, 96.9% and 95.6% in 2009, 2010, 2011 2012 and 2013 respectively. Even though average measles vaccination coverage of the last five years for the under five population in the district was 93.7% and it was reported that few households living in the district was not willing to take vaccine due to poor

health seeking behavior and cultural influence towards modern medicine.

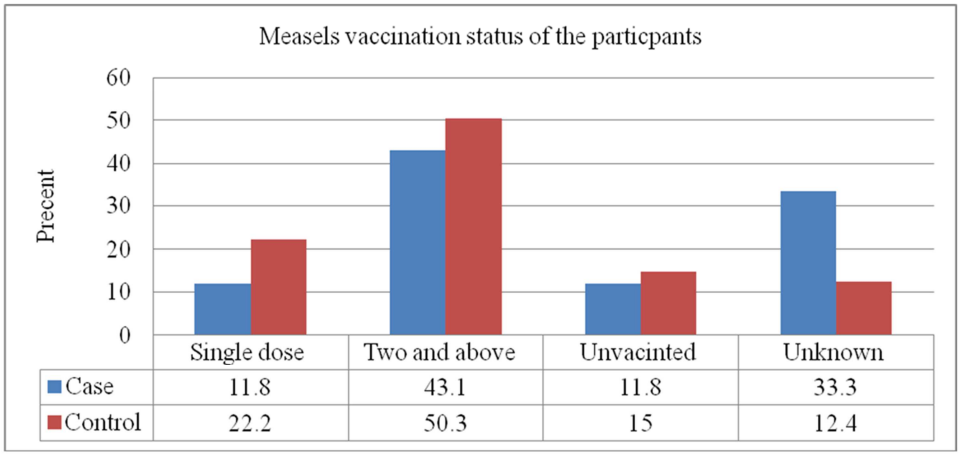

Figure 1. *Vaccination status of study participants in Honkolo-Wabe District, Ethiopia, July, 2014.*

From the total measles cases, 43.1% had two and more doses of measles vaccine, 11.8% had single dose of measles vaccine and 33.3% with unknown status. Of the total control group 50.3% of them were vaccinated two and more times against measles, 22.2% received only one dose and 12.4% controls were unknown (Figure 1).

4.5. Vaccine Effectiveness

Measles vaccine effectiveness was calculated from the proportion of the cases occurring in vaccinated individual (PCV) and the proportion of the population that is vaccinated (PPV) are known. In this study proportion of the population that was vaccinated (PPV) in the district in the last five year for under five population were 0.94 whereas proportion of the measles cases occurring in vaccinated individuals (PCV) was 0.82 and the measles vaccine effectiveness (VE) was estimated to 70.9%.

$$\text{Vaccine effectiveness (VE)} = \frac{\text{PPV}-\text{PCV}}{\text{PPV}\,(1-\text{PCV})} \times 100$$

$$= \frac{0.94-0.82}{0.94\,(1-0.82)} \times 100$$

$$= 70.9\%$$

5. Discussion

Outbreaks occur when the accumulated number of susceptible individuals is greater than the epidemic threshold, for a given population to sustain transmission. An outbreak of measles occurs when the number of cases observed is greater than the number normally expected in the same geographic area for a given period [1, 12]. In this study it confirmed that measles outbreak was occurred in the district due to accumulation of susceptible individual over the years. This study was conducted followed the outbreak by randomly selected cases from the line list of the last outbreak cases then randomly select unmatched community control to describe the vaccine effectiveness and contributing factors for low effectiveness.

Measles vaccination is one of the most cost-effective interventions available. Since measles vaccine was developed in 1958, it has saved the lives of millions of children throughout the world and measles incidence has declined dramatically. Measles vaccine is made from live attenuated virus. When children are correctly administered 0.5 ml of potent live attenuated measles vaccine subcutaneously serologic studies have demonstrated that measles vaccines induce seroconverion of 85% at 9 months and above 95% after 12 months of age [2, 3, 5]. However, the finding of this study show that 45.1% of the participants received first dose of vaccine at their nine months of age, 12.3% after 12months and only 3.9% were vaccinated before nine month. This was support the national routine measles EPI program. However, there was no significant difference between those vaccinated and not vaccinated groups at age of after nine months in respected to measles [OR=0.83, 95% CI=0.25-2.89].

There were no different between sex to be cases and having a less educated mother a risk for measles since mothers are responsible for vaccinating their child. There was no significant different between children who have schooled and none schooled mother with respect to measles [OR=1.08, 95% CI=0.54-2.17].

The overall vaccine effectiveness our study finding was estimated to 70.9% which was low as compared to 95% of the national target at 1year and later age and 80% in case-control study conducted in three hospitals in Dhaka [6], 85% of meta analysis finding of three randomized control trials and two quasi experimental studies [7] and high as compared to study finding conducted in Primary school, Cario, Egypt 53% [8]. This might be due low sample size used in our study.

Measles is a contagious disease and more common in children who had contact history with laboratory confirmed cases or epidemiological linked. This could reflect an increased risk of exposure to measles, increased severity of measles or both [19]. The findings of this study show that more cases were identified among those who had contact

with confirmed cases. The association between contact history with of confirmed cases of under five children in the household and measles cases was statically significant [OR=23.77; 95% CI=9.17-64.25].

To prevent measles outbreaks or interrupt transmission and hence eliminate measles, 95% population immunity is needed [1, 9]. The findings of this study show that the overall average of the five years (2009 -2013) measles vaccine coverage of the district was 93.7% which were not enough to develop herd immunity in the community and prevent an outbreak. In this study (14.2%) of measles case was unvaccinated against measles and (17.6%) was with unknown vaccination status. However, there was no significantly difference among vaccinated and none vaccinated children with regard to the measles (OR=0.97, 95% CI=0.33- 2.94]. This finding disagrees with the study done in Dhaka [6]. This might be due to low sample size in our study.

It had been suspected that malnutrition increased the morbidity and mortality of childhood measles as early as 1885 by Drinkwater, who investigated an epidemic in Sunderland, England, that had an unusually high case fatality rate of 10% [17]. In our study 51.5% of the participants had history of malnutrition during measles outbreak in the district but there was no statically significant among malnutrition children and not malnutrition with regard to the measles [OR=0.88, 95% CI=0.44-1.73]. This might be due to low sample size in our study.

Serologic studies have demonstrated that measles vaccines induce seroconverion of 85% at 9 months and above 95% after 12 months of age [2, 3, 5] if live attenuated virus correctly administered 0.5 ml subcutaneously. According to our study finding 81.3% of the children who received measles vaccine were vaccinated by HEW and the remaining administered by nurse. There was no significant difference between those vaccinated and not vaccinated by HEW with regard to measles [OR=0.62, 95% CI=0.21-1.87]. This is fact that, this vaccine is to be administered only by or under the supervision of health care professional. In Ethiopia measles vaccine administration is recommended by trained HEW at health post and by experienced health professional at others health facilities.

Routine vaccination program more effective as compared to vaccination conducted during campaign or outreach service due to different reasons such as technical experts and shortage of logistics [1]. In our study findings 81.3% of the vaccinated children were received measles vaccine during campaign or outreach service program. So there was no significant difference between those vaccinated and not vaccinated at health facilities with regard to measles [OR=1.52, 95% CI=0.51-4.47]. This might explained by; in Ethiopia the EPI guideline recommended that routine vaccination as well as outreach or campaign vaccination program is conducted by trained and experienced health professional.

Appropriate cold chain is necessary to maintain the efficacy of vaccines. Immunization may not produce protection if the vaccine stored in inappropriate cold chain. Prior to reconstitution, freeze dried measles vaccine is relatively stable and can be stored with safety for a year or more in a freezer or at a refrigerator temperatures 2-8°C [1]. Cold chain management was good and temperature monitor chart was used regularly at zone and district levels, but, there was a problem during vaccine transportation from DHO to the health posts. After reconstitution, the vaccine becomes very heat-sensitive, with rapid loss of potency so it must be used within 6 hours [1, 6, 7]. But, at health posts reconstituted vaccine was used after 6 hours by health extension workers due to the distance of some remote kebeles (up to 20 kilometers from the cold chain center) and infrastructure/transport problem in this pocket area.

There was also cultural influence not to take modern medicine, vaccine in some households and low health seeking behavior. They thought that modern treatment hides and aggravate the measles inside the body. So they prefer to keep the child out of sight inside dark room [34]. The findings of our study shows that few households living in the district was not willing to take vaccine due to poor health seeking behavior and cultural influence towards modern medicine.

6. Conclusions and Recommendations

1) The overall vaccine effectiveness of the Honkolo-Wabe District was estimated to 70.9% which was low as 95% recommended WHO when children received at 12 months and above. Ideally the measles vaccination coverage for the target groups were more than 95% in the recent two years but there was some children were missed in the last three years and increase susceptible individuals in the some pocket kebeles. These susceptible individuals increase the risk of measles outbreak in the district. Therefore, district vaccine effectiveness have to improved through regular monitoring of all birth cohort for it complete vaccination in each kebele by HEW.
2) Age of measles vaccine given, poor health seeking behavior of the community, number of dose and inappropriate vaccine transportation from district health office to health post, administration of reconstituted vaccine after 6hrs by HEW were identified as the contributing factors for low measles vaccine effectiveness in Honkolo-Wabe district. Therefore, the district health office ensure that all birth cohort children have to received measles vaccine at 9months and above, improving health seeking behavior of the community through awareness creation to ward modern treatment and the important of vaccine preventable disease in collaboration with traditional healers and religious leaders will be mandatory. Improving cold chain management of vaccine at health post level by providing kerosene refrigerator particularly for those health posts far from district health offices and must use the reconstitute vaccine within 6 hours.
3) Vaccination status of 17.6% of the study participants

was unknown and 19.6%, 44.6% and 3.9% of the study participated children were received one, two and three & more doses of measles vaccine respectively. Therefore district health office in collaboration with different stakeholders have to ensure all under five children received minimal two dose to improve measles vaccine effectiveness to 95%.

4) In general 3.9%, 45.1% and 12.3% of the participants were received first dose of measles vaccination before, at 9month and after nine month respectively. However 18.6% of the study participants were not received 2nd does where as 3.4% and 35.3% were received their second doses of measles vaccine at nine month and after 12month their birth respectively. Therefore district health office have to ensure all birth cohort children received 1st dose at 9month and the second dose after first dose with minimal interval of 28 days attain 95% WHO target of measles vaccine effectiveness.
5) Mothers/guardians are more responsible for their children to take care and to vaccinate based on the EPI schedule. Majority of the selected cases` mothers were no formal schooling. Therefore the HEW have to identify the educational level of the mothers and closely follow up those mothers with low educational level to adhering and follow the vaccination schedule to reducing number of unvaccinated children due to lack of knowledge/recalling date of appointment.

Abbreviations

AAU	Addis Ababa University
AFENET	African Field Epidemiology Network
CDC	Centers for Disease Control and Prevention
EFETP	Ethiopia Field Epidemiology Training Program
EPI	Expanded program of Immunization
DHO	District Health Office
FMOH	Federal Ministry of Health
HC	Health Center
HP	Health Post
IgG	Immune globulin –G antibody
ORHB	Oromia Regional Health Bureau
SIAs	Supplementary Immunization Activities
SPH	School of Public Health
WHO	World health organization
ZHD	Zonal Health Department

Declaration

Ethics Approval and Consent to Participate

Ethical clearance was obtained from Adama Hospital Medical College ethical committees. A formal letter was submitted to all the concerned bodies (Arsi zone health department and Honkolo-Wabe Health office) to obtain their co-operation. For the study subjects who were agreed to participate, written consent was secured from parents or guardians. Confidentiality and anonymity was maintained for the study participants. All the participants' right to self-determination and autonomy was respected. Confidentiality was assured and no personal details was recorded or produced on any documentation related to the study.

Consent to Publish

Not applicable.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

All the authors do not have any possible conflicts of interest.

Authors' Contributions

All the authors have equal contribution from proposal development to data collection and final write up.

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