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Measles Epidemiology in Ethiopia from 2006 - 2016: Predictors of High Measles Incidence from Surveillance Data Analysis

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ABSTRACT

Background: Ethiopia endorsed the African Regional measles elimination goal and has been implementing the recommended strategies. Measles immunization coverage has been increasing but is still below the target, and measles incidence has remained high.

Objective: To describe the measles epidemiology in Ethiopia, identify predictors of high measles incidence in Ethiopia and recommend strategies to achieve the elimination goal.

Methods: Measles surveillance 2006-2016 data, routine immunization and post measles campaign coverage data was analyzed. We analysed the epidemiology and incidence of measles cases by age, vaccination status, year of occurrence, and geographic area.

Result: There were 66,719 confirmed cases, out of the 94,104 suspected measles cases reported between January 2006 and December 2016. Measles incidence increased from 20 cases per million total population in 2006 to 194 cases per million in 2015 and declined to 49 per million in 2016. On multiple logistic regression analysis, the median age of measles cases, the 2013 measles Supplemental Immunisation Activity (SIAs) coverage, the 2012 routine immunization coverage, and the proportion of reported under-five measles cases were predictors of very high measles incidence (>240 cases per million in the under-five years age population) in the three-year period following the 2013 measles SIAs implementation ($p < 0.01$).

Conclusion: Ethiopia is not on track to achieve the measles elimination goal of less than 1 case per million population by 2020 with the current pace of elimination efforts. Accumulation of susceptible children due to suboptimal routine measles immunization combined with suboptimal and narrow age-group (9-59 months) measles SIAs resulted in continued measles outbreaks.

Recommendation: Ethiopia should scale up the quality and implementation of all the measles elimination strategies, including the introduction of measles second dose and conducting high quality measles SIAs targeting the appropriate age groups as per the measles epidemiology in various parts of the country to accelerate and achieve the 2020 measles elimination goal.

Introduction

Measles is one of the vaccine preventable diseases among the leading causes of under-five child mortality in Ethiopia¹. The Expanded Program on Immunisation (EPI) was started in Ethiopia in 1980 with six antigens including measles vaccine. The measles vaccination coverage has been increasing over the past years in Ethiopia. The national immunization coverage survey in 2012 revealed routine measles immunization coverage of 68.2% in

was done to determine the association between woreda measles incidence in under five-year old children (dependent variable) and the explanatory variables (routine immunization coverage survey result from 2012, post measles SIAs coverage result after the 2013 SIAs, median age of measles cases, population density, geographic area, and the proportion of confirmed under- five measles cases) to determine predictors of high measles incidence. P value of < .05 was considered statistically significant. Step wise logistic regression with backward elimination was performed to identify predictors of highest measles incidence (>240 cases per million under-five population, which corresponds to the 75th percentile of the distribution of measles incidence by woreda level). The significance level for including independent variables in the model was P<0.1 and p<0.05 for dropping from the model.

The following operational definitions were used.

Confirmed measles cases: suspected measles cases that were notified to the surveillance system and confirmed by IgM laboratory serological testing, or by epidemiological linkage or clinical compatibility.

Vaccinated measles cases: Measles cases who have received one or more measles vaccine doses were classified as “vaccinated cases” and those with zero doses and unknown status were classified as “not vaccinated”.

Measles incidence: Measles incidence was calculated by dividing the confirmed measles cases by population-year, and then multiplied by one million to compute measles incidence per million population for single or multiple year period. Source of total population was from CSA population projection.

Proportion of vaccinated measles cases: The number

of vaccinated cases as defined above divided by total measles cases.

Proportion of measles cases in the under five-year age group: the proportion of under five-year old measles cases out of the total confirmed measles cases.

Results

Epidemiological description of reported measles cases

There were 66,719 (70.9%) confirmed cases, out of the 94,104 suspected measles cases reported from January 2006 to December 2016. Measles incidence increased from 20 cases per million in 2006 to 194 cases per million population in 2015 and declined to 49 per million in 2016 following the wide-age group measles SIAs. The number of confirmed measles cases was highest in 2015 with 17,743 confirmed cases (Figure 1).

The proportion of confirmed measles cases aged less than 5 years was 42% and the median age of confirmed

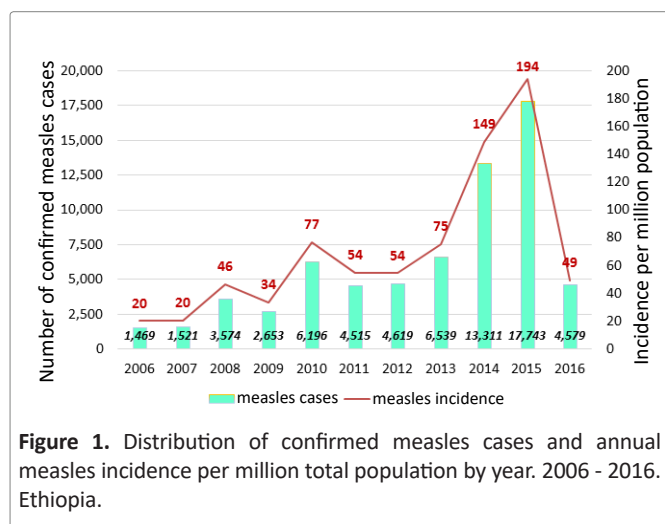


Figure 1. Distribution of confirmed measles cases and annual measles incidence per million total population by year. 2006 - 2016. Ethiopia.

Table 1. Distribution of measles cases by region, Ethiopia, 2006-2016.

Region	Suspected measles cases (2006 - 2016)	Confirmed measles cases**	Median age of confirmed measles cases (years)	# (%) of confirmed measles cases under 5 years age	measles incidence per million population
Addis Ababa	4,780	1,869	6	719 (40%)	70
Afar	1,124	819	3	433 (53%)	36
Amhara	14,324	10,212	9	2,820 (28%)	70
B/Gumuz	1,268	821	6	341 (42%)	139
Dire Dawa	238	115	6	48 (42%)	38
Gambella	846	770	2	492 (64%)	327
Hareri	647	196	3	112 (57%)	77
Oromia	41,191	31,802	4	14,528 (46%)	130
SNNPR	23,477	17,077	5	7,117 (42%)	132
Somali	1,639	1,366	5	541 (42%)	26
Tigray	2,927	1,672	14	495 (30%)	50
Grand Total	92,461	65,865	5	27,646 (42%)	102

** confirmed cases refers to cases confirmed by laboratory (IgM positive), epidemiological linkage or clinical compatible cases.

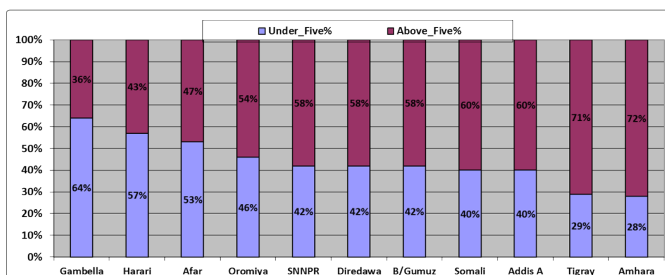


Figure 2. Proportion of under- five and above-five years old conformed measles cases by region for the 2006-2016 period, Ethiopia

measles cases was 6 years for the period 2006 - 2016. The median age of measles cases ranges from 3 years in Gambella to 15 years in Tigray Region (Table 1).

The proportion of under-five cases was high for developing regions such as Gambella (64%), and Afar (53.0%) (Figure 2). On the other-hand, Amhara and Tigray Regions have relatively low proportion of under-five cases (less than 30%). Within the same Region, the zonal proportion of under-five cases vary. In zones with median age lower than 9 years, there was a rapid buildup of under-five measles cases in the three years following the measles SIAs conducted in 2013 as depicted by high and increasing under-five year proportion (37%, 50% and 54% respectively for the three consecutive years post campaign). Conversely, zones with median age 9 years or older had stable proportion of under-five cases (24%, 21% and 22%) for the three years following the 2013 measles SIAs (Figure 3). The proportion of confirmed measles cases who had received at least one dose of measles vaccine was 26% and 31% for all age groups and under-five old children respectively for the 2006 - 2016 period.

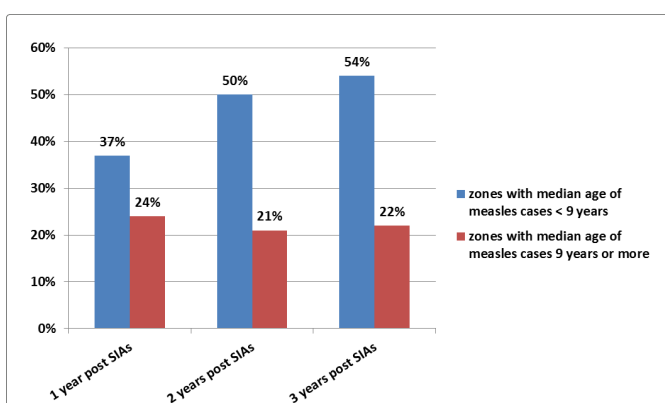


Figure 3. Proportion of under-five measles cases in the years following 2013 measles SIAs in Zones with median age below 9 years and those 9 years and above.

Factors accounting for high number of measles cases following measles SIAs 2013

Regions with more than 80% measles routine immunization coverage as per the result of the 2012 survey had an average measles incidence in 2012 of 91 cases per million as compared to Regions with less than 80% survey coverage (198 per million population). Woredas located in regions with more than 80% measles routine immunization survey coverage had significantly lower incidence of measles in children under-five (less than 240 cases per million population) in the three years (July 2013-June 2016) period following the 2013 measles SIAs. The proportion of woredas located in Regions with routine measles coverage above 80% that had lower measles incidence was higher than those woredas in Regions with less than 80% measles coverage (86% vs 71%, $p=X^2 = 3.96$, $P=0.047$).

There was lower measles incidence in under five years old children in zones with post measles SIAs coverage of 95% and above compared to those zones with less than 95%, in the three years following the 2013 measles SIAs (Figure 4). A large proportion of woredas located in zones with post measles SIAs immunization coverage of 95% and above had lower incidence of measles in the under-five population (less than 240 cases per million population) compared to those woredas located in zones with less than 95% coverage (82.9% vs 71.0%, $X^2, 12.79$, $p<0.001$) in the three years period following measles SIAs 2013.

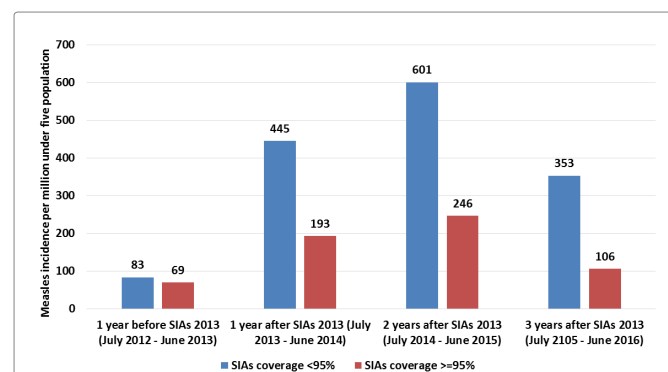


Figure 4. Measles incidence per million under-five population, in the years after the 2013 measles SIAs in zones with different post-measles SIAs survey coverage levels (<95% vs >=95%).

The proportion of measles cases in the age group under-five was significantly associated with measles incidence. The proportion of woredas with highest incidence of measles in the under-five year old population (Incidence >240 per million) was 10.6%, 21.3%, 31.6% and 39.7% for woredas with proportion of under five cases <=24%,

Table 2. Explanatory variables associated with high/low measles incidence on univariate analysis.

Variable	Categories	Total Woredas	Measles Incidence in under-5 year age within 3 years following the 2013 measles SIAs (Incidence per million population)		X ² , p values
			<=240 per million	>240 per million	
Median age of measles cases	< 4 years	177	111(62.7%)	66(37.3%)	X ² =44.9, P<0.0001
	4.0-6.0 years	198	131(66.2%)	67(33.8%)	
	6.1-10.0 years	168	138(82.1%)	30(17.9%)	
	> 10 years	195	172(88.2%)	23(11.8%)	
Proportion of under- five measles cases among all confirmed cases	<=24%	188	168(89.4%)	20(10.6%)	X ² =45.3, P<0.0001
	>24-<36%	169	133(78.7%)	36(21.3%)	
	36-50%	193	132(68.4%)	61(31.6%)	
	>50%	174	105(60.3%)	69(39.7%)	
2012 Measles routine immunization coverage by survey (2012)	<=80%	687	509(74.1%)	178(25.9%)	X ² =3.96 ,p=0.047
	>80%	57	49(86.0%)	8(14.0%)	
2013 measles SIAs coverage by survey	<=95%	458	325(71.0%)	133(29.0%)	X ² =12.79, p=0.0001
	95-100%	263	218(82.9%)	45(17.1%)	
Area	Urban	12	9(75.0%)	3(25.0%)	X ² =0.2, p=0.735
	Agrarian	625	472(75.5%)	153(24.5%)	
	Pastoral	107	77(72.0%)	30(28.0%)	
Population density people per Km ²	<=30	280	179(63.9%)	101(36.1%)	X ² =31.59, p<0.0001
	31-60	144	115(79.9%)	29(20.1%)	
	61-90	147	116(78.9%)	31(21.1%)	
	91-400	173	148(85.5%)	25(14.5%)	

>24%-<36%, 36%-50% and >50% respectively (X² = 45.3, p<0.001). Similarly, the proportion of woredas with highest under-five year measles incidence (>240) was 37.3%, 33.8%, 17.9% and 11.8% for those woredas with median age of < 4 years, 4-6 years, >6-10 years and > 10 years respectively (X² = 44.9, p<0.001).

Predictors of high measles incidence

On univariate analysis, proportion of under-five year cases, median age of measles cases, routine and SIAs immunization coverage, population density were statistically associated with measles incidence (Table 2). The median age of measles cases, routine and SIAs immunization coverage were inversely correlated with measles incidence whereas proportion of under-five cases and population density was positively correlated with under-five year measles incidence.

On multiple logistic regression analysis, the median age of measles cases, the coverage result reported from the post measles SIAs coverage survey, the routine immunization coverage results from the survey in 2012, and the proportion of under-five cases were predictors of highest measles incidence (>240 cases per million under-five years age population) in the three-year period following the 2013 measles SIAs implementation (p<0.01) (Table 3). The predicting power of the model was 74%.

Discussion

Measles under-five mortality is estimated to have decreased from 716 per 100,000 in 1990 to 87 per 100,000 in 2013 in Ethiopia²³. However, according to the case based surveillance data, measles incidence in Ethiopia has been increasing in the last ten years. Partly, this could be due to improved reporting system and confirmation of suspected

Table 3. Predictors of highest measles incidence (>240 per million in under-five year children) using multiple logistic regression.

Under-five years measles incidence (cut off point 240 per million population)	B	Odds Ratio	Std. Err.	P	[95% confidence Interval]	
Measles RI coverage (2012 survey)	0.0197	1.019931	0.008153	0.014	1.004076	1.036037
Post-Measles SIAs survey coverage (2013)	0.0352	1.035861	0.01353	0.007	1.009679	1.062722
Median age of measles cases	0.0738	1.07659	0.039164	0.042	1.002502	1.156153
Proportion of measles cases aged under five years	-0.0165	0.983654	0.008186	0.048	0.96774	0.999831
Constant	-3.3299	0.035798	0.050202	0.018	0.002292	0.559183

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