Original article

National EPI coverage survey report in Ethiopia, 2006

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Abstract

Background: Routine EPI reports have shown an upward trend in immunization coverage in recent years in Ethiopia, however, regional disparities exist.

Objective: To determine regional coverage of child and TT immunization and assess reasons for not utilizing immunization services.

Methods: The revised 2005 WHO-EPI regional coverage cluster survey method was used to determine the sample size for the study. Regional immunization status of 12-23 months of children and mothers with 0-11 months of infants for child immunization and TT immunization respectively were taken as the unit of analysis. A sample of 6,903 children between 12-23 months and 6,952 mothers with infants between 0-11 months from 468 clusters in 11 regions of the country were surveyed in June 2006.

Results: The weighted national immunization coverage assessed by card plus history for children aged 12-23 months vaccinated before the age of one year was BCG 83.4%, DPT_1 84.3%, DPT_3 66.0%, measles 54.3%, and fully immunized children 49.9%. The weighted national TT_{2+} coverage and rate of Protection at Birth (PAB) assessed by card plus history was 75.6% and 63.0% respectively.

Conclusion: The survey showed a 10 percentage point of increment in DPT_3 coverage compared to 2001 survey coverage. However, progress was not uniform in all regions of the country. Despite the improvement in the access to immunization in the country, DPT3 coverage was less than 30% and dropout rate remained very high in three emerging regions. Effective behavioral change communication (BCC) strategies need to be designed and implemented to tackle high dropout rate in the program. Besides, health workers training program on interpersonal communication and Reaching Every District (RED) approach should be fully implemented to increase and sustain high level of immunization coverage in Ethiopia. [*Ethiop.J.Health Dev.* 2008;22(2):148-157]

Introduction

In the EPI program, which started in Ethiopia in 1980, routine immunization services have been provided to children under one year of age for the six vaccine preventable childhood diseases (tuberculosis, poliomyelitis, tetanus, diphtheria, pertussis and measles), and tetanus toxoid is given to women of childbearing age. The schedule for child and TT immunizations is in accordance with the WHO recommended schedule for developing countries (1-3).

Evidences show that Ethiopia has made notable progress in routine immunization coverage with an increase in DPT_3 coverage from 52% in 2003 to 69% in 2005 (4). There are, however, big disparities in regional DPT_3 coverage, which ranges from less than 10% in Somali region to over 80% in Tigray and SNNPR regions. Overall improvement in coverage has been mainly attributed to the Reaching Every District (RED) approach, which was started in 2004 (5-6). The RED approach was developed in 2002 by WHO, UNICEF, USAID and CDC to address common obstacles to increase immunization coverage (7), and Ethiopia was one of the first African countries selected for implementation. In Ethiopia RED was first introduced in 13 highly populated priority zones and then scaled up phase by phase to all zones. RED has five operational components: re-establishing of outreach, supportive supervision, monitoring for action, linking services with the community, and planning and management of services. In Ethiopia, the 13 RED zones reported a 47% increase in DPT3 coverage by administrative records in 2004 over 2003, while the increment was 29% for non RED zones (5).

In addition to coverage assessments by administrative records, serial community surveys have been conducted. In contrast to increasing coverage from administrative records, a consistent upward trend has not been noted in these community surveys. In the national EPI coverage survey in 2001 national DPT_3 coverage was 56% by card plus history (8). The Welfare Monitoring Survey in 2004 (WMS-2004) reported a national DPT_3 coverage of 50.3% (card plus history) for 12-23 months of children at the time of the survey (9). The Ethiopia Demographic and Health Survey (EDHS) in 2005 reported that by card plus history 29% of children aged 12-23 months had been vaccinated for DPT_3 before the age of one year (10). The EDHS 2005 reported coverage was much lower than the 2004 administrative coverage of 61% from regular reports (11). Neither the WMS-2004 nor the EDHS 2005 reports included important reasons for not immunizing. However, documented kebele factors in the national EPI coverage survey were important for assessing

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immunization operations including availability and accessibility of immunization sites, utilization of immunization services, and involvement of kebele administration in the EPI program. In addition, this survey was large enough to allow for calculation and comparison of coverage by region. Regional coverage figures, information about why immunization services are not used, and information about peripheral level service characteristics provide important inputs for program managers at national, regional and sub-regional levels and need to be addressed to further increase and sustain coverage.

In 2005 WHO revised the EPI Coverage survey manual and now recommends that sample size be calculated for a precision level of at least 0.05, instead of the precision level of 0.1 used in previous studies (12). The larger number of children sampled allows for calculation, monitoring and comparison of coverage by region. Therefore, because of the need to assess immunization coverage in each region with acceptable precision, the need to assess availability and accessibility of immunization services and the involvement of kebele administrators and health extension workers (HEWs) in EPI program, and the need to identify reasons for non-immunization, we carried out a national immunization coverage survey according to the revised WHO EPI coverage survey approach.

The objectives of the 2006 National EPI coverage survey were; to determine national and regional coverage of immunization for the six antigens in children aged 12-23 months, to determine TT immunization coverage and Protection at Birth (PAB) in mothers with 0-11 months of infants, to document reasons for target children and women not being immunized, and to record local (kebele) factors known to be important in immunization service delivery.

Methods

Children between 12-23 months and women having infants aged from 0-11 months were the target population for the survey of child and TT immunization respectively. The survey employed WHO-EPI regional cluster sampling, based on the latest WHO immunization Coverage Cluster Survey reference manual (12). The number of children (N) to be sampled in each region was determined using the following formula:

$$N = \frac{DE \times Z^2_{1-\alpha/2} \times p(1-p)}{d^2}$$

Where p is the expected DPT_3 coverage of the region

Design effect (DE) = 2

Precision (d) = 0.05

Confidence level (α=0.05, 95% $Z_{1-\alpha/2}$) = 1.96

The required sample size nationally was 6550. Many researchers commonly add 10% to the sample size to compensate for non-response (13). We added 1-2 children per cluster, depending on the cluster size in each region, to compensate for errors (inclusion of children with birth dates not eligible for the study) that might occur during data collection, which increased the sample size to 7334. The number of clusters per region was determined by taking into consideration the total number of children to be sampled and the homogeneity of immunization coverage in each region. The number of children per cluster in each region was calculated by dividing the total number of children by the number of clusters (Table 1). An equal number of mothers with infants aged between 0-11 months were included in the survey. In each region, woreda clusters were chosen with PPS sampling (Probability Proportional to Size). In each woreda cluster, kebeles were randomly selected using the lottery method. In each kebele, the first household was selected by randomly choosing a direction from a central location in the kebele, and then counting the households along that directional line to the edge of the kebele area and randomly selecting one. Subsequent households were selected by proximity.

Two day training sessions including field exercises were conducted to train supervisors and data collectors at sub-national levels and sub-regional levels. In addition to the standard WHO EPI data collection forms, kebele background information collection forms were used. Each survey team consisted of one supervisor and two data collectors. The supervisors were assigned to zones not in their routine area of work, in order to ensure the quality and reliability of the immunization data collected. The supervisor was responsible for checking completed forms at the end of each day, ensuring proper selection of the first household in each cluster according to the guidelines, and interviewing kebele administrators about the background information of the kebele.

Data collection was undertaken from June 1-30, 2006. Mothers or caretakers were asked to show immunization cards for child or TT immunization and the dates of immunization were copied into the infant and TT immunization forms respectively. If immunization cards were lost then the maternal report of immunizations was recorded. Presence of BCG scar was observed in surveyed infants. Reasons for not being immunized were also recorded. Kebele administrators were interviewed on availability of immunization services, walking distance to immunization sites and involvement of administrators and HEWs in immunization program planning and review meetings in their kebeles.

Table 1: **Planned and surveyed number of children 12-23 months old and mothers with infants 0-11 months old, and those with eligible birth dates among surveyed children and women by region, EPI coverage survey 2006, Ethiopia**

Regions	Planned number of clusters, children per cluster and sample size by region			Actually surveyed clusters, children 12-23 months, women with 0-11 months old infants, and those with eligible birthdates by region				
	No. of clusters	children per cluster	sample size	clusters	children 12-23 months	women with infants 0-11 months	eligible children	eligible women
Tigray	40	10	400	40	400	400	399	394
Afar	30	29	870	30	871	871	797	864
Amhara	70	10	700	70	700	697	682	695
Oromyia	76	10	760	76	760	760	754	749
Somali	31	12	372	31	356	337	279	220
B/Gumz	30	25	750	30	750	751	717	743
SNNPR	70	10	700	70	700	700	692	681
Addis A.	31	22	682	31	682	673	652	660
Gambella	30	25	750	30	709	711	628	665
Harari	30	15	450	30	450	450	440	428
Diredawa	30	30	900	30	878	876	863	853
Total	468		7334	468	7256	7226	6903	6952

Data were entered twice into EPI-Info version 6.04D. Coverage estimates for different antigens were calculated using SPSS 10 for each region and then weighted to estimate the national immunization coverage. Stepwise multiple logistic regression analysis with backward elimination was used to identify predictors of child immunization with DPT_3. For children whose information was based on mother's recall, the proportion of vaccinations given during the first year of life was assumed to be the same as that of children with a written vaccination record.

The following operational definitions were used.

Vaccinated by card only: Only doses documented on immunization card or kebele EPI registration book were considered.

Vaccinated by card plus history: Both documented doses and doses reported by mother to be received were considered.

Valid doses: Doses recorded in child or TT vaccination cards, administered with proper spacing according to the national schedule, and, in the case of child immunization, administered when the child had reached the minimum age for the vaccine.

Fully immunized child (FIC): A child who received 8 doses: a dose of BCG, 3 doses of DPT and polio, and one dose of measles vaccines.

Fully immunized child with valid doses before the age of one year: a child who received valid doses of all the 8 doses before the age of one year.

PAB by card: a child was considered protected at birth against tetanus by card if the mother had documented TT doses either on the mother card or kebele TT registration book and if the child was born within a time that the up-to-date TT status of the mother would confer immunity. (One dose of TT confers no immunity; TT_2, TT_3, TT_4 and TT_5 confer immunity for three years, five years, ten years and life long respectively).

PAB by history: a child was considered protected at birth against tetanus by maternal recall if the mother had received two doses of TT in her last pregnancy or if she had received at least three doses of TT any time in her life.

TT_{2+} coverage: the proportion of women who had received 2 or more doses of TT vaccine

Health Services Extension Workers (HEWs): the most peripheral health workers working at the community level to deliver basic preventive and promotive health care packages including immunization

Results

Of 468 surveyed cluster kebeles, 82.9% had static or outreach immunization sites (of which 91.7% were within 1 hour walking distance), 50% had HEWs (of which 64% provided immunization service), and 50% had kebele administration involvement in EPI planning and review at kebele level. Nationally 40.4% of the immunizations for DPT_1 were delivered from outreach sites followed by health posts (32.0%), health centers (23.1%), hospitals (3.7%) and private health facilities (0.7%). However, health centers were the major immunization delivery sites in Afar (43.5%), Gambella (47.7%) and Somali (36.1%).

As shown in Table 2, the socio-demographic characteristics of mothers surveyed for child and for TT immunization were similar: most mothers were not able to read or write (62%), most were married (95%) and most lived in rural areas (59%). The card retention rate was 60.5% and 50.5% for child and TT immunization cards respectively. The BCG, DPT_1, DPT_3, measles and FIC coverage before the age of one year by card plus history was 83.4%, 84.3%, 66.0%, 54.3% and 49.9% respectively (Table 3). The BCG scar rate was 80 % (82% among vaccinated by card versus 74% among vaccinated by history). At the time of survey, 70.6% of

12-23 months old children were vaccinated for DPT_3 by card plus history; however, only 41.1% were genuinely vaccinated by card only before the age of one year (Table 3). Of the DPT_1 injections, 90.7% were valid doses; however, only 78.8% of measles vaccine doses were valid according to the national EPI schedule.

Table 2: **Socio-demographic characteristics of mothers surveyed for child and TT immunization, EPI coverage survey 2006, Ethiopia**

Characteristics of surveyed mothers	Mothers surveyed for child immunization (n=6903)	Mothers surveyed for TT immunization (n=6952)
Educational status		
Not able to read and write	4260 (62.0%)	4346 (62.5%)
Read and write	302 (4.4%)	300 (4.3%)
Primary schooling	1530 (22.3%)	1540 (22.2%)
Secondary school+	784 (11.4%)	762 (11.0%)
Total	6876* (100%)	6948* (100%)
Residence		
Urban	2838 (41.6%)	2813 (41.0%)
Rural	3985 (58.4%)	4052 (59.0%)
Total	6823* (100%)	6865* (100%)
Marital status		
Married	6530 (94.9%)	6667 (95.9%)
Single	141 (2.0%)	142 (2.0%)
Divorced	114 (1.7%)	72 (1.0%)
Widowed	51 (0.7%)	29 (0.4%)
Separated	44 (0.6%)	39 (0.6%)
Total	6880* (100%)	6949* (100%)
Occupation		
Housewife	6163 (89.6%)	6319 (91.0%)
Daily labourer	223 (3.2%)	181 (2.6)
Governmem employee	204 (3.0%)	166 (2.4%)
Self employed	288 (4.2%)	278 (4.0%)
Total	6878* (100%)	6944* (100%)
Age		
15-24 years	2424 (35.3%)	2826 (40.8%)
25-34 years	3645 (53.1%)	3441 (49.6%)
35-44 years	764 (11.1%)	642 (9.3%)
>=45 years	34 (0.5%)	22 (0.3%)
	n-6867*	n=6931*
	Median age 26	Median age 25
	Mean age (26.6±5.6) years	Mean age (25.8±5.5) years
Parity		
1 child	1772 (26.3%)	1936 (28.4%)
2 children	1534 (22.8%)	1631 (24.0%)
3 children	1190 (17.7%)	1143 (16.8%)
>=4 children	2244 (33.3%)	2098 (30.8%)
	n=6740*	n=6808*
	Median parity 3	Median Parity 2
	Mean parity (3.0±2.0)	Mean parity (2.9±2.0)

* The difference in totals is due to missing values

On univariate analysis, DPT_3 vaccination coverage among children aged 12-23 months by the time of the survey (card plus history) was significantly higher in urban than rural areas (81.5% versus 60.8%, $p<0.001$), in kebeles where the kebele administration was involved in EPI planning and review than in kebeles where administrations was not involved (79.2% versus 60.9%, $p<0.001$), in kebeles with HEWs than those without (84.1% versus 59.3%, $p<0.001$), in kebeles with immunization sites than those without (73.2% versus 53.1%, $p<0.001$), and in kebeles where the immunization site was within 1 hour walking distance than those farther (74.2% versus 55.6%, $p<0.001$). Infants born from literate mothers had higher coverage than those with mothers unable to read and write (83.8% versus 60.5%, $p<0.001$) (Table 4). DPT3 coverage was significantly different by maternal occupation. Infants from mothers who were governmental employees had higher immunization coverage while infants of mothers who were housewives had lower coverage: housewife (66.4%), daily labourer (74.0%), self employed (80.6%), governmental employee (84.8%), $p<0.001$. Infants born from mothers with lower parity had higher coverage than those with mothers of high parity; parity 1 (77.4%), parity 2 (69.6%), parity 3 (66.1%), parity >=4 (61.6%),

Table 3: **Immunization Coverage rates among surveyed children aged 12-23 months by region (%), 2006 Ethiopia.**

Region	Coverage by the time of the survey (card + history)						Coverage by card + history before the age of 1 year						Validly vaccinated before the age of 1 year coverage on card only					
	BCG	DPT_1	DPT_3	OPV_3	Msl*	FIC	BCG	DPT_1	DPT_3	OPV_3	Msl*	FIC	BCG	DPT_1	DPT_3	OPV_3	Msl*	FIC
Tigray	98.5	98.7	93.7	94.0	86.0	84.7	98.2	98.7	91.2	91.4	79.3	76.5	88.2	80.2	72.4	70.9	46.9	38.8
Afar	44.0	49.2	31.4	31.6	33.4	26.1	39.7	44.0	25.7	25.9	27.5	18.4	9.3	10.0	5.6	5.3	3.9	2.5
Amhara	86.5	87.7	72.7	72.4	63.8	60.7	84.0	85.7	68.2	68.4	56.0	51.4	48.8	43.8	35.6	33.7	23.5	16.3
Oromyia	85.7	86.6	63.5	63.4	54.0	49.9	83.6	84.4	58.0	58.1	41.7	38.2	58.0	55.7	36.7	35.5	22.0	15.5
Somali	48.4	43.7	23.3	39.8	52.0	18.3	41.4	36.3	20.8	34.8	29.0	14.4	25.4	20.8	11.8	10.4	7.2	3.9
B/Gumz	70.9	84.1	61.8	59.3	50.6	41.0	68.2	82.3	56.5	54.8	40.0	31.2	43.4	51.0	36.0	31.9	18.0	9.6
SNNPR	93.4	95.5	85.8	86.0	80.3	76.7	91.9	93.3	81.0	81.5	70.4	67.8	72.0	64.9	52.7	51.3	35.4	26.7
Gambella	48.6	54.5	32.2	31.2	31.4	25.0	42.5	42.6	27.4	26.1	21.0	18.3	22.5	22.5	14.8	12.9	12.6	7.8
Harari	95.0	96.8	85.2	85.2	75.2	74.8	94.2	95.8	79.7	79.4	66.4	63.7	80.0	73.6	60.0	57.5	49.8	38.9
Addis A	99.7	99.7	98.8	98.5	95.2	94.6	99.5	99.5	97.4	95.7	92.8	86.8	79.1	73.8	68.9	63.3	66.6	51.2
DireDawa	98.0	98.0	87.3	87.0	78.0	75.3	96.5	96.5	80.7	80.4	64.7	62.6	72.1	64.8	52.7	52.0	38.1	31.3
Weighted	85.6	86.7	70.6	71.4	64.4	59.5	83.4	84.3	66.0	66.8	54.3	49.9	58.2	53.8	41.1	39.5	27.2	19.9

Msl* = measles

Table 4: **Predictors of DPT_3 vaccination at the time of the survey in children aged 12-23 months old by card + history, EPI coverage survey 2006, Ethiopia**

Variables	Univariate analysis			Multivariate analysis	
	DPT_3 unvaccinated				
Area	**/DPT_3 vaccinated**	**Odds Ratio**	**P-Value**	**Odds Ratio**	**P-Value**
Rural	1413/2191	1		1	
Urban	484/2126	2.83 (2.51-3.20)	<0.001	2.34(2.04-2.68)	<0.001
Immunization site in kebele					
No	538/610	1		1	
Yes	1359/3707	2.41 (2.10-2.75)	<0.001	2.58(2.21-3.02)	<0.001
HEW in kebele					
No	1490/2169	1		1	
Yes	407/2148	3.63(3.19-4.12)	<0.001	3.05(2.67-3.49)	<0.001
Kebele involved in EPI plan & review					
No	1293/2016	1		1	
Yes	604/2301	2.44(2.18-2.74)	<0.001	2.11(1.86-2.39)	<0.001
Education					
Not able to read and write	1507/2304	1		1	
Literate	390/2013	3.38(2.97-3.84)	<0.001	2.95(2.56-3.41)	<0.001
Parity		0.89(0.86-0.90)	<0.001	0.93(0.90-0.96)	<0.001
Occupation					
Housewife	1772/3789	1			
All other	125/528	1.98(1.60-2.43)	<0.001	NA*	
Sex of child					
Female	934/2009	1			
Male	963/2308	1.11(1.00-1.24)	0.053	NA*	

NA* not applicable, p-value <0.06 was used for entry and p>=0.05 for removal from the model and only variables with p-value<0.05 were kept in the final model.

p<0.001. Mean parity of mothers for vaccinated infants was significantly lower than for unvaccinated infants (2.9±1.9 versus 3.4±2.1, p=0.021). However DPT_3 coverage did not significantly differ for different maternal age groups: 15-24 years (68.2%), 25-34 years (68.6%), 35-44 years (63.9%), >=45 years (64.7%), p=0.082. Infants by sex were not significantly associated with DPT_3 coverage (males 70.6% versus females 68.3%, p=0.053). In Tigray region there was no statistically significant difference in DPT_3 coverage among 12-23 months children at the time of the survey by residence (92.4% urban versus 94.1% rural, p=0.55) and by maternal education (96.9% mother literate versus 91.9% mother unable to read and write, p= 0.062).

On multivariate analysis using logistic regression, cluster kebeles attributes (residence, presence of HEWs in kebele, kebele administration involvement in EPI planning and review) and maternal factors (education and parity) remained in the model as significant predictors for DPT_3 vaccination (all with p value <0.001). Maternal occupation and child sex were not however statistically significant on multiple logistic regression.

The national weighted DPT_1 to DPT_3 and DPT_1 to measles dropout rates were 21.7% and 35.6% respectively (card plus history). The most common reasons given by parents or caretakers for not immunizing 12-23 months of children were; unaware of need for immunization (22.8%), unaware of need to return for subsequent doses (12.8%), vaccine not available (12.5%), mothers too busy (6.3%), vaccinator absent (6.1%), place and time of vaccination session unknown (6.0%), fear of side reactions (4.0%) and vaccination time and place not convenient (2.6%).

Table 5: **TT coverage and PAB on card only and by card plus history by region, EPI coverage survey 2006, Ethiopia**

Region	TT doses on card plus history						TT doses on card only						Protection at Birth (PAB)	
	0	TT_{1+}	TT_{2+}	TT_{3+}	TT_{4+}	TT_{5+}	0	TT_{1+}	TT_{2+}	TT_{3+}	TT_{4+}	TT_{5+}	card only	card plus history
Tigray	3.8	96.2	91.4	69.8	51.3	42.1	37.1	62.9	58.1	40.4	27.2	20.1	42.6	80.7
Afar	46.9	53.1	40.9	16.0	3.8	1.3	90.9	9.1	8.2	2.5	0.7	0.1	6.8	36.7
Amhara	12.5	87.5	75.5	45.6	20.1	12.1	55.3	44.7	37.1	19.7	7.9	3.7	20.7	59.8
Oromyia	14.0	86.0	72.4	40.6	17.6	9.9	52.3	47.7	41.0	22.0	8.3	3.2	28.8	58.2
Somali	46.8	53.2	40.0	26.8	18.2	15.5	77.7	22.3	15.9	6.4	1.4	0.9	7.7	31.8
B/Gumz	7.8	92.2	81.8	46.6	33.8	25.7	43.9	56.1	49.3	24.0	16.4	11.4	36.3	67.0
SNNPR	5.9	94.1	86.8	46.8	19.4	13.2	44.1	55.9	50.4	25.0	8.2	4.3	37.7	76.1
Gambella	40.6	59.4	46.6	31.9	21.2	17.3	74.7	25.3	16.8	11.1	8.0	6.3	13.2	41.0
Harari	5.4	94.6	89.0	54.0	22.2	12.1	41.4	58.6	55.1	28.0	11.4	4.4	45.3	82.0
Addis A	2.7	97.3	92.0	50.8	24.1	19.1	41.4	86.6	55.2	26.8	9.1	5.3	51.5	90.9
DireDawa	8.2	91.8	84.9	53.3	25.5	19.0	49.8	50.2	45.0	22.7	8.1	4.2	35.3	75.8
Total	13.5	86.5	75.6	44.1	20.8	13.7	52.3	47.7	41.4	22.0	8.8	4.5	28.7	63.0

The weighted national TT_{2+} coverage and PAB for mothers of 0-11 months of infants was 41.5% and 28.7% by card only 75.6% and 63.0% by card plus history (Table 5). Mothers able to read and write had higher TT_{2+} coverage by card plus history than those who could not read or write (81.0% versus 73.3, $p < 0.001$). Similarly urban mothers of 0-11 months of infants had higher TT_{2+} coverage than their rural counterparts (83.3% versus 73.6%, $p < 0.001$.)

Discussion

As each region was sampled independently, the proportion of urban (41%) and (38%) literate mothers in our study is higher than the national figurers. Regions with the majority of their population in urban areas (Addis Ababa, Diredawa and Hareri) accounted for 20% of the sampled clusters. This explains the higher proportion of urban and literate mothers in the study. However, the national coverage figures reported from our study are weighed regional averages, which are not affected by the over representation of the urban and literate mothers.

Our survey showed a 10 percentage point of increment in DPT_3 coverage over the 2001 survey coverage (56% versus 66%). The 66% DPT3 coverage reported in our survey was much higher than the 29% coverage reported in the EDHS 2005. One reason could be that the methods employed by the two surveys are different. In the EDHS sample size was not determined for each region based on the regional DPT_3 coverage, and sample size was not calculated using the currently WHO recommended precision level. This may have contributed to differences in weighted national coverage figures. Of note, our survey findings were very close to the 69% DPT3 administrative coverage reported in 2004/2005 (14). This suggests that the EPI program has a functional reporting system.

Access, as defined in EPI programs by DPT_1 coverage, in our survey was more than 80% nationally. However, in three regions (Somali, Gambella and Afar), access to immunization is still a major problem ($DPT_1 < 50\%$) and the DPT_3 coverage is less than 30%. Common kebele background features of the three poorly performing regions as compared to the better performing regions were: the percent of kebeles with HEWs was lower than in better performing regions (6.3% versus 49.1%, $p<0.001$); the percent of kebeles with administration involvement in EPI planning and review was lower (20.7% versus 52.7%, $p<0.001$); the percent of kebeles with outreach immunization sites was low (60.0% versus 86.5%) $p<0.001$), and the percent of children vaccinated for DPT_1 in outreach sites was low (18.2% versus 42.1%, $p<0.001$).

The DPT1 to measles dropout rates was very high (35.6%), and was above 10% in all regions except Addis Ababa. Lack of awareness on immunization and the need of subsequent doses were the most common reasons for not immunizing. Poor knowledge about the need for vaccination is a good predictor of poor compliance and high dropout rates are often due to poor or inadequate information-sharing by health providers (15). Training health workers on interpersonal communication can be useful strategy to improve their communication skills in order to reduce the high dropout rates. Promoting immunization through community networks is a proven means to build trust and acceptance of vaccines: as maintained high immunization coverage through extensive networks of community mobilization in Zimbabwe (15). Community mobilization for immunization and defaulter tracking using community health workers might be effective in reducing dropout rate in Ethiopia. Use of sticker reminders and immunization diplomas have also been reported to be effective in reducing immunization dropout rates (16) and increasing measles and fully immunization coverage before the child's first birthday (17). Developing and using effective Behavioral Change Communication (BCC) strategies might be a crucial way to increase the awareness of parents on immunization in order to reduce dropout rates and increase immunization coverage.

A study done in USA in 2001 to determine the proportion of invalid doses reported that 2.3% of DPT_1 doses were invalid because they were given before the age of six weeks and another 1.7% of DPT doses were invalid because the interval between doses was less than the recommended 4 weeks (18). The proportion of invalid doses in our survey is much higher; 9.3% for DPT_1 and 21.2% for measles. This serious problem calls for training and close supportive supervision to ensure health workers adhere to national immunization schedule for maximum immunologic response of vaccines.

Many studies have reported that immunization coverage in urban areas is higher than in rural areas (19-21) and the finding in our survey was similar. This may be explained by the ease of access to information on immunization and immunization services in urban areas Similarly, maternal education has been reported in many studies as a determinant of child immunization (3,10,22-24), and in our study maternal education was a factor that positively influenced child immunization. This may be due to better knowledge of vaccine preventable diseases and importance of vaccination among literate mothers. Some studies including the EDHS 2005 have shown that high birth order of infants to be associated with low immunization coverage (10,25-26). This is explained by the fact that larger numbers of children place competing demands on mothers while time and resources available to provide for the care of each child become more limited. In our study increased maternal parity was associated with low infant immunization which may be explained by the above fact. Availability of

immunization service and accessibility in terms of distance in kebeles were also factors that positively influence child immunization.

In Tigray region, community-based organizations function well and are strong pillars for community based health promotion activities, community health workers are actively involved in community mobilization for immunization and defaulter tracking (3). In our study there was no significant difference in DPT_3 coverage by residence or maternal education in Tigray region. This suggests that disparities in coverage emanating from maternal education and residence can be diminished by strong community mobilization using community networks.

TT_{2+} by card plus history has increased from 55.3% in 2001 (7) to 75.6% in this survey. As in many other studies (10, 27-28), the TT_{2+} coverage in our survey was higher among urban than rural areas, and TT_{2+} coverage was also higher among literate mothers than illiterate mothers, as found in other studies (3,10,27,29); this may be due to easy access to immunization services and having information and knowledge in urban and literate mothers.

The national administrative coverage for TT_{2+} for the July 2004 to June 2005 period was 43.3% (14), suggesting that the routine reporting system underestimates actual TT coverage. Routine TT indicators underestimate coverage because they do not exclude from the denominator women who have completed TT_5. Thus it is important to use a more appropriate indicator to monitor TT immunization in Ethiopia. The PAB method was developed as a means of monitoring TT coverage through routine reporting. It is potentially more accurate than the TT_{2+} indicator in countries with high coverage for DPT_1 (>80%) (30-32). The PAB is calculated by dividing the number of infants who are Protected at Birth by the total live births in the area. The Strategic Advisory Group of Experts to WHO (SAGE) in 1996 recommended that the proportion of infants protected at birth through the immunization of mothers with TT should be used as the routine indicator in every district. It is, therefore, timely to apply the PAB method to appropriately monitor the progress in TT immunization in Ethiopia, since DPT_1 coverage has reached >80% in most regions of the country.

Establishing outreach sites closer to communities and linking EPI services to communities through community based organizations and community focal persons are RED strategies that increase access to immunization and foster ownership of the EPI program by communities in order to improve EPI coverage (33). Our study revealed that involvement of kebele administration in EPI planning and review, and availability and accessibility of immunization service in kebeles were significantly associated with higher immunization coverage. This indicates that full implementation of all RED operational components in all areas, and particularly in those regions with low immunization coverage, can improve access and utilization of immunization services and increase the immunization coverage in the country. As lack of knowledge is the main reason for poor service utilization, effective Behavioral Change Communication (BCC) strategies need to be designed, and implemented to address the high dropout rate in the program.

We recommend EPI coverage surveys similar to this one to be conducted at zonal and district levels by EPI managers in order to monitor coverage and identify local problems that hinder immunization service delivery and take corrective actions locally.

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References

1. Berehane Y, Masresha F, Zerfu M, Kebede S, Shashikant S. Status of expanded program on immunization in a rural town south Ethiopia. Ethiop Med J. 1995;33(2):83-93.
2. World Health Organization /WHO/. Immunization policy. Geneva; WHOGPV/GEN /95.03REV.1, 1996.
3. Kidane T, Tekie M. Factors influencing child immunization coverage in a rural district of Ethiopia, 2000.Ethiop.J.Health Dev. 2003;17(2):105-110.
4. WHO/UNICEF. Review of National Immunization Coverage 1980-2005. August, 2006, Geneva.
5. Ethiopia FMOH, WHO, UNICEF,CDC, USAID/IMMUNIZATION/basics. Report on the Evaluation of the implementation of the RED Strategy in Ethiopia. 20-25 June, 2005, Addis Ababa.

6. Federal Ministry of Health Ethiopia. Ethiopia Expanded Program on Immunization 2006-2010 Multi-Year Plan. September 2006, Addis Ababa.
7. WHO, USAID, CDC and UNICEF. Reaching Every District Strategy Implementation in the African Region: Evaluation Report. June 2005.
8. Family Health Department, FMOH, Ethiopia. National EPI Coverage Survey Report. August 2001, Addis Ababa.
9. The Federal Democratic Republic of Ethiopia Central Statistics Authority. Welfare Monitoring Survey 2004: Analytical Report. Statistical Bulletin 339-A. June 2004.
10. Central Statistical Authority, Addis Ababa. ORC Macro. Ethiopia Demographic and Health Survey 2005. Addis Ababa, Ethiopia and Calverton, Maryland. August 2006.
11. Federal Democratic Republic of Ethiopia Ministry of Health. Health and Health Related Indicators 2003/2004. December 2004, Addis Ababa.
12. World Health Organization. Immunization coverage cluster survey Reference manual. Immunization, Vaccines and Biologicals. WHO/IVB/04.23. 2005 Geneva.
13. Isreal GD. Determining Sample Size. Available at: http://edis.ifas.ufl.edu/PD006. Accessed February 2008.
14. Federal Democratic Republic of Ethiopia Ministry of Health. Health and Health Related Indicators 2004/2005. December 2005, Addis Ababa.
15. Waisbord S, Larson H. Why Invest on Communication for Immunization: Evidence and lessons learned. A joint publication of the Health Communication partnership based at Johns Hopkins Bloomberg School of Public Health / Center for Communication Program and UNICEF (New York). June 2005.
16. Berhane Y, Pickering J. Are reminder stickers effective in reducing immunization dropout rates in Addis Ababa, Ethiopia?. Journal of Tropical Medicine and Hygiene. 1993;(96):139-145.
17. Guyon A; Beyero M; Hainworth M; Quinn V, Carnell M; Mulligan B; Solomon E; Murphy M. Community Assessment in selected ESHE focus weredas in Amhara, Oromyia and SNNPR regions. Ethiopia June 2006.
18. Butte AJ, Shaw JS, Bernstein H. Strict interpretation of vaccination guidelines with computerized algorithms and improper timing of administered doses. Pediatr Infect Dis J. 2001;20(6):561–5
19. Rahman M, Islam MA, Mahalanabis D. Mothers' knowledge about vaccine preventable diseases and immunization coverage in a population with high rate of illiteracy. J Trop Pediatr. 1995;41(6):376-8.
20. Tuma JN, Smith SM, Kirk RH, Hagmann CE, Zemel PC. Beliefs and attitudes of caregivers towards compliance with childhood immunization in Cameroon. Public Health. 2002;116:55-61.
21. Al-Sheikh OG, Al-Samarrai JI, Al-Sumaidaie MM, Al-Mohammad SA, Al- Dujaily AA. Immunization coverage among children born between 1989 and 1994 in Saladdin Governorate, Iraq. Eastern Mediterranean Health Journal. 1999;5(5):933-940.
22. Nair TN, Varughese E. Immunization coverage of infants –rural-urban difference in Kerala. Indian Pediatr. 1994;31(2):139-43.
23. Hanon P, Byass P, Yamuah M, Hayes R, Bennett S, M'Boge BH. Factors influencing vaccination compliance in peri-urban Gambian children. Journal of Tropical Medicine and Hygiene. 1988;91:29-33.
24. Tekie M. Immunization coverage and barriers in Mekelle Tigray, Ethiopia [Dissertation]. Dublin: University of Dublin, 1999.
25. Wood D, Halfon N, Donald-Sherbourne C, Mazel RM, et al. Increasing immunization rates among inner-city, African American Children: A randomized trial of case management. JAMA. 1998;279(1):29-34.
26. Brenner RA, Simons-Morton BG, Bhaskar B, Das A, Clemens JD: NIH-D.C. National Immunization Working Group. Prevalence and predictors of immunization among inner-city infants: a birth cohort study. Pediatrics 2001;108(3):661– 670.
27. Central Statistical Authority. ORC Macro. Ethiopia Demographic and Health Survey 2000. Addis Ababa, Ethiopia and Calverton, Maryland. May 2001.
28. Deming MS, Roungou JB, Kristiansen M, et al. Tetanus toxoid coverage as indicator of serological protection against neonatal tetanus. Bulletin of the World Health Organization. 2002;80(9):696-703.
29. Kidane T. Factors influencing TT immunization coverage and Protection at Birth coverage in rural district, Ethiopia. Ethiop. J. Health Dev. 2004;18(3):153-158.
30. Expanded Program on Immunization Global Advisory Group. Protection-at-Birth (PAB) method, Tunisia. Weekly Epidemiological Record. 2000;75(25):201-208.
31. WHO/UNICEF. Maternal and Neonatal tetanus elimination African Region. WHO/UNICEF Five Year Regional Plan of Action 2001-2005. January 2001.
32. Expanded Program on Immunization Global Advisory Group. Neonatal Tetanus. Weekly Epidemiological Record. 1996;71(35):261-268.
33. Federal Ministry of Health Ethiopia. Reaching Every District (RED) approach: Field Guide and essential tools for implementation. 2004 Addis Ababa.