Early infant diagnosis and associated factors among HIV exposed infants in West Shoa Zone, Ethiopia: A mixed methods study

Gurmesa Tura Debelew (✉ gurmesatura@gmail.com)

Jimma University   https://orcid.org/0000-0002-6216-3804

Bontu Berhanu Fana

Alliance for Better Health (ABH)

Mahilet Birhanu Habte

Jimma University

Research

Abstract

Background: The World Health Organization recommends testing of all HIV exposed infants at 4–6 weeks of age to optimize detection of intrauterine, intrapartum, and early postnatal HIV transmissions. However, the global coverage of early infant diagnosis remains low. With less than 25% national coverage, the progress of this early diagnosis in Ethiopia is one of the slowest in the World. Furthermore, local studies are limited to determine the status and identify the associated factors in many parts of the country in general and in West Shoa Zone in particular. Thus, this study aimed to fill this gap.

Methods: A mixed method study by using retrospective record review of four years facility data of 342 mother-infant pairs supplemented by qualitative method was conducted in West Shoa Zone, Oromia Region, Ethiopia in 2018. The quantitative data related to maternal and HIV exposed infants' cares were collected by using questionnaire. The qualitative data related to facility related barriers were collected by key-informants interview with selected mothers and service providers. Factors associated with early infant diagnosis of HIV infection were identified by using multivariable logistic regression analysis. The qualitative data were analyzed thematically and triangulated with the quantitative findings.

Results: The status of early infant diagnosis was 58.5% (95%CI: 53.3%, 63.7%). Attending secondary education or above (AOR=2.41; 95%CI: 1.54, 3.28), having <4 living children (AOR=4.76, 95%CI: 02.56, 9.09), knowing HIV sero-status during or before pregnancy (AOR=6.24, 95%CI: 2.40, 10.08) and sero-status disclosure (AOR=8.30, 95%CI: 3.30, 20.60) were significantly associated with early infant diagnosis. Attending ANC visit (AOR=5.32; 95%CI: 2.53, 8.11), giving birth in health facility (AOR=62; 95%CI: 3.39, 11.85) and Neverapine provision at enrolment (AOR=6.05; 95%CI: 2.48, 14.73) were also significantly associated with early infant diagnosis of HIV infection.

Conclusion: The status of early infant diagnosis in the study area is low to achieve the national target of 95% coverage by 2020. Maternal socio-demography, maternal behavior in knowing sero-status and disclosing and using services during pregnancy and delivery were among the determinants of early infant diagnosis. Promoting ANC and PMTCT cascade through behavioral interventions and fulfilling the essential equipments and supplies are required.

Introduction

The Human Immunodeficiency Virus (HIV) is a global pandemic with its epicenter in Sub-Saharan Africa and continues to be unfinished agenda for the post-2015 era. Since its emergence, about 75 million people have become infected with HIV and more than 32 million have died from Acquired Immunodeficiency Syndrome (AIDS) related illnesses till the end of 2018. Though there has been promising progress in the HIV prevention and control globally, children continue to be affected by the pandemic. From about 38 million people living with HIV in the world in 2019, about 1.8 million were children under 15 years, with about 410 new infections daily. This is mostly due to problems related to limited access to HIV prevention, early diagnosis, care and treatment [1].

Antiretroviral therapy (ART) for pregnant and breastfeeding women should ideally be delivered within maternal, newborn and child health (MNCH) continuum by integrating HIV and antenatal care (ANC) services. However, achieving this integration in low income countries depends on the context and the resources available in terms of staff time and physical space. To address this, prevention of mother-to-child transmission (PMTCT) of HIV has been at the forefront of global HIV prevention efforts among children since 1998 and in Ethiopia since 2001 [2, 3].

Existing evidence shows that early initiation of antiretroviral drugs in infants with HIV can save lives; yet, coverage of critical intervention among children remains very low. While there has been slowly progressing report in scaling up of access to treatment for children living with HIV, the 90-90-90 treatment targets, which calls for 90% of those living with HIV to know their

status, 90% of those who know their status to be on treatment and 90% of those on treatment to be virally suppressed, may not be realized with the recent progress [4, 5].

As a result, new HIV infections in children continue to occur globally and timely diagnosis of HIV exposed infants (HEIs) and treatments of children living with HIV remain critically important. For infants acquiring HIV before or around delivery, disease progression occurs rapidly in the first few months of life and often leads to death with over 80% of HIV infected infants who are well at 6 weeks progress to become eligible to start ART before 6 months of age. Hence, the World Health Organization (WHO) recommends early infant diagnosis (EID) of viral testing by using Deoxyribonucleic Acid-Polymerase Chain Reaction (DNA-PCR) at 4-6 weeks of age for all HIV exposed infants and HIV antibody test to provide confirmatory diagnosis at 18 months of age [6].

However, the global coverage of early infant diagnosis still remains low. In 2016, only 43% of infants exposed to HIV received an HIV test within the first two months of life globally [7]. Furthermore, early infant diagnosis of HIV infection among HIV exposed infants at the primary care level has been very much challenged, particularly in resource-poor settings. For instance, in 2013, only 42% of infants born to mothers living with HIV in low- and middle-income countries received this test within two months [8].

Country-specific experiences also show similar situation. For example, in a study conducted in Iringa, Tanzania in 2016, 34.6% of HIV exposed infants were presented for early diagnosis [9]. Similarly, in a study conducted in Kenya in 2015, about 56.7% of the infants were examined for HIV by dried blood spot at 6 weeks and only 10.6% of the infected infants started treatment immediately [10].

According to the existing literatures, these challenges may arise from different factors. For one thing, many infants in the HIV diagnosis and treatment programs do not show up for early diagnosis and usually lost to follow-up at various stages. Secondly, diagnostic tools with higher positive predictive value and point-of-care capacity are limited. Thirdly, better infrastructures for administering ART to improve the management of HIV-exposed and HIV-infected infants are very much limited in the resource poor settings [9-11].

In Ethiopia, even though PMTCT service has been provided at primary health care level, the testing for HIV, averting transmission and following up of HIV exposed infants until final status determination remain huge challenges. As a result, early diagnosis of the HEIs by using DNA-PCR within the first six weeks of birth is not progressing very well. According to the 2013 WHO global update on the health sector response to HIV, the proportion of HIV exposed infants receiving virological testing at two months were 21% in Ethiopia [12]. The 2016 health facility statistics report also has shown very slow progress with early infant diagnosis coverage of 25% [13].

With this progress, it may be challenging to achieve the 95% coverage of early diagnosis of HIV infection among HEIs by 2020 as set in the national eliminating mother to child transmission of HIV (EMTCT) strategic plan of Ethiopia for the years 2017-2020 [14]. Similarly, the data of the Joint United Nations Programme on HIV/AIDS (UNAIDS) analyzed by the United Nations Children's Fund (UNICEF) in 2017 suggested that without accelerated action, the 2020 super-fast-track targets for EMTCT of HIV may not be met unless extra efforts are made to engage the HIV-exposed infants into care by 6 weeks of age [5].

Thus, to have evidence-based interventions and further improve the existing efforts to enhance the early diagnosis of the HEIs, conducting studies and determining the status of the early diagnosis and identifying the determinants at a local level are very crucial. Despite this importance, the status of early infant diagnosis and determinant factors in West Shoa Zone of the Oromia regional state of Ethiopia hasn't been well assessed before.

Hence, this study aimed to fill this gap by determining the status of early infant diagnosis and identifying the associated factors among HIV exposed infants in West Shoa Zone, by using four years' facility data, 2014-2017, supplemented by qualitative study.

Methods And Materials

Study design, setting and period

A retrospective record review of four years (2014-2017) facility data supplemented with cross-sectional qualitative methods was conducted in public health facilities of West Shoa Zone, Oromia Region State, Ethiopia, from March 10 to April 22, 2018. West Shoa Zone is one of the 21 Zones of the Oromia Regional state, located about 114 kilometers west of Addis Ababa, the Capital city of Ethiopia. In the Zone, there were 7 hospitals and 80 Health Centers (HCs) rendering preventive and curative services to the catchment population in 2018.

However, only 26 of these facilities (7 hospitals and 19 health centers) were providing the HEIs enrolment and diagnosis during the four years period considered for this study, from January 01, 2014 to December 31, 2017 by using dry blood spots (DBS) sample referral to Nekemt, Adama and Ethiopian Public Health Institute (EPHI) Regional Laboratories. According to the West Shoa Zonal Health Management Information System (HMIS) report, 894 HEIs were enrolled and tested during the four years period in the 26 facilities [15].

Study population and study unit

As the primary objective of this study was to determine the status of early infant diagnosis among all the diagnoses made in the four years period, the source population were all HIV exposed infants enrolled and tested from January 01, 2014 to December 30, 2017 in Health facilities in West Shoa Zone, Ethiopia. Whereas, the study population were those HIV exposed infants randomly selected and included in the study during the sampling procedure. The study unit was HIV exposed infant and his/her mother's record enrolled and tested from January 01, 2014 to December 30, 2017 in randomly selected health facilities.

The study participants for the qualitative methods were purposively selected key-informants, who were working in the areas of HIV exposed infants' program and services, including the Laboratory technician in regional laboratories, health care works providing the services to HEIs and selected mothers attending their HEIs care.

Inclusion and exclusion criteria

The HIV exposed infants and their mother's record enrolled and tested from January 01, 2014 to December 31, 2017 in selected health facilities in West Showa Zone were included. Whereas, infant-mother pairs transferred in after being tested from other facilities and infants and mothers whose complete record were not obtained in the facility were excluded.

Sample size determination

The sample size for the quantitative part was determined by using Epi Info version 7 based on the following assumptions. The status of early infant diagnosis among HIV exposed infants who were enrolled and tested for HIV was assumed to be 41% [16]. In addition, 95% level of confidence, 5% margin of error and 10% for non-response were considered. As the total number of HEIs

enrolled and tested in the Zone during the four years period was 894 (<10,000), finite population correction was considered. Based on this, the minimum required sample size became 289. However, during, the primary identification of records during the sampling procedure, a total of 342 HIV exposed infants, who were enrolled and tested for HIV in the study period were found in the selected health facilities and all were included to increase the level of precision.

Sampling techniques

First, a list of the 26 health facilities providing HIV exposed infants care service during the four years period in the Zone was prepared. Then, more than 30% (9 out of 26) health facilities were selected by lottery method and this gave 2 hospitals and 7 health centres. Then, the lists of all HEIs enrolled to HEI's care and tested from January 01, 2014 to December 31, 2017 were obtained from the registration books of each facility.

While the sample size (289) was allocated proportionally to each health facility, the sample size allocated to each health facility and the total number of HEIs enrolled in the facility in the four years period were almost close to each other. Hence, decision was made to include all the 342 HIV exposed and tested infants and their mother's records in all the 9 selected health facilities. The details are indicated in the schematic presentation of the sampling procedure below (Figure 1).

For the qualitative methods

From each facility, purposively selected 1 health care worker providing care for HEIs and 1 mother (care giver of HEI) were selected, making a total of 9 health care workers and 9 mothers (care givers of HEIs) as key informants. Besides, two laboratory technologists from two regional laboratories (one from each) were included as key informants.

Data collection tools and process

The quantitative data were collected by using structured checklist, to extract the required data from the HEIs' as well as mother's records/registry. This was done by two experienced and trained data collectors who were working in ART and PMTCT clinics in non-selected health facilities. The quantitative data collected included the primary outcome variable (time of HIV diagnosis among HEIs), the HEIs related characteristics such as sex, age at enrollment and Nevirapine provisions. It also included HEI's mother's characteristics such as age, number of living children, marital status, residence, antenatal care use (ANC), place of delivery, time of HIV diagnosis, chronic care enrollment status and HIV sero-status disclosure.

The qualitative data were collected by two experienced masters of public health (MPH) holders by using key-informants interview guide. The qualitative data focused on the maternal behavior and facility related characteristics that can be barriers to early infant diagnoses that were not obtained by the quantitative record review. This included DBS kits stock-out, trained human power on DBS sample collection, presence of mother support group at facility, presence of support from health care workers, functionality of test machine (failure), reagent stock-outs and DBS transportations. The details of the variables for both the quantitative and qualitative methods are indicated in the conceptual framework of the study (Figure 2).

Operational definition of terms

Early Infant Diagnosis (EID): HIV exposed infant for whom whole blood (DBS sample) was collected within the first 6 week of age to diagnose HIV status by DNA- PCR.

Late Infant Diagnosis (LID): HIV exposed infant for whom whole blood (DBS sample) was collected for a test after 6 week of age to diagnose HIV status by DNA- PCR.

HIV Exposed Infant (HEI): A baby, whose age is less than 12 months (0-47 weeks of age) born from known HIV positive woman.

DBS kits stock-out (not available sometimes): Kit unavailability for more than one weak during the study period.

HIV sero-status disclosure: If the mother disclosed her sero-status to at least one person (husband, parent, children, siblings, relative or non-relative), otherwise, non-disclosed.

Data quality assurance

To ensure the quality, the data were collected by experienced health care workers working in ART and PMTCT clinics of non-selected health facility. All the data collectors and supervisors were trained for two days on data collection procedures and supervision, respectively. Pre-test was also done on 5% of the sample size in non-selected health facility to familiarize them with the data collection tools so as to increase accuracy and completeness of the data. The collected data were also checked daily for completeness and consistency by the supervisors.

Data entry was also done by EpiData version 4.1 to control for skip patterns and legal values. The qualitative data were collected by experienced one interviewer and one note taker and all were audio-taped after consent in order not to miss important points.

Data processing and analysis

The quantitative Data were entered into EpiData version 4.1 and then exported to SPSS for windows version 22 for cleaning and analysis. First, frequency distributions and central tendencies were computed to see the overall distribution and characteristics of the study participants.

Then, to identify the variables having statistically significant association with the early infant diagnosis, bivariate logistic regression analyses were done by cross-tabulating each independent variable with the dependent variable. Finally, all the variables that had statistically significant association with the early infant diagnosis at $p < 0.05$ were included in the multivariable binary logistic regression model to control for the possible confounders.

Model fitness was also checked by using Hosmer and Lemeshow test and it showed the model was best fit for the data set ($p = 0.98$). Multicollinearity between different independent variables were also checked by using variance inflation factor (VIF) and the maximum detected was 3.05, indicating non-existence of multicollinearity. At the end, adjusted odds ratios with their corresponding 95% confidence intervals were used to show the level of statistical significance at $p < 0.05$. For the qualitative data, first the collected data were transcribed verbatim and then analyzed thematically. Then, the findings were narrated and triangulated with the quantitative findings.

Results

Socio-Demographic Characteristics of mothers and HEIs

Among 342 HIV exposed infants included in the study, more than half, 190(55.5%), were from rural residents. The largest proportion, 154(45%), of the mothers were in the age range of 31-40 years, with the mean age of 30.8 (±6.7) years. More than a quarter, 94(27.4%), of the mothers never attended any formal education. The leading religion was Orthodox Christian, 141(41.2%), followed by protestant, 107(31.3%).

The great majority, 295(85.8%), of the mothers were either married or in union and most, 286(83.6%), were not employed in formal governmental, non-governmental or private organizations. About seven in ten, 242(70.8%) had three or less living children. The proportion of the sex of the HEIs is comparable with male accounting, 172(50.3%). (Table 1).

Table 1: Socio-demographic and reproductive characteristics of HEI and their mothers, West Shoa Zone, 2018 (n=342)

Variables	Categories	Frequency	Percentage
Place of residence	Rural	190	55.5
	Urban	152	44.4
Age of the mothers (years)	≤20	25	7.4
	21-30	137	40.0
	31-40	154	45.0
	>40	26	7.6
Educational status of the mothers	No formal Education	94	27.4
	Primary	103	30.2
	Secondary or above	145	42.4
Religion of the mothers	Orthodox christian	151	44.2
	Protestant	114	33.3
	Muslim	39	11.4
	Catholic	22	6.4
	Others*	16	4.7
Marital status	Married or in union	295	85.8
	Divorced or separated	31	9.0
	Widowed	10	2.9
	Never married	8	2.3
Occupation of the mothers	Not employed in formal organization	286	83.6
	Employed in Government or private organization	56	16.4
Number of living children	1-3 children	242	70.8
	≥4 children	100	29.2
Sex of the HIV exposed infant	Male	172	50.3
	Female	170	49.7

*Jova, 'Wakefata'

Maternal and HIV related cares for mothers and the HEIs

Majority, 290(84.8%), of the mothers had attended at least one ANC visit during the pregnancy of the HEI and 296 (86.5%) had given birth in health facility. About nine in ten, 307(89.8%), of the mothers already know their HIV sero-status either during pregnancy or before and few were diagnosed at the time of labor or after. Though majority, 236(60%), of the mothers had disclosed their HIV sero-status to someone (husband, parent, children, siblings, relative or non-relative), significant proportion, 106(40%), never disclosed to anyone. About seven in ten, 246(71.9%) of the HEIs were enrolled in to the care within a month of birth and most, 279(81.6%), had received Neverapine at enrolment. **(Table 2)**

Table 2: Maternal and HIV related cares among the mothers and HEIs in West Shoa Zone, Ethiopia, 2018 (n = 342)

Variables	Categories	Frequency	Percentage
Had at least one ANC visit	Yes	290	84.8
	No	52	15.2
Place of delivery	Health facility	296	86.5
	Home	46	13.5
Time to know HIV sero- status	Before or during pregnancy	307	89.8
	During or after labor	35	10.2
HIV sero-status disclosure to family member	Disclosed to at least one member	236	60.0
	Not disclosed to any one	106	40.0
Age of HEI Enrolment to care	Within a month after birth	246	71.9
	After a month of birth	96	28.1
HEI Received Neverapine at enrolment	Yes	279	81.6
	No	63	18.4

Status of early infant diagnosis

Among the 342 HIV exposed infants tested and enrolled in the study; 200(58.5%) (95%CI: 53.3%, 63.7%) were diagnosed early (tested in the first 6 weeks of birth). Among this, the majority, 175(51.8%) were done in the first one month of birth. The median testing age of the HEIs was 6 weeks with the mean age of 11.2 weeks. Among the tested 342 HEIs, 13(3.8%) were positive, 4 among early diagnosis and 9 among late diagnosis, showing positivity rate of 2% among early diagnosis and 6.3% among late diagnosis. (**Figure 3**).

Factors associated with early infant diagnosis

The factors that affect early infant diagnosis were assessed mainly by quantitative method and supplemented by qualitative methods. As indicated in the conceptual framework in the figure 2 above, factors related to maternal socio-demography, maternal and HIV related cares, and infant related variables were assessed quantitatively; whereas, maternal behavior and facility related factors were explored qualitatively.

In the bivariate analysis, among the socio-demographic characteristics, place of residence, maternal education, maternal occupation and number of living children had statistically significant association with the time of HEIs diagnosis. Among the maternal and HIV related cares, time of knowing HIV sero-status, sero-status disclosure, ANC use and place of delivery had statistically significant association. Sex of HEIs and receiving Neverapine at enrolment were among the HEIs related variables that had significant association in the bivariate analysis.

However, after adjustment in the multivariable logistic regression analysis, maternal education and number of living children had statistically significant association among the socio-demographic variables. Among the maternal and HEIs related variables, time to know HIV sero-status, sero-status disclosure, ANC use, place of delivery and receiving Nevirapine at enrolment had statistically significant association with the time of HEIs diagnosis.

The HEIs, whose mothers had attended primary education or above were more likely to be tested and diagnosed early as compared with HEIs whose mothers never attended formal education (AOR=2.41; 95%CI: 1.54, 3.28). Mothers who had fewer (1-3) living children were more than four times more likely to have their HEIs get diagnosed early as compared with those having four or more living children (AOR= 4.76, 95%CI: 2.56, 9.09).

Mothers, who had known their HIV sero-status before or during pregnancy were more likely to have their HEIs get diagnosed early as compared with those who had known their status during delivery or after (AOR=6.24, 95%CI: 2.40, 10.08). Similarly, mothers who had disclosed their HIV sero-status to someone (AOR=8.30, 95%CI: 3.30, 20.60) were more likely to have their HEIs get diagnosed early as compared with those who never disclosed to anyone.

Mothers who had attended at least one ANC (AOR=5.32; 95%CI: 2.53, 8.11) and who had given birth at health facility (AOR=62; 95%CI: 3.39, 11.85) were more likely to have their HEIs get diagnosed early as compared with those having no ANC visit at all and had given birth at home, respectively. Those HEIs who received Neverapine at enrolment were about six times more likely to get diagnosed early as compare with those who didn't receive (AOR=6.05; 95%CI: 2.48, 14.73) **(Table 3).**

Table 3. Factors associated with early infant diagnosis among HEIs in West Shoa Zone, Ethiopia, 2018 (n=342)

Variables	Categories	Diagnosis status		Crude OR (95%CI)	Adjusted OR (95%CI)
		Early diagnosis n(%)	Late diagnosis n(%)		
Place of residence	Urban	103(67.7)	49(32.3)	1.00	1.00
	Rural	97(51.0)	93(49.0)	0.50(0.32, 0.77)	0.83(0.44, 1.22)
Educational status of mother	No Formal Education	37(39.3)	57(60.7)	1.00	1.00
	Primary or above	163(65.7)	85(34.3)	3.00(1.81, 4.83)	2.41(1.54, 3.28)
Occupation of mother	Not employed in formal sector	158(55.3)	128(44.7)	1.00	
	Employed in formal sector	42(75.0)	14(25.0)	2.43(1.27, 4.65)	1.84(0.74, 2.94)
Number of living Children	less than four	170(70.3)	72(29.7)	1.00	1.00
	≥4	30(30.0)	70(70.0)	0.18 (0.11, 0.30)	0.21(0.11, 0.39)
Sex of the infant	Male	87(50.6)	85(49.4)	1.00	1.00
	Female	113(66.5)	57(33.5)	1.94(1.25, 3.00)	1.23 (0.57, 1.89)
Time to know sero-status	During or after labor	6(17.1)	29(82.9)	1.00	
	Before or during pregnancy	194(63.2)	113(36.8)	8.30(3.30, 20.60)	6.24(2.40, 10.08)
HIV status disclosure	Not disclosed	25(23.6)	81(76.4)	1.00	1.00
	Disclosed	175(74.2)	61(25.8)	9.30(5.45, 15.87)	6.28(3.42, 11.57)
At least one ANC visit	No	12(23.1)	40(76.9)	1.00	1.00
	Yes	188(64.8)	102(35.2)	8.10(3.60, 18.00)	5.32(2.53, 8.11)
Place of delivery	Home	6(13.0)	40(87.0)	1.00	
	Health facility	194(65.5)	102(34.5)	12.70(5.20, 30.90)	7.62(3.39, 11.85)
Infant Received Neverapine	No	10(15.8)	53(84.2)	1.00	1.00
	Yes	190(68.2)	89(31.8)	11.30(5.50, 23.20)	6.05(2.48,14.73)

Qualitative findings

As barriers to early diagnosis of HEIs, the qualitative methods identified the following themes: low awareness of mothers, fear of stigma and discrimination, distance from facility, shortage of trained health care workers, DBS shortage at facility, delay in sample transportation and reagent shortage at regional laboratories.

Most of the key informants (6 of the 9 mothers and 5 of the 9 health care workers interviewed) reported that most mothers do not know the importance of early diagnosis of HEIs. As a result, most do not bring their infants timely, some even do not show

up at all and they bring when the infant gets sick.

A 34 years old mother who brought her HEI to one of the health centers said,

 "…I had given birth at this health center and the health worker had told me to bring the infant in two months so that the drug he used to take has to be changed to another drug. But, I was not aware about the test to know his status of HIV infection. Now, the infant is about four months old and I brought him to take syrups as he got sick. I don't know but, the health worker took blood from my baby's leg and told me the sample will be sent to far town for test…"

A health worker providing care for the HEIs at one of the health centers also explained,

 "…We have been telling to all HIV positive mothers to bring their babies at six weeks to take DBS sample to know the infant's HIV infection status starting from ANC visit; but, most of them do not take the information carefully and do not bring timely and some do not show up at all. As a result, we don't lose only infants but also we lose mothers from the treatment and care…"

Most (13) of the key informants (7 of the 9 mothers and 6 of the 9 health care workers) also responded that most mothers of HEIs do not bring their infants to the facility even for immunization, unless the infant gets sick, with the fear that their HIV status will be disclosed to others that may lead to stigma and discrimination as well as conflict from husbands.

A 28 years old mother who brought her HEI to one of the hospitals responded as,

".. *Most mothers do not come alone when they bring their child to health facility for care or immunization. If the person who came with them doesn't know their HIV status, they do not bring the baby to HEI's clinic for test, rather they simply go back home…"*

Another 36 years old mother added,

"… *Mothers whose sero-status is not known by family members usually do not come again to the facility after giving birth with the fear that the infant may be HIV positive and their husband may have a conflict with them, including divorce…"*

A health worker working at HEIs clinic of one of the hospitals supplemented by saying, *"…Some mothers of HEIs come to our hospital after six months or latter of delivery when they or their infants get sick. When we ask them, they usually tell us that they fear the results may be told to anyone else, including their husbands. I know one mother, who came to this hospital after she became bed ridden and the infant got very sick. When we test, the infant was HIV positive…."*

Distance from health facility was also reported as one of the barriers to early diagnosis of HEIs by some of the key informants.

A health worker working at one of the health centers explained,

"…*Some mothers, who know that they are HIV positive, do not use the nearby health facility for HIV related cares and hence travel far distances to reach other health facility, where they are not known. Once, they give birth; they usually don't bring their infants to the facility for test timely because of the long distance and transportation problems…."*

About half, 5 of the 9 health care workers and 4 of the 9 mothers included as key informants, reported shortage of trained health care workers and shortage of DBS kits for sample collection to be sent to regional laboratory for the early diagnosis of HEIs, particularly at the health center level.

A health care worker working on ANC and HEIs care at one of the health centers explained,

"…*I work alone in ANC room and HEIs care as there is no one else trained on DBS sample collection other than me. The ANC follow up clients' flow is very high in this Health Center and it is very difficult for me to serve HEIs care additionally, it would be better if HEIs clinic is in a separate room…"*

Another female Nurse health care worker from other Health centre supplemented,

"…I haven't received any special training on HEIs care, particularly DBS sample collection. But, as there was no other trained health care worker, I had been giving care for HEIs including DBS sample collection and sending it to regional laboratory…"

She continued saying,

"…In addition to shortage of trained health worker, we don't have any DBS kits at all in the last one year in our health centre. We repeatedly reported to Woreda Health Office and Zonal Health Department; but, haven't received yet. When mothers bring their HEIs for test, we used to tell them to bring another time or to come at 18 months and get tested by antibody test…"

One mother key informant added,

"…Based on the information I received during delivery, I have been bringing my baby to the health centre repeatedly and asking them to test her; but they have been telling me that no sample collecting kit and no trained health care worker to take the sample. This is my third visit and they took the sample today when my baby is about six months old. But, they haven't told me the result and told me to come again when called when the result is ready ….."

The two key informants interviewed from the regional laboratories reported that delay in DBS sample transportation by postal service, reagent shortage and work load at the regional laboratories were the major reasons for the delay in knowing the results of the HEIs.

A laboratory technologist in one of the regional laboratories explained,

"…We call it early diagnosis of HEIs when the sample is collected before six weeks of age and the result is known immediately. But, sometimes it takes more than a month for the sample to reach at this laboratory through postal service transported by non-medical stuffs using public transport. Besides, one reagent is used for 48 or 96 tests. Because of this, sometimes we are enforced to wait until the sample reaches this number. The other reason is work load, it takes 12 hours to process and finish the test; but there is only one professional assigned on the machine…"

Discussion

The WHO recommends early diagnosis of viral testing by using DNA-PCR within the first 6 weeks of age for all HIV exposed infants in order to avert the risk of acquiring the infection and reduce the disease progression among the positives by providing appropriate treatment and care timely [7]. But, in this study, less than six in ten, 58.5%, of HIV exposed infants were tested and diagnosed early, within six weeks of birth, by using DNA-PCR. This finding is comparable with the findings of studies conducted in Nairobi, Kenya in 2015 (56.7%) [11], in Muheza District, North-East Tanzania in 2016 (57.1%) [17] and in Zambia in 2012 (58.6%) [18].

But, the fining of this study is higher than the finding of the other study done in Iringa city, Tanzania in 2016 (34.6%) [10], the 2013 WHO's global update for Ethiopia (21%) [13] and a study conducted in Amhara region, Northern Ethiopia in 2014 (41%) [16]. This difference might be due to the progress of improvement in interventions in the last four years in the country, Ethiopia.

On the other hand, the finding of this study is lower as compared with the findings of studies conducted in Bishoftu Hospital, Ethiopia (66.7%) [19] and other similar African countries such as Malawi (72%) [20] and Nigeria (69%) [21]. The deference may arise from setting or methodological deference as the study conducted in Bishoftu hospital included only hospital births and the EID definition used was extended to two months unlike this study that used 6 weeks. The reasons for the deference from other countries' findings may be due to the difference in the PMTCT interventions or health care system between Ethiopia and these countries or deference in socio-demographic, economic and service use culture of the HIV infected mothers.

In this study, HEIs whose mothers had attended secondary education or above were more than two times more likely to have their HEIs get diagnosed early as compared to whose mother never attended any formal education. This finding is consistent with the findings of studies conducted in Nairobi Kenya [11] and in Muheza District Tanzania [17]. This may be explained by

the fact that educated mothers are more likely to understand, accept and practice the information given during pregnancy and delivery on the importance of early diagnosis of HEIs.

In this study, mothers having fewer number of living children (1-3) were more than four times more likely to get their HEIs get diagnosed early as compared with mothers having four or more living children. This was also reported in a study conducted in West Ethiopia [22] and in a study conducted in Johannesburg, South Africa [23]. This may be explained by the reason that in resources limited settings, when mothers have few numbers of living children, they are more likely to give the required care, including health seeking behavior and this decreases as the number of children increases.

In this study, HEIs whose mothers had known their HIV sero-status before or during pregnancy and had disclosed to any one of the family members were more than six times more likely to be diagnosed early. This finding has also been reported in previous studies conducted in Ethiopia and other countries [10, 11, 16, 17, 21, 24]. This may be due to the fact that those who had already known their status during or before pregnancy and already disclosed are more likely on PMTCT or ART and may not have any fear of stigma and discrimination. They are also more likely to accept the care of the HEIs, including testing and treatments. This finding was also well supported by the qualitative method in this study. This will have a significant programmatic implication of testing all pregnant women during ANC, partner testing as well as option B+ PMTCT.

In this study, attending at least one ANC visit during pregnancy and giving birth in health facility had increased the likelihood of early diagnosis among the HEIs by more than five times and seven times, respectively. This finding is consistent with the findings of previous studies done in Northwest Ethiopia [16], in Tanzania [10] and in Kenya [11]. This may be explained by the health information and counseling during ANC and delivery on the importance of early diagnosis of HEIs. This will also have important programmatic implication of promoting ANC, PMTCT and facility delivery for all HIV positive women.

In this study, HIEs who received prophylactic Neverapine at enrolment to HEIs' care were about six times more likely to be diagnosed early as compared with those who didn't receive. Similar finding has been reported in a study conducted in India [24]. This may be due to the reason that usually those HEIs who receive Neverapine at enrolment are among whose mothers know their sero-status and using ART for themselves or by their husbands. In which case, they are more knowledgeable about the importance of the early diagnosis and they bring the HEIs as per the schedule as they don't have any fear of disclosure or stigma and discrimination.

The qualitative part of this study identified health care related barriers to early diagnosis of HEIs, including lack of linkage with psychosocial support group, shortage of trained health care workers, DBS shortage at facility, delay in sample transportation and reagent shortage at regional laboratories. These barriers have also been reported in previous studies [10, 17, 22, 25, 26]. This has a programmatic implication of strengthening the health care facilities by the Woreda Health Office and Zonal Health department by continues supportive supervision and follow up of the availability of supplies and reagents and fulfilling in order to minimize the missed opportunities in the early diagnosis of HEIs.

Limitations of the study

Because of the retrospective record review nature of the quantitative study, some variables such as household income, maternal knowledge and attitude related factors were not assessed. The HEIs whose records were not found and those who were completely lost to follow after once enrolled to care were excluded, which might have slightly over estimated the status of early diagnosis.

Conclusion

The status of early infant diagnosis in this study is low as seen inline with the WHO recommendation of testing all HEIs before six weeks of birth and the national plan of achieving 95% coverage by 2020. Maternal education, number of living children, time to know HIV sero-status by the mothers, disclosing HIV sero-status, ANC use, facility delivery and provision of Neverapine at enrolment were identified as determinants of the early diagnosis of HEIs. Behavioral change communications at the community as well as at the facility are essential to enhance ANC use and promote testing of all pregnant women so that they

know their sero-status for early initiation of option B+ PMTCT. Promoting sero-status disclosure and facility delivery for all HIV positive mothers is also very crucial. Equipping the facilities with the necessary essential equipments and supplies to enable the early diagnosis is an urgent priority.

List Of Abbreviations

AIDS: Acquired Immunodeficiency Syndrome; ANC: Antenatal Care; AOR: Adjusted Odds Ratio; ART: Antiretroviral Therapy; CI: Confidence Interval; DBS: Dry Blood Spots; DNA: Deoxyribonucleic Acid; EID: Early Infant Diagnosis; EMTCT: Elimination of Mother To Child Transmission; EPHI: Ethiopian Public Health Institute; HC: Health Centre; HEI: HIV Exposed Infants; HIV: Human Immunodeficiency Virus; HMIS: Health Management Information System; LID: Late Infant Diagnosis; MNCH: Maternal, Newborn and Child Health; PCR: Polymerase Chain Reaction; PMTCT: Prevention of Mother To Child Prevention; UNAIDS: Joint United Nations Programme on HIV/AIDS; UNICEF: United Nations Children's Fund; VIF: Variance Inflation factor; WHO: World Health Organization

Declarations

- ### Ethics approval and consent to participate

Before the data collection, the proposal was reviewed and ethical clearance was obtained from Institutional Review Board (IRB) of Jimma University Institute of Health. Permission letter was also obtained from Zonal and Woreda Health offices and health facilities' managers. Finally, informed consent was obtained from all the study participants of the qualitative study. Right to refuse or withdraw at any time was also maintained during the interviews. The collected data were anonymous and there were no any identifiers collected and the collected data were kept in locked cabinets and used only for the study purpose.

- ### Consent for publication Not applicable
- ### Availability of data and materials

All the necessary data analyzed and supporting the findings of this study are included in this manuscript. In addition, the SPSS dataset used for the current study are available from the corresponding author on reasonable request.

- ### Competing interests

The authors declare that they have no competing interests.

- ### Funding

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- ### Authors' contributions

GTD and BBF contributed in the conception of the research idea. GTD, BBF and MBH designed and implemented the study, collected data, carried out statistical analysis, interpreted the findings and drafted the manuscript. All the authors critically reviewed the manuscript and approved the final version for publication and agreed to be accountable for all aspects of the work.

- ### Authors' information

GTD is holder of MPH and PhD in Public Health, Reproductive Health specialty. He is also an Associate Professor of Reproductive Health and Head of the Department of Population and Family Health of the Institute of Health of Jimma University, Jimma, Ethiopia. BBF is a holder of MPH in Reproductive health and currently working as A Research Assistant at Alliance for Better Health (ABH), Addis Ababa, Ethiopia. MBH is also holder of MPH in Reproductive Health and currently

working as a Lecturer of Reproductive Health under the Department of Population and Family Health of the Institute of Health of Jimma University, Jimma, Ethiopia.

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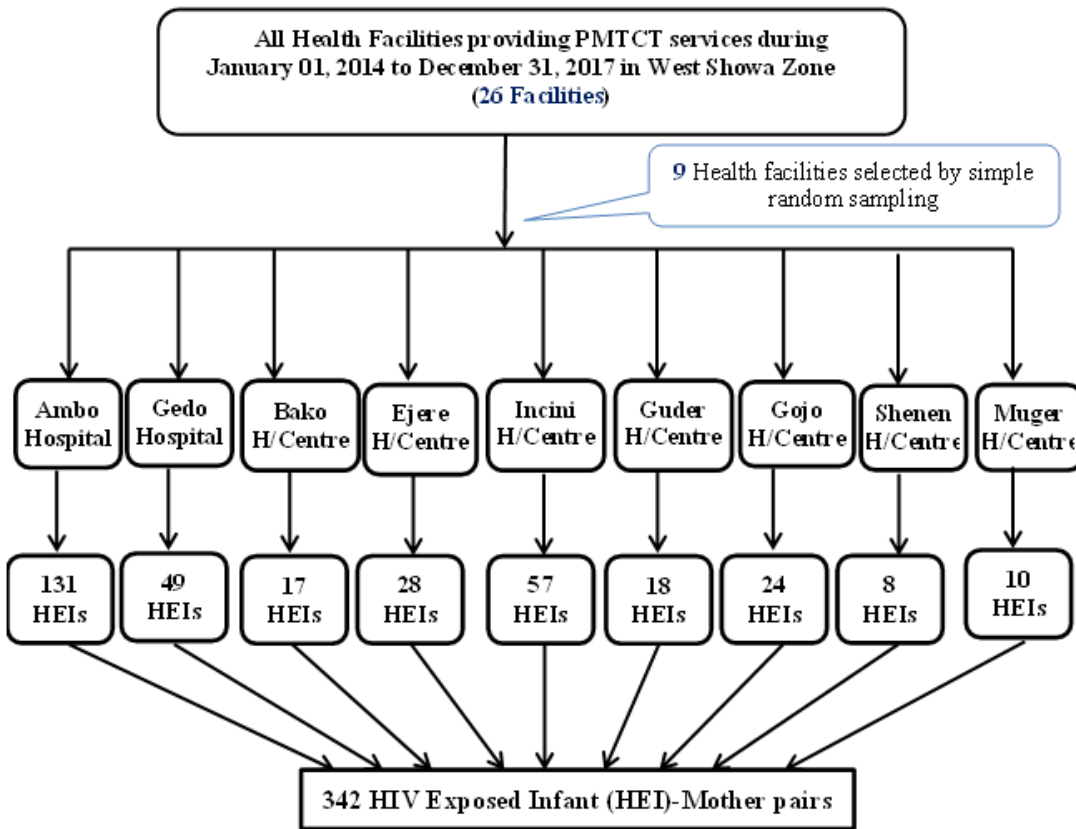
Figures

Figure 1

Schematic presentation of sampling methods to determine the status of early infant diagnosis and associated factors in West Shoa Zone, Ethiopia, 2018.
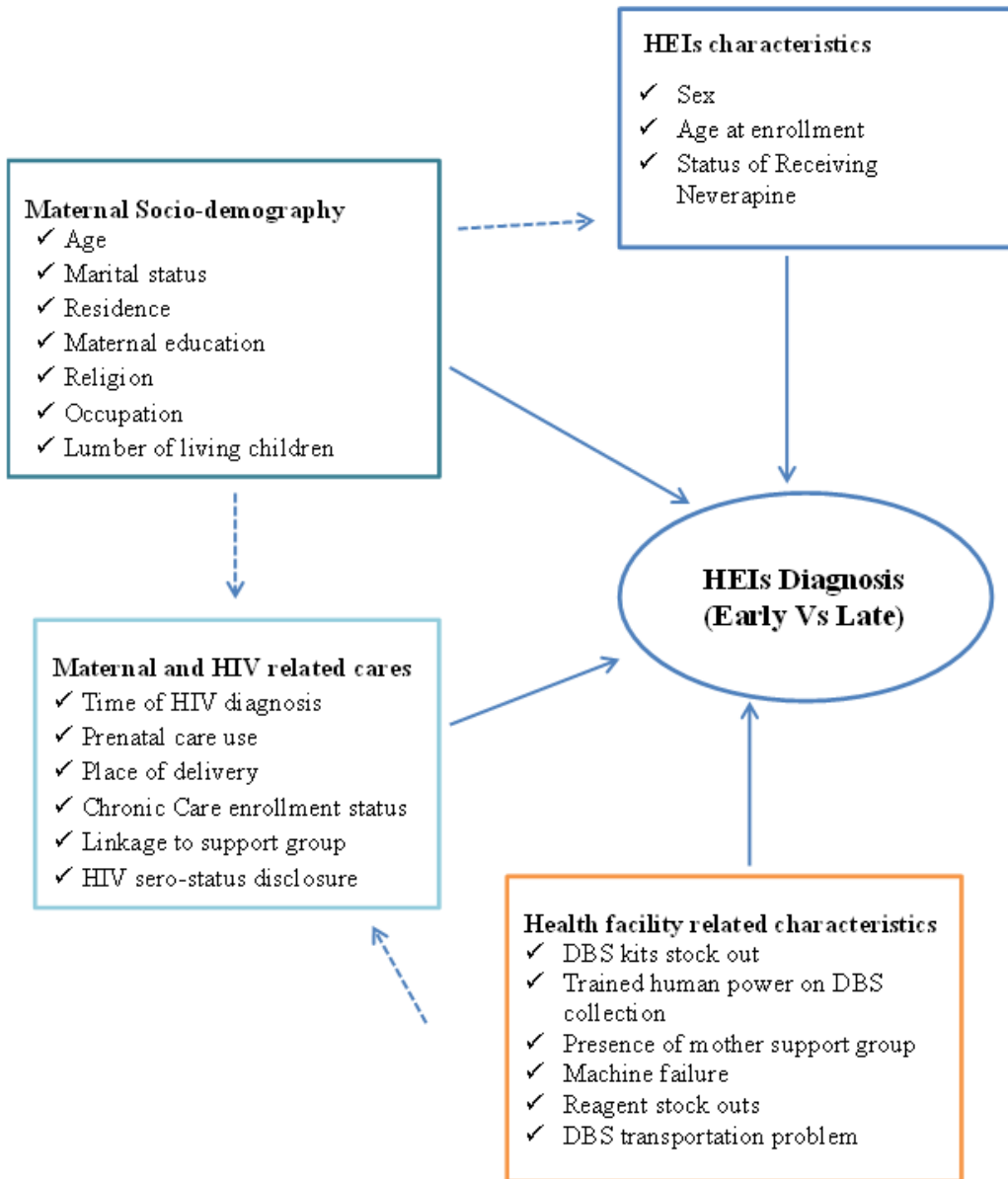
Figure 2

Conceptual framework of the factors associated with early infant diagnosis among HEIs in West Shoa Zone, Ethiopia, 2018
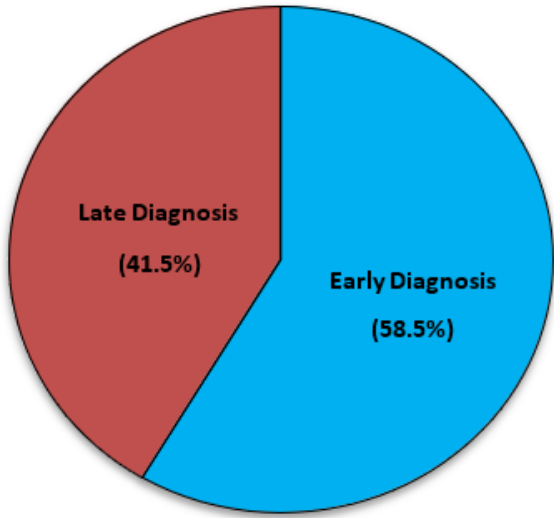
Figure 3

Proportion of Early Diagnosis among HEIs, West Shoa Zone, Ethiopia, 2018.