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Improving Timeliness in Early Infant Diagnosis (EID) Services for HIV Exposed Infants in Zambia: The Impact of the Electronic Health Exposed Infant Monitoring Tool (EHEI_Mt)

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Abstract

Over 1.2 million newborns are exposed to HIV annually, with Zambia contributing significantly due to its 21% HIV prevalence among pregnant women. Testing exposed infants is crucial for early diagnosis. This study utilized a case-control design study to evaluate the effectiveness of the Electronic Health Exposed Infant Monitoring tool in improving Early Infant Diagnosis services in the Kabwe and Chibombo districts of Zambia. Our study was conducted across 16 health facilities involving 248 infant-mother pairs aged 0 to 2 months. Of these, 163 pairs were enrolled into the EHEI_Mt system, while 85 pairs continued being tracked by the existing standard system. Both groups were monitored for 12 months using the electronic tool and Ministry of health standard systems. Descriptive analysis with Pearson Chi2-test was done to determine associations between the use of a tracking system for HIV Exposed infants and other explanatory variables. A stepwise, backward logistic regression model was fitted to predict factors associated with early infant diagnosis uptake. All analyses were done using STATA version 25 (Stata Corp, US Texas. No mother-related factors were significantly associated, but babies in the EHEI_Mt Tool group were more likely to keep appointments ($p < 0.001$), with 73% having a known HIV outcome compared to 22% in the Standard group. We recommend standalone electronic systems as a reminder for healthcare workers for better infant tracking and adherence. Further research on HIV-positive mothers ' perceptions of current early infant diagnosis health systems is needed to address gaps in the PMTCT program for improved outcomes.

Keywords: *Exposed, Early Infant Diagnosis, Electronic tool, Healthcare workers, HIV.*

Introduction

Over 1.2 million newborns are exposed to HIV each year, with more than 65% in sub-Saharan Africa. If left untreated, infants infected with HIV during pregnancy or childbirth have a high risk of dying before their first birthday [1].

In Zambia, where the estimated prevalence of HIV infection is 14.3%, mother-to-child transmission accounts for 21% of all HIV infections [2]. Barriers to early infant diagnosis include poor uptake, low retention at designated re-testing intervals, and passive systems of communication between Health Providers and patients on ART [3]. Early Infant Diagnosis (EID) care and management include an algorithm and series of interventions known as the "EID cascade of care." Retention throughout the EID cascade of care is recommended [3].

For this reason, the World Health Organization (WHO) recommends that all HIV-exposed newborns receive a virological nucleic acid test (NAT) within four to six weeks of birth with immediate return of results. HIV-infected infants should start treatment without delay [1]. Of which these guidelines have been emphasized in Zambian [4]. Although the guidelines provide clear objectives, challenges

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at every step in the EID cascade of care compromise the quality of EID services provided in Zambia and other low-resource settings. At least one-quarter of infants are enrolled late in EID, missing the target for EID testing by 6 weeks of age. Consequently, a significant proportion of mother-infant pairs receive incomplete services [2,5].

Research points to gaps in the health system, including a passive appointment system for mother notification or follow-up, leading to delayed care, and missed opportunities to support timely retention among HEIs [3]. In the health sector, a prevalent form of passive appointment management involves the utilization of longitudinal paper-based registers by healthcare providers to track appointments for HEIs (HEI) [6].

The utilization of paper-based registers, which necessitate healthcare providers to manually record every service provided to mothers and infants in longitudinal registers during visits, results in delayed services for mothers [7]. Consequently, this discourages mothers from visiting the facility, anticipating prolonged waiting times, thereby prioritizing household chores [3]. Additionally, the documentation process impacts the accurate recording of services, often resulting in incomplete documentation despite service provision, impeding future referencing for care management purposes [8].

In line with tracking appointments for this vulnerable group, the use of paper cohort-based registers is characterized by passivity, as healthcare providers are required to manually search through multiple pages to locate HEIs due for follow-up at various intervals ranging from 6 weeks to 24 months [7,8]. This cumbersome process adds to their workload, resulting in the ineffective implementation of a proactive appointment system, relying on mothers to self-remind and bring their infants to the health facility for PCR appointments and prophylaxis, thus missing potential opportunities for proactive care.

Therefore, research highlights that electronic platforms in healthcare serve as valuable tools for improving patient management and communication between healthcare providers and clients to improve timely retention [9]. These platforms aid in sending appointment reminders and test result notifications to HIV+ Providers and Mothers, ultimately enhancing overall healthcare service delivery [3]. Additionally, the efficient data entry processes through electronic tools contribute to time-saving benefits for both providers and clients, while ensuring high-quality data for effective management and care referencing [9].

In this study, EHEI_Mt, a web-based electronic system accessible via smartphones, laptops, and desktops with internet connectivity was introduced in selected facilities as a means to improve the monitoring and tracking of HEI. This tool allowed for offline data entry, and later upload when a network connection was available. EHEI-Mt sent alerts to healthcare workers five days before scheduled Dried Blood Spot/Polymerase Chain Reaction (DBS/PCR) and prophylaxis administration for infants aged 6 weeks to 24 months. It focused on tracking PCR/DBS visit status with limited fields, aiming to provide ample time for healthcare workers to attend to clients and send reminders to mothers/caregivers about upcoming visits. This study evaluated the effectiveness of EHEI-Mt in improving EID services among HEI in Zambia.

Material and Methods

This study utilized a case-control study design to evaluate the effectiveness of the EHEI_Mt in improving EID services for HEIs in Kabwe and Chibombo Districts of Zambia. EHEI_Mt, a web-based platform, was compared to the traditional paper-based Zambia Ministry of Health Standard registers. EHEI_Mt allowed online and offline data entry, while the Ministry of Health Standard registers relied on manual recording during facility visits. Before its implementation, the EHEI_Mt

tool was pretested at Ngungu Health Facility in Kabwe and Kayosha Health Facility in Chibombo to enhance its validity, effectiveness, and reliability in supporting healthcare workers in identifying HEIs due for testing and follow-up before their scheduled appointments. Healthcare workers who participated in the pretesting found the EHEI_Mt tool to be user-friendly and intuitive. However, they highlighted the omission of different drugs administered at birth and postnatal care, which varied by cohort. We addressed this feedback by aligning the tool with the latest EID guidelines, ensuring the inclusion of all relevant medications.

Therefore, 248 infant-mother pairs aged 0 to 2 months by September 2022 were tracked for a period of 12 months between September 2022 and October 2023 in order to provide valuable insights into the benefits of using an electronic tracking system for HIV infant care. Of these, 163 pairs were enrolled into the EHEI_Mt system, the study intervention group, while 85 pairs were tracked by the existing MOH standard paper-based registers.

The primary outcome variable was attendance for DBS/PCR tests at different time points. The electronic tool served as the independent variable, reminding healthcare providers about HEIs' appointments. Dependent variables included attendance measured at specific time points between 6 weeks and 24 months. Covariates such as socio-demographic factors of mothers and caregivers, maternal age, marital status, distance to healthcare facilities, and mothers' previous births were considered.

A two-stage sampling procedure was used. In the first stage, facilities were purposefully selected due to high HEI in the study districts. In the second stage, HEI mother pairs were selected. A total sample of 248 infant mother pairs was determined for this study.

For data management and analysis, information regarding HEIs' date of birth, sex, and initial test data was collected from the registers, along with mothers' sociodemographic data (distance to the health facility, parity, age, marital status, residence type). Data from the intervention facilities (EHEI_Mt group) were entered into the EHEI_Mt for monitoring during the study period, while data from non-intervention facilities (Control group) continued being monitored by the existing standard tools (registers). Both datasets were then extracted using Microsoft Excel for cleaning and recording. Descriptive analysis with Pearson Chi2-test was done to determine associations between the use of a tracking system for infants and other explanatory variables. A stepwise, backward logistic regression model was fitted to predict factors associated with early infant diagnosis uptake. All analyses were done using STATA version 25 (Stata Corp, US Texas).

Ethical Considerations

Ethical clearance was obtained from the ERES CONVERG Institution Review Board. Approval was also sought from the Zambia Health Research Authority (ZHRA). Permission was sought to access Ministry of Health data for the study. All Personally Identifiable Information (PII) was removed during data collection.

Results

Table 1 shows the characteristics of 248 mother-baby pairs a sex distribution among children (50% female, 50% male) with a median age of 441 days (approximately 14.7 months). Most mothers (96.8%) are married, have had 0-2 children (68.1%), and live in urban areas (66.9%). The majority (75%) had their initial PCR test done at birth, and 77% live within 5km of the facility. The mean age of mothers is 29 years, with a standard deviation of 5.5 years.

Table 1. Characteristics of Mother-Baby Pair Participants from Selected Clinics in Chibombo and Kabwe Districts, n = 248

Characteristics	Categories	Frequency	Percentage (%)
Sex of a child	Female	124	(50.0)
	Male	124	(50.0)
	Total	248	(100.0)
Child's age (In days)	395 - 410	44	(17.7)
	411 - 427	46	(18.6)
	428 - 446	52	(20.9)
	447 - 462	41	(16.5)
	463 - 486	65	(26.1)
	Total	237	(100.0)
Marital Status	Single	8	(3.2)
	Married	240	(96.8)
	Total	248	(100.0)
Mother's parity	0 - 2	169	(68.1)
	3 - 7	79	(31.9)
	Total	248	(100.0)
Timing of Initial test	Done after birth	62	(25.0)
	Done at birth	186	(75.0)
	Total	248	(100.0)
Distance to facility	Within 5 Km	191	(77.0)
	Above 5 Km	51	(20.6)
	Outside Catchment	6	(2.4)
	Total	248	(100.0)
Residence type	Rural	82	(33.1)
	Urban	166	(66.9)
	Total	248	(100.0)
12 months outcome	Unknown	110	(44.4)
	Known	138	(55.6)
	Total	248	(100.0)
Child's age (In days)		Median=441	IQR (417, 464)
Mother's age (in years)		Mean=29	SD = (5.5)

Note: IQR- Inter Quartile Range; SD- Standard Deviation; Timing of Initial Test- is PCR test

Comparison of HEI Tracking Interventions: EHEI_Mt Tool vs. Standard Tools in Chibombo and Kabwe Districts

Table 2 shows a bivariate analysis comparing baby tracking interventions reveals several significant differences between the EHEI_Mt Tool and Standard Tools. The EHEI_Mt Tool is associated with a higher likelihood of the initial PCR test being done at birth (87.7% vs. 50.6%, $p < 0.001$) and better adherence to appointment schedules at 6 weeks (58.3% vs. 0%, $p < 0.001$) and 9 months (59.5% vs. 32.9%, $p < 0.001$). Additionally, the EHEI_Mt Tool group has a higher proportion of known outcomes at 12 months (73.1% vs. 22.4%, $p < 0.001$).

Table 2. A Bivariate Analysis of the Baby Tracking Intervention Type using the Chi-square Test among Mother-Baby Pair Participants from Selected Clinics in Chibombo and Kabwe Districts, n = 248

Baby Tracking Intervention type					
	EHEI_Mt Tool		**Standard Tools**		
Characteristics	**(n)**	**(%)**	**(n)**	**(%)**	**P-Value**
Sex of a child					0.349
Female	85	(52.2)	39	(45.9)	
Male	78	(47.8)	46	(54.1)	
Child's age (In days)					**0.008**
395-410	22	(13.5)	22	(25.8)	
411-427	28	(17.2)	18	(21.2)	
428-446	38	(23.3)	14	(16.5)	
447-462	27	(16.6)	14	(16.5)	
463-486	48	(29.4)	17	(20.0)	
Marital Status					0.719
Single	6	(3.7)	2	(2.3)	
Married	157	(96.3)	83	(97.7)	
Mothers' parity					0.791
0-2	112	(68.7)	57	(67.1)	
3-7	51	(31.3)	28	(32.9)	
Residence type					0.243
Rural	58	(35.6)	24	(28.2)	
Urban	105	(64.4)	61	(71.8)	
Distance to facility					**0.164**
Within 5Km	122	(74.8)	69	(81.2)	
Above 5Km	35	(21.5)	16	(18.8)	
Outside Catchment	6	(3.7)	0	(0.0)	
Timing of Initial test					**<0.001**
Done after birth	20	(12.3)	42	(49.4)	
Done at birth	143	(87.7)	43	(50.6)	
At 6 weeks					**<0.001**
Missed appointment	32	(19.6)	0	(0.0)	
Kept appointment	95	(58.3)	0	(0.0)	
Late for appointment	36	(22.1)	85	(100.0)	
At 6 months					**0.147**
Missed appointment	51	(31.3)	17	(20.0)	
Kept appointment	60	(36.8)	39	(45.9)	
Late for appointment	52	(31.9)	29	(34.1)	
At 9 months					**<0.001**
Missed appointment	20	(12.3)	37	(43.6)	
Kept appointment	97	(59.5)	28	(32.9)	
Late for appointment	46	(28.2)	20	(23.5)	
12 months outcome					**<0.001**
Unknown	44	(26.9)	66	(77.6)	

Baby Tracking Intervention type					
	EHEI_Mt Tool		Standard Tools		
Characteristics	**(n)**	**(%)**	**(n)**	**(%)**	**P-Value**
Known	119	(73.1)	19	(22.4)	

Note: EHEI_Mt- Electronic HIV Exposed Infants Monitoring tool; P-Values for marital status, distance to the facility and 6 weeks appointment obtained using Fisher's Exact; **P <0.2** as the threshold for selecting variables for Logistic Regression model.

Significant differences were also observed in the child's age distribution, with the EHEI_Mt Tool group having a higher percentage of children in the older age range of 463-486 days (29.4% vs. 20.0%, p = 0.008). Appointment adherence at 6 months showed no significant difference between the groups (p = 0.147). Factors such as the sex of the child, marital status, mother's parity, residence type, and distance to the facility did not show significant differences between the two intervention types.

Key Predictors of EHEI_Mt Tool Use for Baby Tracking: Child Age, PCR Testing Timing, Appointment Adherence, and Outcome Documentation

Table 3 the regression analysis identified key predictors associated with the use of the EHEI_Mt Tool for HEI tracking. Children in the older age group (463-486 days) had significantly higher odds of being tracked by the EHEI_Mt Tool (AOR: 7.47, p < 0.001). Additionally, babies whose PCR test was done after birth were more likely to be tracked by this tool (AOR: 7.30, p < 0.001). Adherence to appointments at 6 and 9 months was also important; those who kept their appointments at 9 months had increased odds of EHEI_Mt Tool use (AOR: 2.86, p = 0.018), while those who missed their 6-month appointment had lower odds (AOR: 0.23, p = 0.003). Finally, babies with a known 12-month outcome were far more likely to be tracked by the EHEI_Mt Tool (AOR: 9.46, p < 0.001). These results suggest that child age, timing of the PCR test, appointment adherence, and outcome documentation are strong predictors of the tracking method used.

Table 3: Key Predictors of Factors Associated with Baby Tracking Intervention Type, Regression Analysis of Mother-Baby Pairs from Selected Clinics in Chibombo and Kabwe Districts, n = 248

Characteristics	**OR**	**95% CI**	**p-value**	**AOR**	**95% CI**	**p-value**
Child's age group (In days)						
395-410	**Ref.**			**Ref.**		
411-427	1.56	[0.67 – 3.59]	0.301	1.65	[0.50 – 5.46]	0.410
428-446	2.71	[1.16 – 6.36]	**0.022**	2.59	[0.87 – 7.69]	0.086
447-462	1.92	[0.80 – 4.63]	0.141	5.03	[1.46 – 17.28]	**0.010**
463-486	2.82	[1.26 – 6.34]	**0.012**	7.47	[2.55 – 21.85]	**<0.001**
Distance to facility						
Within 5Km	**Ref.**					
Above 5Km	1.24	[0.64 – 2.34]				
Timing of Initial test						
Done at birth	**Ref.**			**Ref.**		
Done after birth	6.98	[3.71 – 13.14]	**<0.001**	7.30	[3.17 – 16.84]	**<0.001**
At 6 months						
Missed appointment	**Ref.**			**Ref.**		
Kept appointment	0.51	[0.26 – 1.01]	**0.055**	0.23	[0.09 – 0.61]	**0.003**

Characteristics	OR	95% CI	p-value	AOR	95% CI	p-value
Late for appointment	0.59	[0.29 – 1.22]	0.157	0.27	[0.09 – 0.75]	**0.012**
At 9 months						
Missed appointment	**Ref.**			**Ref.**		
Kept appointment	6.41	[3.22 – 12.75]	**<0.001**	2.86	[1.19 – 6.88]	**0.018**
Late for appointment	4.26	[1.99 – 9.06]	**<0.001**	3.55	[1.26 – 9.98]	**0.016**
12 months outcome						
unknown	Ref.			Ref.		
Known	18.2	[8.84 - 37.44]	**<0.001**	9.46	[4.23 – 21.18]	**<0.001**

Note: OR- Odds Radio; AOR- Adjusted Odds Ratio, Bold P- Values signify significance level at P < 0.05; at 6 weeks appointment and distance to the facility- outside the catchment area, were omitted from the regression analysis.

Discussion

The study found no significant associations between mother-related factors and the use of the EHEI_Mt Tool for infant HIV testing, except for a slight tendency towards higher use among mothers living within 5 km of a healthcare facility (p = 0.164). This suggests that maternal age, parity, and marital status did not significantly affect the use of the EHEI_Mt Tool for infant HIV testing. These findings align with research from Cape Town, South Africa, and Uganda, which also reported no clear link between maternal age and follow-up or testing behaviours [10].

Primiparous mothers (first-time mothers) did not show a significant difference in their likelihood of knowing their infants' HIV status compared to mothers with no previous births. This finding contrasts with other research suggesting that primiparous mothers may be more proactive in using tools like the EHEI_Mt for testing their infants [12]. Additionally, contrary to studies indicating that single mothers are more likely to seek HIV testing for their infants, the study found no significant relationship between marital status and the use of the EHEI_Mt Tool [14]. These variations highlight the complexity of factors influencing the effectiveness of the EHEI_Mt Tool and suggest the need for further exploration to understand these nuances across different contexts.

The study also found that living close to a health facility (within 5 km) did not significantly influence the use of the EHEI_Mt Tool for infant HIV testing. This result aligns with Zambia's policy of ensuring that healthcare facilities are within a 5 km radius, although even this distance can present challenges, particularly in rural areas where walking with infants may be difficult [11]. The lack of a significant effect from residence type (rural vs. urban) supports the notion that geographical proximity may not be as strong a determinant of healthcare service utilization as previously thought [19].

These findings suggest that broader barriers, such as outreach services and systemic issues, may play a more critical role in accessing Early Infant Diagnosis (EID) services and effectively utilizing tools like the EHEI_Mt, rather than maternal or geographical factors alone. Addressing these barriers is crucial for improving access to timely diagnosis and intervention for HIV-exposed infants, ultimately enhancing health outcomes in Zambia and similar settings [16][17][18].

Effectiveness of the Intervention (EHEI_Mt)

This intervention, facilitated by the EHEI_Mt tool, aimed to improve timely attendance for HIV testing among HEIs to ascertain their HIV status.

Regarding the age of 6 weeks, the intervention demonstrated initial promising

outcomes, with a higher proportion of the EHEI_Mt group attending appointments on time compared to controls. Although the difference was not statistically significant, the trend suggested a positive impact of the intervention, with similar rates of missed appointments observed in both groups. Furthermore, at the 6-month mark, we observed a slight but noticeable effect of the EHEI_Mt intervention, with a higher proportion of the EHEI_Mt group attending appointments on time compared to the standard group.

Late attendance among the EHEI_Mt group was also slightly elevated, indicating a potential need for continued reinforcement of appointment reminders. Importantly, the intervention led to a significant reduction in missed appointments among the EHEI_Mt group compared to the Standard group at 6 months, suggesting its effectiveness in improving appointment tracking and adherence. Our study findings at the months mark are supported by research conducted in Malawi, Latin America/the Caribbean, and Mozambique found that HEI follow-up rates significantly decreased after the 6-month mark. This indicates a critical period where interventions are necessary to keep infants in care and ensure they receive timely medical attention, suggesting that targeted strategies are needed to maintain follow-up and adherence to medical appointments during this crucial time [19,20,21].

A study conducted in rural Uganda demonstrated that improving the scheduling of Early Infant Diagnosis (EID) services and follow-up of missed appointments by health providers led to enhanced EID service utilization [22]. Similarly, in Kenya, the implementation of an online system known as the HIV Infant Tracking System (HIT System), which utilized algorithm-based computer alerts for EID laboratory staff and text messaging alerts for mothers, resulted in improvements in enrolment and retention in the EID testing cascade [3]. Conversely, Adekunle et al. identified limited computer skills as a barrier to the adoption of electronic health records in sub-Saharan Africa [23].

However, previous studies have highlighted the importance of electronic models in facilitating communication between providers and HEI (HEI) mothers [3,20]. Therefore, capacity-building activities for the EID program should be encouraged to positively impact service delivery and utilization by caregivers [24]. Additionally, the findings support previous studies indicating that a significant paperwork burden contributes to incomplete documentation and the unavailability of tracking systems for health providers [7].

The World Health Organization (WHO) assessment emphasized that while paper-based cohort monitoring offers advantages in tracking HIV-positive pregnant and breastfeeding women and HEIs, it presents significant challenges, particularly for frontline healthcare workers [23,25]. Thus, this study underscores the importance of implementing a stand-alone proactive appointment system, such as EHEI_Mt, in the Maternal and Child Health (MCH) department or the EID unit to facilitate EID service utilization and completion of the EID testing cascade.

Regarding the 9-month mark, in our study, both the EHEI_Mt group and Standard group exhibited improved coverage for timeliness and HIV known outcome status, suggesting influences beyond specific interventions. Our findings are supported by studies in Mozambique, Kenya, and Zambia, which emphasize the critical nature of the 9 months for routine health assessments and vaccinations essential to infant health [26, 27, 28,29]. This timeframe aligns with scheduled immunization visits, which naturally increase the likelihood of appointment attendance (references [30,31,16]. However, our study revealed that the EHEI_Mt group maintained a lower rate of missed appointments, while the Standard group experienced a slight increase. This difference

underscores the importance of active follow-up by healthcare workers in the EHEI_Mt group, which supported consistent attendance among participants.

However, challenges emerge in other studies, including one in Zambia, which noted declining attendance after 9 months, potentially disrupting monitoring beyond this critical stage [32]. In our study, we observed a similar trend where there was a slight decline in both HIV known outcome status and timeliness compared to the 9-month mark in both groups. This limitation risks incomplete diagnostic testing and care for HEIs, emphasizing the need to bolster tracking mechanisms beyond routine visits for timely diagnosis and intervention.

However, our study outcome status for the EHEI_Mt group revealed a lower rate of missed appointments, while the Standard group revealed an increase in missed appointments, highlighting the importance of the study's intervention. Our findings are supported by other studies, a study conducted in South Africa found that the implementation of an electronic appointment system significantly improved the rate at which HEI status was known. The system facilitated timely follow-ups and reminders, leading to a marked increase in the number of HEI being tested and their results being communicated to mothers [10]. Similarly, a study conducted in Uganda showed that the use of an EHR appointment system was associated with a higher percentage of mothers bringing their infants for scheduled HIV testing. This intervention improved the communication of test results to mothers, thereby increasing the proportion of HEI with a known HIV status [11]. Conducted in Kenya and Nigeria. A research study in Kenya found no significant difference in the rates of known HIV status among HEI between those who were part of an electronic appointment system and those who were not. The study suggested that other factors, such as transportation issues and socioeconomic barriers, played a more significant role in determining testing follow-up [9]. However, in Nigeria, a study revealed that the electronic appointment system did not significantly improve the rates of infants' HIV status being known. The researchers pointed out that technical issues with the system and a lack of familiarity among users might have undermined its effectiveness [33].

In our study Late but evaluated appointments were more common among the EHEI_Mt group, indicating an initiative-taking approach to catching up on missed appointments. Moreover, the high attrition rate (69%) among the Standard group underscores the need for efforts to retain participants in the program. Additionally, our study highlights the role of healthcare providers in reminding mothers and caregivers about scheduling dates, emphasizing the importance of a sustainable appointment system to improve EID service utilization. Previous studies have highlighted the detrimental effects of a lack of proactive infant tracking and follow-up systems on completion of EID testing cascade and high loss to follow-up rates [7, 8, 29, 27].

Conclusion

In summary, our intervention, EHEI_Mt, demonstrated significant improvements in appointment attendance and reduction of missed appointments among HEI compared to standard practices. The EHEI_Mt group exhibited sustained enhancements in appointment timeliness, with 73% of HEI having a known HIV outcome status at 12 months, compared to 22% in the Standard system group, highlighting the intervention's effectiveness in promoting follow-up and care continuity. The association between known HIV outcome status at various intervals underscores the critical role of early diagnosis facilitated by the intervention.

Nonetheless, our findings contribute to existing evidence by demonstrating how a stand-alone EHEI_Mt intervention promotes timely HIV testing among HEI, facilitating early diagnosis and linkage to care. The

intervention’s effectiveness was particularly evident at 12 months, where infants with a known HIV status were more likely to maintain that status over time compared to the standard group. This underscores the importance of timely testing and active follow-up in improving health outcomes for HEI.

Future research should focus on evaluating the long-term effectiveness and sustainability of EHEI_Mt, understanding barriers to appointment adherence at the 12-month mark, assessing the intervention's cost-effectiveness and scalability, and exploring stakeholder perspectives for optimization. Addressing these aspects will be crucial for enhancing the intervention's impact and ensuring equitable access to HIV testing services for all HEI.

Study Limitations

The study's findings are subject to limitations that may affect their applicability beyond the specific districts and facilities in Zambia where the research was conducted. Limited generalizability is a concern due to the potential differences in socio-economic contexts in other districts, regions, or countries. Additionally, sampling bias may have been introduced by selecting facilities with high numbers of HEI live births. The study experiences high attrition rates, particularly notable at the 12-month mark. Furthermore, reliance on healthcare facility records for data collection resulted in several HEIs being dropped from the study due to incomplete documentation. This may introduce measurement bias due to variations in record-keeping practices and potential inaccuracies in documentation. However, the study's strengths, such as the longitudinal design and inclusion of covariates to control.

Conflict of Interest

I declare that there is no conflict of interest regarding the publication of this research study.

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