HIV Status Impact on Oral Health Related Quality of Life in 3- to 4-year-old Kenyan Children

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Abstract

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Purpose: This study investigates the impact of HIV status on oral health manifestations and oral health-related quality of life (OHRQoL) in Kenyan children aged 3 to 4 years old.

Methods:
360 children living in Kisumu County in West Kenya were enrolled in a longitudinal study with recruitment from 31 clinics and hospitals for patients: age 3- to 4-years-old at time of enrollment, with medical clearance, living in Kisumu County the next subsequent 12 months from enrollment, and with parent-caregiver consent. A nested cross-sectional study analyzed scores from Early Childhood Oral Health Impact Scale (ECHOIS) questionnaires given to those same childrens' parent-caregivers. Equal-sized HIV status groups included: children HIV positive (HIV), exposed to but uninfected (HEU), and unexposed and uninfected (HUU). Parent-caregivers evaluated OHRQoL through nine child-focused questions across four domains: symptoms, function, psychology, and self-image/social interaction. Higher ECOHIS scores indicated a greater perceived negative impact on quality of life. Data was analyzed using descriptive statistics, t-test, and regression analysis ($P<.05$) for each group.

Results: The total population demographics descriptive analysis showed: mean age of 3.4 years, females 51%, majority attending a private school 47% (no school 31%, public school 22%), and a majority live in a rural area 49% (urban 35%, peri-urban 16%). Significant differences were not detected between HIV status groups for all oral manifestations except for abnormal findings. However, the HIV group did have an increased prevalence of abnormal findings with 81% compared to the HEU group at 60% and the HUU group at 54%.

The HIV group reported the lowest ECOHIS score (15%) compared to HEU (24.2%) and HUU (34.2%) in the *Combined Child Function* domain (p=0.003) Within that domain, the HIV group reported the lowest ECOHIS score (8.3%) compared to HEU (12.5%) and HUU (22.5%) for the specific question, *Difficulty of drinking cold and hot beverages* (p=0.006). Differences for other questions and domains were not statistically significant between HIV groups.

Conclusion: Statistically significant findings were limited to the *Child Function Domain* and the specific question, *Difficulty drinking hot or cold beverages*, with lower ECOHIS scores in the HIV group. Further research is proposed to assess how life-threatening conditions like HIV influence parental-caregivers' perception of the oral health and OHRQoL with a longitudinal study design.

I. BACKGROUND

HIV/AIDS continues to represent a significant global health crisis. According to the World Health Organization (WHO), as of 2023, an estimated 38 million people globally are living with HIV, with approximately 1.5 million new infections occurring annually[49]. The epidemic's profound impact is not only on the health of individuals but also on economies, healthcare systems, and social structures. Despite significant advancements in HIV treatment, prevention, and care, there remain stark challenges, particularly in sub-Saharan Africa, where the burden of the epidemic is highest. The global effort to combat HIV/AIDS has seen notable improvements in treatment accessibility, including antiretroviral therapy (ART), but a continued focus on prevention and structural inequities remains critical.

The pediatric HIV epidemic in Africa is of particular concern. Sub-Saharan Africa accounts for over 90% of the world's HIV-positive children, with the highest prevalence found in countries like South Africa, Nigeria, and Uganda[44]. In 2021, approximately 300,000 children were newly infected with HIV, primarily through mother-to-child transmission, although the implementation of interventions to prevent such transmission has shown improvements. In Africa, the incidence of pediatric HIV is intricately linked to socioeconomic factors, healthcare access, and the prevalence of untreated maternal HIV[44]. Additionally, children living with HIV often face the compounded challenges of poor nutritional status, lack of education, and social stigma, exacerbating their vulnerability.

Financial aid, organizations, and infrastructure have played an essential role in addressing these issues. International bodies like the Global Fund, PEPFAR (President's Emergency Plan for AIDS Relief), and UNAIDS support numerous initiatives that aim to provide financial resources, technical assistance, and healthcare infrastructure in sub-Saharan Africa. These organizations focus on expanding access to ART, prevention of mother-to-child transmission (PMTCT) programs, and promoting local health systems strengthening. Moreover, various grants and partnerships facilitate the mobilization of resources for community-based interventions, which are crucial for addressing the social inequities faced by individuals living with HIV. Efforts are also being made to address the broader social determinants of health, such as poverty, gender inequality, and education, which heavily influence the spread of HIV in the region. Strengthening health systems, improving educational opportunities, and ensuring financial access to HIV care are key components of the ongoing fight against pediatric HIV/AIDS. Kenya's national HIV response has highlighted certain regions as critical areas of intervention. In particular, Kenya's AIDS Strategic Framework has identified 13 counties, including Kisumu County, as high-priority areas due to the escalating incidence of HIV in these regions[24].

HIV infection can result in a wide range of oral manifestations due to the virus's impact on the immune system. The mouth often serves as a critical site for early clinical signs of HIV disease, and oral health complications are commonly seen in individuals living with HIV/AIDS. These manifestations are largely due to the immunocompromised state that HIV induces, leading to increased susceptibility to infections and other oral conditions. Common oral conditions associated with HIV include oral candidiasis, gingivitis, periodontal disease, Kaposi's sarcoma, parotid gland enlargement, herpes labialis, and oral hairy leukoplakia[16,28]. These oral manifestations not only affect the individual's health but also contribute to social stigma and poor quality of life.

Children living with HIV are particularly vulnerable to oral manifestations due to the developmental nature of their immune systems and the early age at which they are exposed to the virus. Studies have shown that HIV-infected children are at an increased risk for a range of oral conditions, including recurrent oral thrush, delayed tooth eruption, and more severe forms of periodontal disease compared to their HIV-negative peers[23,34]. A significant issue is the higher prevalence of oral candidiasis, which remains one of the most common oral infections in children with HIV[36]. Additionally, children with HIV often experience altered salivary flow, leading to a higher risk of dental caries and difficulty in managing oral hygiene[27]. Early intervention not only improves oral health outcomes but also contributes to the overall quality of life for children living with HIV[2]. However, this pattern of increased oral manifestations associated with HIV status has not been shown to be consistent in other studies conducted, such as in the context of Uganda[36].

The purpose of this study was two-fold: to examine the link between HIV exposure status and the occurrence of oral diseases in 3- to 4-year-old children in Kenya and to determine if HIV exposure status affected these children's quality of life as measured by Early Childhood Oral Health Impact Scale (ECOHIS). We hypothesize that children living with HIV will exhibit a notably higher prevalence of oral diseases compared to those in the HEU and HUU groups, and that HIV exposure, even without infection, will still elevate the risk of oral health problems. Similarly, we hypothesize that the 9 measures of life quality for the children would be negatively influenced by exposure to HIV, thus showing a higher ECOHIS score.

Oral health is a vital aspect of pediatric HIV care, yet it is frequently overlooked. Parents and caregivers significantly influence children's oral hygiene habits and dietary choices, directly affecting their risk for oral diseases. Active parental involvement in children's oral care routines during formative years is instrumental in establishing strong oral hygiene habits[41]. Additionally, assessing the impact of oral

conditions in young children presents methodological challenges, as those under five often struggle with self-reporting symptoms, long-term patterns, and quality-of-life impacts. Developing age-specific instruments for children affected by HIV is essential to address these challenges with various surveys following different OHRQoL models. For example, the Locker method is an adaptation of 1980 WHO International Classification of Impairments, Disabilities and Handicaps model with emphasis on pain, impairment, and function[21]. Other models, like Ferrans model, include individual and environmental factors[10,39]. There have been various tools to define domains of pediatric quality of life to include: physical functioning, emotional and cognitive functioning, general behavior at social, school, or home), health perception, coping and adaptation, pain and discomfort, extended effects, life perspective, and autonomy[8]. The Early Childhood Oral Health Impact Scale (ECOHIS) was developed by Pahel to address this need, providing a standardized tool to evaluate oral health-related quality of life (OHRQoL) in preschool-aged children. Adapted from existing OHRQoL instruments designed for older children and adults, ECOHIS was specifically designed to capture the impact of oral conditions through caregiver proxy reports. The instrument consists of 13 items divided into two domains: the child impact section (CIS), which assesses pain, function, psychological distress, and social well-being, and the family impact section (FIS), which evaluates caregiver burden, financial strain, and emotional distress related to the child's oral health. Responses are recorded on a Likert scale, allowing for quantitative assessment of disease burden[29].

ECOHIS has been utilized in relation with pediatric research topics such as: caries among HEU and HUU Ugandan children[3], pediatric dental surgery wait times[18], after dental treatment[1]. However, despite its broad application, limited research has explored its use in children living with HIV, a population at heightened risk for oral disease due to immunosuppression and medication-related side effects. Given the increased burden of oral conditions in children with HIV, ECOHIS represents a valuable tool for assessing how these manifestations affect daily life and well-being, offering insights that can inform targeted interventions and improve long-term oral health outcomes.Therefore, we aimed to utilize an established and validate parent-caregiver questionnaire to better assess the OHRQoL between HIV status groups for Kenyan children.

II. MATERIAL AND METHODS

Study Design and Population

This cross-sectional analysis was nested in an established longitudinal cohort study in Kisumu, Kenya. The longitudinal cohort study collected population demographics and oral findings from oral

examinations for children living with HIV (CALHIV). The cross-sectional analysis of oral health-related quality of life (OHRQoL) was measured with an established and validated parental-caregiver perception questionnaire on Early Childhood Oral Health Impact Scales (ECOHIS). This study was approved by the Institutional Review Board (IRB) at the University of Washington (UW) (FWA #000006878) and Jaramogi Oginga Odinga Teaching and Referral Hospital Ethics Review Committee (ISERC/JOOTRH/688/23;Kenya).

This study's population included 360 patients from Kisumu County of Kenya ages 3 to 4-year-old children equally representing three sub-cohorts of 120 children: HIV-infected (HIV+), HIV-exposed uninfected (HEU), and HIV-unexposed uninfected (HUU). Children recruited fulfilled inclusion/exclusion criteria: age 3- to 4-year-old at time of enrollment, medical clearance from a primary care physician, resident of Kisumu County of Kenya for 12 months from time of enrollment, and obtained consent in preferred language (English, Luo, Swahili) from caregiver. Children living with HIV needed to be in ART for a minimum of 6 months.

Recruitment and Enrolment of Participants

From April 2023 to November 2023, HIV+ children were recruited from HIV treatment clinics, while HEU children were recruited from local Prevention of Mother to Child Transmission (PMTCT) clinics, and HUU children were recruited from Mother Child Health (MCH) during wellness checkups. Using the existing health system network, medical site nurses invited all eligible participants to participate in the study over the phone. If caregivers were interested in participating, they were provided with transportation and walked through the informed consent process for the child's and their participation in the study. Once consent was obtained, each child was given a unique generated participant identification (PID) number.

Oral Examination Training and Calibration

All oral examinations completed by a pediatric dentist highly calibrated by a senior pediatric dentist, Dr. Arthur Kemoli, with expertise in oral health research. This pediatric dentist's training included: identification and diagnosis of oral mucosal lesions, hard tissue diseases, plaque, and gingival bleeding after toothbrushing, as well as the collection of oral specimens. Calibration determined with 95% commendable score from 80% correct diagnosis of conditions or diseases in a training module oral mucosal examination slide presentation. Additionally, pediatric dentists were calibrated on standardized procedures for identification and charting of caries, erosion, fluorosis, dental trauma, and presence of

plaque on two pediatric patients. Calibration determined with 70% agreement with Dr. Arthur Kemoli in the in-person dental examination diagnosis. The Kappa score for inter- and intra-calibration achieved 0.95 for both assessments utilizing diagnostic criteria was based on the World Health Organization's (WHO) Oral Health diagnosis criteria[51].

Data Collection Procedure

Oral examination and Specimen Collection: All clinical extraoral and intraoral soft and hard tissue examinations were performed as indicated by WHO Oral Health Surveys and Record Form for Oral Manifestations of HIV/AIDS[52]. With disposable mirror, overhead light, and visual assessment, intraoral examinations were completed with findings recorded in the oral health assessment paper form. Intra oral examinations assessed: identification of plaque accumulation, dental caries, dental trauma, dental fluorosis, missing teeth for other reasons, and other tooth-related pathologies. Toothbrushing completed to assess gingival health and gingival bleeding. After saliva collection, microbiome samples were obtained from both right and left cheeks using sterile, individually wrapped, molded 80 mm FLOQSwabs (BP). For Candida analysis, sterile polyester-tipped Puritan swabs were used to swab the right cheeks and dorsum of the tongue for 10 and 5 seconds respectively. All specimens were immediately transferred into appropriate vials, placed in a cooler bag, and transported by a designated rider to a -80°C freezer.

ECOHIS Questionnaire: ECOHIS questionnaire was created by Pahel, Rozier, and Slade in 2007. ECOHIS questionnaire utilizes an outcomes model with the aim to measure OHRQoL in preschool children[29]. The concept of OHRQoL implements an outcomes model of parent-caregivers' self-reports in conjunction with a biomedical model of clinical disease and diagnosis oriented data[15]. The ECOHIS questionnaire was created in response to limited testing of OHRQoL scale in clinical settings and no instruments available to measure specifically OHRQoL for preschoolers with epidemiological surveys[29]. ECOHIS questionnaire focused on parental-caregiver perceptions of OHRQoL since due to psychology literature that demonstrated children younger than 6-year-old are not able to accurately report everyday events or impacts beyond 24 hours[35]. Through various development stages followed by testing stages, ECOHIS developed a 13-item questionnaire that focused on pertinent items relevant to impacting preschooler's OHRQoL. Of those 13 items, 9 items were assessing direct impact on the child and 4 items were assessing impacts on the parents and families. For assessing 3- to 4-year-old OHRQoL, this study focused on the 9 items pertaining to impacts on children: symptoms, function, psychological, and self-image/social interaction to measure OHRQoL of preschool children by parent-caregiver perceptions[29]. To ensure comprehension, the ECOHIS questionnaire was translated into Swahili, the

national language, and Luo, the local dialect, and administered by a trained research assistant fluent in English, Swahili, and Luo. ECOHIS questionnaire was assessed for validity and internal consistency reliability using Cronbach's alpha and test-retest reliability using intraclass correlation coefficient,[11,13].

Measured Variables

Socio-demographic variables included the child's age, sex, school type (public or private), and residence (rural, urban, or peri-urban). The child's medical records were used for HIV status (HIV+, HEU, HUU) and HIV+ patients': duration of ART, viral load, and adherence. Oral lesions and hard tissue findings were noted as present (0=no / 1=yes). Decayed-missing-filled teeth (dmft) and decayed-missing-filled surfaces (dmfs) indices were used with *missing* due to caries. This study included decay for obvious cavitations only.

The ECOHIS questionnaire completed by parental-caregivers used 9 items to assess 4 domains: symptom, function, psychological, and self-image/social interaction. Questionnaire assessed impact on the children with 1 item to assess symptom (pain), 4 items to assess function (difficulty drinking hot/cold beverages, eating, pronouncing any words and missed school), 2 items to assess psychological (trouble sleeping and irritable or frustrated), and 2 items to assess self-image / social interaction (avoided smiling or laughing and avoided talking). Each item was measured on a Likert scale from 0 (never/hardly ever), 1 (Occasionally), and 3 (Don't know). Score 3 (Don't know) was converted to 0 (missing). Data were excluded if parents reported more than two child items and one family item as "Don't know" or missing responses. ECOHIS scores were measured as the simple sum of the response codes for the child and family items separately. Higher ECOHIS scores represent a larger negative impact on OHRQoL.

Data analysis

One-way analysis of variance (ANOVA) was used to compare HIV status groups (HIV+, HEU, and HUU) for continuous variables for population demographics, oral findings, and ECOHIS item/domain scores. Chi-square test was used to compare HIV status groups (HIV+, HEU, and HUU) for categorical variables for population demographics, oral findings, and ECOHIS item/domain scores. Logistic regression model was used to assess association between oral disease and HIV status, adjusted for sex, school type, and residence. Similarly, logistic regression was used to assess association between ECOHIS item/domain scores and HIV status. ECOHIS items were evaluated dichotomously as yes or no for impact on OHRQoL. No responses for impact on OHRQoL included scores of 0 (never/hardly ever)

and 3 (don't know), which was re-coded to a value of 0 (missing). On the other hand, yes responses for impact on OHRQoL received a score of 1 (Occasionally). Additionally, ECOHIS items were evaluated for mean and standard deviation for the sum of ECOHIS scores 1-3 for child and family individually. SAS 9.4 was used for statistical analysis with statistical significance determined at a p-value of <0.05.

III. RESULTS

Cohort Characteristics

The study included 360 children aged 3 to 4 years from the county of Kisumu, West Kenya. The average age of the participants was 3.4 years (SD = ±0.5), with an almost equal sex distribution (50.8% female) (Table 1). In terms of schooling, 47.2% of the children were enrolled in private schools, 21.7% in public schools, and 31.1% were not attending school at all. The majority of the children lived in rural areas (48.6%), followed by urban (35.5%) and peri-urban regions (15.9%). While there were no significant differences in age ($p = 0.35$), sex ($p = 0.792$), or location ($p = 0.697$) across the study groups. There was a significant difference in the distribution of children by the type of school attended and HIV status ($p = 0.007$).

Among the 120 HIV-positive participants, all were undergoing ART treatment, with current regimens predominantly NRTI-based (Table 1). Prior to their current treatment, 65% had been on PI-based regimens, while 35% had received NRTI-based regimens. ART treatment durations ranged from less than 12 months to over 49 months, with 61.7% of the children being treated for a period between 25 and 48 months. On average, the duration of ART treatment was 29.89 months (SD = 14.38). In terms of viral load, 65% of the HIV-positive children had an undetectable viral load (<50 copies/mL), 18.3% had a viral load between 50 and 400 copies/mL, and 16.7% had a viral load exceeding 400 copies/mL. The mean viral load could not be determined due to incomplete data—only 49 out of 120 HIV-positive children provided the necessary raw viral load numbers. Nonetheless, a substantial majority (78.3%) of the HIV-positive children demonstrated adequate ART adherence, defined as 90% or higher.

Oral disease prevalence by HIV status

While the majority of children experienced serious oral health issues, none of the variables examined, except abnormal findings, were statistically significant between HIV status groups. As such, our original hypothesis predicting significant differences was not supported in all but one case. Nearly half of the children in the study (51.1%) were diagnosed with dental caries; with the HIV-positive group displaying the highest prevalence (56.7%) compared to the HEU (43.3%) and HUU (53.3%) cohorts ($p = 0.099$) (Table 2). Similarly, dental plaque was present in the majority of the children (90.8%), and again, the HIV group had the highest incidence (93.3%) relative to the HEU (89.2%) and HUU (90%) groups ($p = 0.496$). Gingival bleeding during brushing was observed in 147 children (40.8%), with the highest rate seen in the HIV group (45%) compared to the HEU (40.8%) and HUU (36.4%) cohorts ($p = 0.422$). Children living with HIV were significantly more likely to exhibit abnormal findings (80.8%) than their HEU (60%) and HUU (54.2%) counterparts ($p < 0.001$). These abnormalities included conditions such as parotid gland enlargement, geographic tongue, submandibular lymphadenopathy, general skin rash, and perioral fungal infection. Due to the small sample size, it was not possible to determine the distribution of enamel fluorosis, dental erosion, salivary gland swelling, angular cheilitis, herpetic lesions, and HPV/wart-like lesions.

Dental and oral findings were categorized by intervention urgency into routine/preventative needs, non-urgent treatment needs, and urgent treatment needs (due to pain or infection). Most children fell into the routine/preventative category (72.2%), followed by non-urgent treatment (20%) and urgent treatment (7.8%) ($p = 0.908$). While the mean dmft (3.4) and mean dmfs (5.9) scores were higher in the HIV group, these differences were not statistically significant ($p = 0.084$ and $p = 0.243$, respectively).

ECOHIS scores by HIV status

Similar to oral disease prevalence, our hypothesis that HIV group status would negatively impact ECOHIS scores as a proxy for quality of life measures was not supported except for one variable within the *Child Function* Domain and the overall *Combined Child Function* Domain..

Domain 1: Child Symptoms

Pain in teeth, mouth, or jaw: In the HIV+ group, 11.7% reported pain with a mean score of 0.12 ± 0.32. In the HEU group, 14.2% reported pain with a mean of 0.14 ± 0.35. In the HUU group, 15% experienced pain, with a mean score of 0.15 ± 0.36. The overall sample showed 13.6% with pain, with a mean score of 0.14 ± 0.34. The p-value for this finding was 0.736, indicating no significant differences between groups.

Domain 2: Child Function

Difficulty drinking hot or cold beverages: In the HIV+ group, 8.3% had difficulty drinking hot or cold beverages, with a mean score of 0.08 ± 0.28. The HEU group had 12.5% children reporting difficulty, with a mean of 0.13 ± 0.33. In the HUU group, 22.5% experienced this difficulty with a mean of 0.23 ± 0.42. The total sample showed 14.4% with difficulty with a mean score of 0.08 ± 0.28. The p-value was 0.006, indicating a statistically significant difference with the HUU group having the highest prevalence. *Difficulty eating certain foods, pronouncing words, missed school*: p-value findings were 0.147, 0.748, and 0.902 respectively, indicating no significant differences across groups within the *Child Function* domain. *Combined Child Function Domain:* For the combined domain, the HIV group had a mean score of 0.77 ± 1.83, the HEU group had 0.96 ± 2.03, and the HUU group had 1.32 ± 2.19. The overall sample had a mean of 1.01 ± 2.03. The p-value was 0.003, indicating a statistically significant difference, with the HUU group showing the greatest functional impact.

Domain 3: Child Psychology

Had trouble sleeping and been irritable or frustrated: p-value findings were 0.346 and 0.812 respectively, indicating no significant differences across groups within the *Child Psychology* domain. *Combined Child Psychology Domain:* For the combined domain, the HIV group had a mean score of 0.48 ± 1.24, the HEU group had 0.61 ± 1.49, and the HUU group had 0.79 ± 1.61. The overall sample had a mean of 0.63 ± 1.46. The p-value for the combined domain was 0.264, indicating no significant differences across groups.

Domain 4: Child Self-Image/Social Interaction

Avoided smiling and Avoided talking: p-value findings were 0.71 and 0.168 respectively, indicating no significant differences across groups within the *Child Self-image / Social Interaction* domain. *Combined Child Self-Image/Self Domain:* The HIV group had a mean score of 0.41 ± 0.99, the HEU group had 0.52 ± 1.20, and the HUU group had 0.66 ± 1.28. The total sample showed a mean score of 0.53 ± 1.17. The p-value for this domain was 0.372, indicating no significant differences across groups.

IV. DISCUSSION

This study aimed to examine whether HIV status impacts oral disease prevalence and the oral health-related quality of life (OHRQoL) of children aged 3 to 4 years living in Kisumu County, Kenya. In contrast to our original hypotheses, our findings revealed that only within the Combined Child Function domain of the Early Childhood Oral Health Impact Scale (ECOHIS) and the specific question from the *Child Function* domain, *Difficulty drinking hot or cold beverages* showed a statistically significant lower ECOHIS score among HIV-positive children, indicating a lower negative impact on their OHRQoL. However, no significant differences were observed across other overall domains or questions within the Child Function domain.

Dental Caries and Other Health Findings

Consistent with previous research in similar settings, our study found a high prevalence of dental caries and plaque accumulation among preschool-aged children in Kenya, irrespective of HIV status. These findings align with multiple studies highlighting the significant burden of dental caries among young children, particularly in underserved populations such as rural areas[7,22,3347]. Research, including the 2015 National Oral Health Survey for Kenya, underscores the need for targeted interventions to improve access to dental care, in alignment with the Kenyan National Oral Health Strategic Plan 2022-2026[50].

There remains conflicting research data connecting dental caries amongst HIV, HEU, and HUU groups, where some show positive correlation between dental caries and HIV[26,37,42] and some show no statistical differences between the groups[38]. Our study also found no statistically significant difference in caries prevalence between the HIV, HEU, and HUU groups.

Interestingly, a statistically significant difference was observed in abnormal oral findings, which were more prevalent among HIV-positive children. Other oral health characteristics, including caries, gingival bleeding, herpetic lesions, and DMFT scores, showed no significant variation across the groups. These results did not confirm our hypothesis except for abnormal oral findings and contrasted with other African pediatric studies that have suggested a predisposition of HIV-positive children to increased prevalence of oral lesions, such as angular cheilitis and oral candidiasis[38]. Nevertheless, our findings highlight the importance of regular dental evaluations for children for all HIV status groups.

Medical Oversight and Oral Health Implications

Frequent medical visits for HIV management might be hypothesized to provide indirect and direct benefits for oral health, particularly through early identification of oral manifestations. Children with HIV often require consistent medical oversight, leading to frequent interactions with healthcare providers across multiple specialties. This increased medical engagement may allow for earlier detection of oral health issues by non-dental professionals, such as pediatricians and infectious disease specialists, who may then refer these children for necessary dental care.

Additionally, parents of HIV-infected children may be more attuned to their child's symptoms, leading to earlier interventions. Research suggests that parents of HIV-positive children report their child's health concerns similarly as their children compared to parents of uninfected children, indicating heightened awareness and attentiveness[9]. Furthermore, chronic and frequent medical procedures in children with HIV may lower their pain threshold, making them more likely to verbalize discomfort and seek intervention sooner than their uninfected peers[4]. Therefore, children with HIV may receive earlier intervention from parents and medical providers due to earlier perceived discomfort.

Moreover, public health initiatives and specialized programs supporting children affected by HIV might be expected to further enhance access to dental care. These programs often prioritize comprehensive healthcare services, including dental screenings, for HIV-affected populations. In contrast, uninfected or unexposed children may not receive the same level of coordinated healthcare, potentially delaying oral health diagnoses and treatment. This may partially explain the similar oral health outcomes observed across HIV, HEU, and HUU groups despite research indicating a greater oral disease burden in HIV-positive children.

Pain Perception and Parental Influence

Young children living with HIV may perceive and process pain differently due to the multifaceted nature of their condition, which often involves chronic symptoms, opportunistic infections, medication side effects and continuous tests (e.g. blood assessments) to monitor their health status. Caregivers are primary interpreters of their child's pain and can significantly influence pain perception and management[12], especially since preschool aged children have been shown to be poor pain reporters[32]. Children's responses to pain are also shaped by parental behaviors, such as granting permission to avoid regular activities due to discomfort[6,20,45]. There is continual growth in the research around the bidirectional relationship between a young child and their caregiver that continue to show the complexity of perception and beliefs regarding pain[48]. The cumulative burden of these health challenges may alter their sensitivity to or prioritization of pain, including oral pain.

Parental perceptions and beliefs play a critical role in the oral health of 3- to 4-year-old children, as caregivers are responsible for maintaining daily hygiene, recognizing oral health concerns, and seeking professional care when needed. Anecdotal reports from the dental team involved in this study indicated that HIV-exposed but uninfected (HEU) children demonstrated better oral hygiene and were more consistently brought to routine dental visits compared to their unexposed peers. HEU children were often referred to as "miracle babies," reflecting the profound parental and medical appreciation for their survival without HIV infection despite exposure. This heightened perception may have contributed to increased vigilance and adherence to preventive healthcare, including dental care. These positive oral health perceptions could, in turn, translate into improved oral health outcomes through more diligent oral hygiene practices and reliable attendance at medical and dental appointments.

On the other hand, caring for a children with a chronic illness has been linked to caregiver depression and anxiety[25] from the concerns for the child, enduring struggle for control over their lives, stress of not being able to help their child in pain or find a cure[14,30,31]. In this context, oral health concerns may be deprioritized compared to other pressing medical and psychosocial issues. Similarly, parents of HIV-positive children often face significant stressors related to managing their child's illness, navigating healthcare systems, and addressing other socioeconomic or familial obligations. Research has shown a correlation with chronic pain having poor family function as the management of that chronic illness can influence family life, post financial burdements, and daily activities[31,40].

Caregivers of children with HIV/AIDS are also directly shown to be negatively impacted by the social and familial challenges associated with HIV/AIDS including cultural, social, or religious issues or having to keep diagnoses and care secret so as to avoid stigmatization[2]. Previous research has also established that children's pain experiences are shaped by their caregivers' reactions, meaning that parental stress and competing health priorities could lead to an underreporting or a different interpretation of oral health-related impacts in this population[9]. Therefore, the interplay between parents, non-familial caregivers, and children may interact to shape the responses to the questions posed in ECOHIS and as such require additional research.

One of the key strengths of this study was the large and diverse study sample, comprising 360 children aged 3 to 4 years from various regions of Kenya, with an almost equal sex distribution. This diversity enhances the generalizability of the findings and reflects a wide range of socio-economic and regional factors that could impact oral health outcomes. Furthermore, the study's cross-sectional design allowed for the examination of associations between HIV status and oral health findings at a specific point

in time, providing a snapshot of the health needs within the population. While cross-sectional studies are limited in their ability to establish causality, this baseline analysis will provide the basis for longitudinal assessments on the impact of oral diseases and HIV status on the OHRQoL on this young group of children.

Limitations of ECOHIS in HIV-positive children in Africa

Additionally, while the ECOHIS scores provided a valuable measure of children's oral health-related quality of life, there may be concerns about the cultural appropriateness of the tool in this Kenyan population. Although ECOHIS has been utilized in other research studies in Kenya[37,38,47] and Uganda[3], the ECOHIS questionnaire wasn't designed nor adapted for this study's specific population, and its relevance in a diverse cultural setting may not fully capture all dimensions of oral health-related quality of life in this cohort. Although the survey itself has been well-validated, and thus adapted into many languages- such as French[19], Spanish[5], Chinese[17] for use in other countries, the ECOHIS survey may not take into the account of how context and culture shape an parent and/or child's belief systems regarding health and illness[46]. There is research assessing the use of Child Perception Questionnaire showing differential item function by ethnicity, showing importance of context and ethnicity for specific questionnaires to accurately capture OHQoL[43]. Research on influence factors on OHRQoL in African children have noted some context-reliant for African children, such as whether parents could afford dental care, area of residence, child psyche and overall mental health, and socioeconomic status[21]. Similarly, context-reliant influencing factors for parents can greatly impact their overall impressions and views of oral health by the individual and environmental context[10]. However, its inclusion allowed for an assessment of oral health impact from the perspective of both parents and children, which is a strength in understanding the broader implications of oral health in this population. Future research could explore the development or adaptation of more culturally relevant instruments to better capture the nuances of oral health-related quality of life in African populations.

In summary, our study's results are in line with several key studies that highlight the high prevalence of oral diseases and other oral health problems in young children living with HIV in West Kenya. Our findings also show limited support for the growing body of literature that links poor oral health to diminished quality of life, particularly in functional domains such as eating and speaking. Integrating oral health within medical care that children receive in Kenya will not only reduce the risk of oral diseases but improve the quality of life of families affected by HIV.

V. CONCLUSION

In conclusion, this study highlights the high prevalence of oral disease among children in Kenya, with significant differences in oral health outcomes for 3 variables based on HIV status. While the hypothesis that HIV status and oral disease would negatively impact oral quality of life was not confirmed, the findings underscore the importance of comprehensive oral health assessments for all children, particularly those in vulnerable groups. Significant differences in functional impacts, as measured by ECOHIS, were observed, especially in the HUU group, suggesting that oral health challenges may have broader effects on children's daily activities and overall well-being, or at least for specific tasks. These results add to the growing body of literature showing still unresolved patterns of significant and non-significant effects of HIV status on children's oral disease prevalence and quality of life. Future research should extend this cross-sectional analysis into longitudinal studies to better understand the long-term progression of oral health outcomes and their evolving impact on quality of life, including HIV status and other socio-economic factors.

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VI. DATA TABLES

Table 1. Characteristics of 3-4-year-old Kenyan children infected with, exposed to, or not exposed to HIV assessed for oral manifestations of HIV infection

Variables	HIV 120	HEU 120	HUU 120	Total 360	*P Value*
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age					
Months	3.4 (0.5)	3.4 (0.5)	3.3 (0.5)	3.4 (0.5)	0.350
Sex					
Female	58 (48.33)	63 (52.50)	62 (51.67)	183 (50.83)	0.792
School					
Public	29 (24.17)	32 (26.67)	17 (14.17)	78 (21.67)	0.007
Private	46 (38.22)	52 (43.33)	72 (60.00)	170 (47.22)	
No school	45 (37.50)	36 (30.00)	31 (25.83)	112 (31.11)	
Residence					
Urban	39 (32.50)	41 (34.17)	47 (39.83)	127 (35.47)	0.697
Peri-urban	21 (17.50)	21 (17.50)	15 (12.71)	57 (15.92)	
Rural	60 (50.00)	58 (48.33)	56 (47.46)	174 (48.60)	
Duration of ART Treatment					
12 mo or less	20 (16.67)				
13-24 mo	18 (15.00)				
25-36 mo	37 (30.83)				
37-48 mo	37 (30.83)				
49 mo or more	8 (6.67)				
Viral load (copies/mL)					
VL <50, Not detectable	78 (65.00)				
VL 50-400	22 (18.33)				
VL 400+	20 (16.67)				
Adherence					
≥95%	17 (14.17)				
90-94%	77 (64.16)				
<90%	26 (21.67)				

HIV-infected (HIV), HIV-exposed uninfected (HEU), and HIV-unexposed uninfected (HUU

Table 2. Bivariate analysis of oral characteristics and in 3-4-year-old Kenyan children infected with, exposed to, or not exposed to HIV

Oral Characteristics	**HIV 120**	**HEU 120**	**HUU 120**	**Total 360**	***P Value***
	n (%)	n (%)	n (%)	n (%)	
Oral Findings					
Dental caries	68 (56.7)	52 (43.3)	64 (53.3)	184 (51.1)	0.099
Dental plaque	112 (93.3)	107 (89.2)	108 (90.0)	327 (90.8)	0.496
Gingival bleeding at brushing	54 (45.0)	49 (40.8)	44 (36.7)	147 (40.8)	0.422
Abnormal findings*	97 (80.8)	72 (60.0)	65 (54.2)	234 (65.0)	<0.001
Enamel fluorosis	8	9	7		N/A**
Dental erosion	2	1	0		N/A**
Salivary gland swelling	3	2	0		N/A**
Other Oral Diseases					
Angular Cheilitis	1	0	3		N/A**
Herpetic lesions	1	0	0		N/A**
HPV/wart-like lesions	1	0	0		N/A**
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
DMFT score	3.4 (4.7)	2.2 (3.7)	2.9 (4.4)	2.8 (4.3)	0.084
DMFS score	5.9 (11.2)	3.8 (8.6)	5.4 (11.5)	5 (10.5)	0.253

HIV-infected (HIV), HIV-exposed uninfected (HEU), and HIV-unexposed uninfected (HUU)
*Abnormal findings include: submandibular lymphadenopathy, parotid gland enlargement, geographic tongue, general skin rash, perioral fungal infection
**Unable to calculate p-values due to too small of sample size

Table 3. ECOHIS Scores for 3-4-year-old Kenyan Children Infected with, Exposed to, or Not Exposed to HIV

Variables for ECOHIS scores	HIV (120)		HEU (120)		HUU (120)		Total (360)		*P value*
	n (%)	Mean ± SD	n (%)	Mean ± SD	n (%)	Mean ± SD	n (%)	Mean ± SD	
Domain (Child Symptoms): How often has your child had…?									
Pain in the teeth, mouth or jaw	14 (11.7)	0.12±0.32	17 (14.2)	0.14±0.35	18 (15)	0.15±0.36	49 (13.6)	0.14±0.34	0.736
Domain (Child Function): How often has your child ....because of dental problems or dental treatments?									
Difficulty drinking hot or cold beverages	10 (8.3)	0.08±0.28	15 (12.5)	0.13±0.33	27 (22.5)	0.23±0.42	52 (14.4)	0.08±0.28	0.006
Difficulty eating some foods	13 (10.8)	0.11±0.31	15 (12.5)	0.13±0.33	23 (19.2)	0.19±0.4	51 (14.2)	0.11±0.31	0.147
Difficulty pronouncing any words	7 (5.8)	0.06 ±0.24	9 (7.5)	0.08±0.26	10 (8.3)	0.08±0.28	26 (7.2)	0.06±0.24	0.748
Missed preschool, day-care, or school	4 (3.3)	0.03±0.18	3 (2.5)	0.03±0.16	3 (2.5)	0.03±0.16	10 (2.8)	0.03±0.18	0.902
Combined Domain	18 (15)	0.77±1.83	29 (24.2)	0.96±2.03	41 (34.2)	1.32±2.19	88 (24.4)	1.01±2.03	0.003
Domain (Child Psychology): How often has your child ....because of dental problems or dental treatments?									
Had trouble sleeping	5 (4.2)	0.04±0.2	6 (5)	0.05±0.22	10 (8.3)	0.08±0.28	21 (5.8)	0.04±0.20	0.346
Been irritable or frustrated	4 (3.3)	0.03±0.18	5 (4.2)	0.04±0.2	6 (5)	0.05±0.22	15 (4.2)	0.03±0.18	0.812
Combined Domain	6 (5)	0.48±1.24	7 (5.8)	0.61±1.49	12 (10)	0.79±1.61	25 (6.9)	0.63±1.46	0.264
Domain (Self-image / Social Interaction): How often has your child ....because of dental problems or dental treatments?									
Avoided smiling	2 (1.7)	0.02±0.13	3 (2.5)	0.03±0.16	4 (3.3)	0.03±0.18	9 (2.5)	0.02±0.13	0.710
Avoided talking	1 (0.8)	0.01±0.09	4 (3.3)	0.03±0.18	6 (5)	0.05±0.22	11 (3.1)	0.01±0.09	0.168
Combined Domain	21 (17.5)	0.41±0.99	22 (18.3)	0.52±1.2	29 (24.2)	0.66±1.28	72 (20)	0.53±1.17	0.372

HIV-infected (HIV), HIV-exposed uninfected (HEU), and HIV-unexposed uninfected (HUU)
Summation of ECOHIS score based on survey responses: "*Never/Hardly Ever"=0* and "*Occasionally"=1, "Don't know"=0 (coded as missing)*

VII. REFERENCES

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