

Integrating WaSH Into HIV Care: Structural Determinants of Enteric Disease in HIV-Exposed Infants in a Central District in Malawi.

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Research Article

Keywords: HIV-Exposed Infants, Water, Sanitation, and Hygiene (WaSH), Diarrhoea, Infantile, Cotrimoxazole Prophylaxis, Malawi, Joint Monitoring Programme (JMP)

Posted Date: September 25th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10553444/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Poor water, sanitation, and hygiene (WaSH) conditions undermine clinical interventions for HIV-exposed infants (HEIs) in low-resource settings. While cotrimoxazole prophylaxis significantly reduces opportunistic infections, its efficacy against environmental pathogens in the absence of adequate household infrastructure remains critical yet under-explored.

Materials and Methods

A quantitative cross-sectional design was employed to profile **291** mother–infant pairs aged **6 weeks–24 months**, recruited using a systematic sampling interval of **K = 3** in Kasungu District, Malawi. Data collection integrated caregiver interviews, clinical record audits, and direct household inspections using WHO/UNICEF JMP metrics. Two-week diarrhoeal

prevalence was defined as ≥ 3 loose stools within 24 hours. Multivariable logistic regression generated adjusted odds ratios (AORs) and **95% CIs**, controlling for sociodemographic, environmental, and biomedical factors.

Results

Severe WaSH deficits were widespread: **79.7%** of households had no hygiene service, **73.5%** had poor-quality latrines, and **84.5%** lacked handwashing compliance. Unsafe drinking water access showed the strongest association with diarrhoea (AOR **14.38**, 95% CI 6.51–31.75), followed by poor hygiene service (AOR **12.64**, 95% CI 6.24–25.61), limited sanitation (AOR **8.78**, 95% CI 4.58–16.83), and worsened family sanitation status (AOR **6.17**, 95% CI 2.60–14.64). Poor neonatal NVP adherence also increased risk (AOR **6.87**, 95% CI 1.30–36.24).

Conclusion

Household WaSH conditions are the strongest predictors of diarrhoeal morbidity among HIV-exposed infants, far outweighing biomedical or sociodemographic factors. Clinical prophylaxis cannot offset unsafe water, poor sanitation, or absent hygiene infrastructure. Integrating safe water, improved latrines, and handwashing stations into HIV programmes is essential for reducing enteric disease and advancing key SDGs.

1. Introduction

Poor water, sanitation, and hygiene (WaSH) conditions profoundly complicate the HIV/AIDS epidemic and undermine clinical responses in resource-limited settings. In Malawi, approximately 81,000 infants are exposed to HIV annually (Ng'ambi et al., 2022; Afework et al., 2021), and despite widespread implementation of short-course antiretrovirals (ARVs) and routine co-trimoxazole prophylaxis, more than

half of infected infants die in early childhood (Chavura et al., 2023; UNAIDS, 2021). Co-trimoxazole reduces diarrhoeal morbidity by about 41% and respiratory morbidity by 36% (Davis et al., 2017), yet it offers no protection against common viral pathogens such as Rotavirus or heavy burdens of soil-transmitted helminths. These pathogens are frequently introduced through substandard household hygiene and sanitation, meaning biomedical interventions alone cannot offset the environmental drivers of recurrent enteric disease.

A major policy gap persists: although improved sanitation clearly enhances child health, there is no practical roadmap for integrating safe water infrastructure into HIV treatment, care, and support services. This gap is increasingly urgent as the global population of HIV-exposed infants (HEI) approaches 15 million. WHO guidelines require breastfed HEI to receive co-trimoxazole from six weeks of age until HIV status is definitively confirmed after breastfeeding cessation. Improved WaSH practices also reduce neglected tropical diseases (NTDs), particularly helminth infections, which undermine child survival and interact pathologically with HIV Ghosh,et al., 2021. Anthelmintic treatment during pregnancy may reduce mother-to-child transmission (MTCT) by preventing transplacental parasite antigens from triggering harmful lymphocyte activation (Lampejo, 2022). Helminths accelerate HIV-1 progression by disrupting host immunity, increasing susceptibility to viral acquisition, and weakening the body's ability to control replication (Mawa et al., 2021; Babu & Nutman, 2020). The Th1/Th2 cytokine model explains this synergy: helminth infections induce chronic Th2 polarization, suppressing Th1-mediated antiviral immunity and accelerating HIV-1 disease progression (Mwangi et al., 2022; Webster, 2021; Modjarrad & Vermund, 2020).

This intersection creates a critical vulnerability for HEI living in environments with inadequate WaSH infrastructure. These infants face a dual burden of recurrent diarrhoea and intestinal helminth infestations. Together, these infections trigger Environmental Enteric Dysfunction (EED), a chronic condition marked by intestinal inflammation, villous atrophy, and compromised mucosal barrier integrity (Agustina et al., 2015). EED amplifies HIV-1 transmission risk because maternal helminth infections elevate systemic viral loads and induce foetal Th2 polarization in utero. Postnatally, unsafe mixed-feeding practices, often necessitated by lack of safe water (George et al, 2021); introduce contaminated liquids and formula, creating a direct faecal-oral vector for severe diarrhoea (Maizels & McSorley, 2021; Modjarrad & Vermund, 2020; Afework et al., 2022, Anthonj et al, 2022). The resulting systemic inflammation and malabsorption impair the gut's ability to absorb essential nutrients and daily oral biomedical therapies, thereby undermining the efficacy of co-trimoxazole and antiretroviral therapy (ART). The present study addresses this gap by testing how household WaSH characteristics influence two-week diarrhoeal prevalence among HEI, aligning with SDGs 3, 6, 8, and 10. Clinical protocols provide essential protection but do not alter environmental reservoirs of infection. Co-trimoxazole reduces bacterial and protozoal diarrhoea but is ineffective against viral pathogens and helminths (Platts-Mills et al., 2022; Kotloff et al., 2021). ART suppresses viral replication and reduces MTCT but does not prevent opportunistic enteric infections arising from poor WaSH (Chandna et al., 2021). Anthelmintic treatment clears worm burdens but reinfection occurs rapidly without improved sanitation (Rollins et al., 2021; Kim

et al., 2017). These gaps illustrate why biomedical interventions alone cannot resolve the environmental drivers of disease.

The conceptual framework (Fig. 1) proposes that environmental deficits pathologically undermine clinical treatment through three interconnected mechanisms. First, structural WaSH deficits diverge into dual exposure pathways. In the antenatal pathway, poor sanitation exposes pregnant mothers to helminths, elevating viral loads and inducing transplacental Th2 polarization that increases foetal susceptibility to HIV-1 acquisition. In the postnatal pathway, lack of safe water forces mothers into mixed-feeding or contaminated formula use, directly exposing infants to heavy pathogen loads and recurrent diarrhoea.

Second, chronic infection triggers gut degradation and immune shifts. Recurrent diarrhoea and helminthiasis reshape infant biology by causing EED, characterized by persistent inflammation, villous atrophy, and mucosal barrier failure. Chronic helminth infections further tip the immune balance toward Th2 dominance, weakening Th1-mediated antiviral responses essential for controlling HIV-1 replication.

Third, these pathways converge into “biomedical blunting.” EED-induced malabsorption prevents infants from effectively absorbing oral therapies, neutralizing the protective effects of co-trimoxazole and ART. Because environmental exposure remains unchanged, clinical efficacy is masked, accelerating progression to symptomatic AIDS and contributing to high paediatric mortality.

To evaluate these intersections, the study tests three hypotheses. The first examines whether household WaSH characteristics predict two-week diarrhoeal prevalence and soil-transmitted helminth acquisition among HEI. The second assesses whether environmental pathogen loads and recurrent enteric infections alter the clinical efficacy of co-trimoxazole prophylaxis by overwhelming its protective capacity. The third investigates whether unsafe infant feeding practices moderate or confound the relationship between household WaSH conditions and infant health outcomes, particularly through their role in amplifying EED and severe diarrhoea. Together, these hypotheses operationalize the conceptual framework and provide an empirical foundation for understanding how structural environmental neglect interacts with biological vulnerability to shape health outcomes among HIV-exposed infants as shown in Fig. 1.

2. Methodology

2.1 Study Setting and Design

This quantitative, cross-sectional study examined environmental and sociodemographic determinants of diarrhoeal disease among HIV-exposed infants (HEIs) in Kasungu District, approximately 120 km north of Lilongwe, Malawi. Data collection occurred from 4 May to 22 July 2022, covering the seasonal transition into the dry period. The design integrated caregiver interviews, clinical record audits, and direct household environmental inspections. Kasungu District is a predominantly rural and agrarian region characterized by high poverty levels, limited household infrastructure, and reliance on communal or

unimproved water sources. Most families reside in densely clustered compounds where sanitation facilities are shared across multiple households, accelerating structural deterioration and increasing faecal contamination around latrine sites. The HIV clinic serving this cohort is a district-level public facility providing routine ART, cotrimoxazole prophylaxis, and maternal- child health services, but it does not offer integrated WaSH support. Ethnic groups represented in the sample; primarily Chewa, Tumbuka, and Yao experience broadly similar socioeconomic constraints, though variations exist in household size, land tenure, and access to improved water points. These contextual realities shape daily caregiving practices and directly influence infants' exposure to unsafe water, poor sanitation, and inadequate hygiene infrastructure.

2.2 Population, Eligibility, and Sampling Framework

Eligible participants were mother–infant pairs in which infants were aged 6 weeks to 24 months, born to HIV-positive mothers, actively registered at a district HIV clinic, and had complete, verifiable clinical records. Exclusions included refusal of written consent, rejection of household follow-up visits, or missing critical clinical fields.

Sample size was calculated using Slovin's (1960) formula: $n = N / (1 + Ne^2)$ with a 5% margin of error ($e = 0.05$), generating a requirement of $n = 277$, plus a 5% non-response buffer (14), yielding a final target of **291 participants**. Systematic random sampling was applied using a sampling interval of $K = 3$, beginning with a randomly selected index between 1 and 3 and recruiting every third eligible caregiver-infant pair.

Participant Selection Pipeline

A multi-stage sampling process refined the final cohort:

1,219 Register Records → [Minus 276 Pre-Screen] → 943 Screened → [Minus 44 Field Drop] → 899 Eligible → [Random Sample] → 291 Final

Phase 1: Institutional Identification From 1,219 initial records, **276** were excluded: **267** due to incomplete fields, **6** due to clinical ineligibility, and **3** duplicates. This produced **943** complete records.

Phase 2: Field Screening A further **44** cases were removed: **41** lacked traceable contact information and **3** declined home visits. This yielded **899** fully eligible candidates.

Phase 3: Sample Calculation and Randomization Slovin's formula produced a baseline requirement of **277**, increased to **291** with a non-response cushion. Simple random sampling extracted the final **291 mother–infant pairs** who completed all study procedures.

2.3 Data Collection Instruments and Variables

A dual-source workflow linked clinical history with household exposure conditions. Kobo Collect was used for digital data capture, with household interviews averaging 30 minutes.

2.3.1 Clinical Record Extraction

Infant health passbooks and patient cards were audited for DNA/PCR results, rapid antibody tests, natal history, and adherence to preventive biomedical protocols, including Nevirapine prophylaxis (first 6 weeks) and cotrimoxazole prophylaxis (6 weeks to 24 months).

2.3.2 Household Surveys and Maternal Interviews

Clinical registry data were linked to households using GPS coordinates and caregiver contact details. Surveys captured sociodemographic characteristics and infant feeding practices (exclusive breastfeeding, mixed feeding, complementary feeding, or replacement feeding). The primary outcome; two-week diarrhoeal prevalence was defined as ≥ 3 loose or watery stools within 24 hours during the 14 days preceding the interview.

2.3.3 Direct Observation and Sanitary Inspections

Enumerators conducted standardized inspections of household sanitation infrastructure using WHO/UNICEF Joint Monitoring Programme (JMP) metrics. Sanitation quality was assessed through pit structure, slab integrity, superstructure condition, design compliance, waste containment, and visible hygiene practices, categorizing facilities as **Good**, **Intermediate**, or **Poor**.

Sanitation service levels followed JMP ladder definitions:

- **Safely Managed/Basic:** Private improved facility (VIP latrine, pit latrine with slab).
- **Limited:** Improved facility shared by ≥ 2 households.
- **Unimproved:** Pit latrine without slab, hanging latrine, bucket latrine.
- **No Service:** Open defecation.

Hygiene service levels were classified as **Basic** (water + soap present), **Limited** (one missing), or **No Service** (no facility).

2.4 Statistical Data Analysis

Data were exported from Kobo Collect and analyzed using IBM SPSS Version 25. Descriptive statistics summarized sociodemographic and WaSH characteristics. Binary logistic regression assessed associations between explanatory variables and two-week diarrhoea prevalence.

Model development followed: **[All Variables]** → **[Bivariate Screen (cOR)]** → **[Multivariable Logistic Model (aOR)]**, with diagnostic checks for multicollinearity using the Variance Inflation Factor (VIF), ensuring all retained variables had **VIF < 2.5**. Model fit was evaluated using standard goodness-of-fit tests.

2.5 Ethical Considerations

Ethical approval

was granted by the Mzuzu University Research and Ethics Committee (MZUNIREC/DOR/22/72) and the Kasungu District Health Research Coordinating Committee (KDH PF 435). Written informed consent was obtained from all caregivers. All data were anonymized using unique alphanumeric identifiers to ensure confidentiality.

3. Results

Multivariable logistic regression analysis was conducted to identify independent predictors of two-week diarrhoeal prevalence among HIV-exposed infants. The model incorporated sociodemographic, environmental, and biomedical variables to adjust for potential confounding effects. Figure 2 presents the adjusted odds ratios (aORs) and 95% confidence intervals for each predictor, illustrating the relative contribution of household hygiene service tier, latrine condition, handwashing compliance, spatial sanitation access, maternal education, marital status, infant feeding practice, and cotrimoxazole adherence to diarrhoeal risk within the study cohort.

Table 1
Bivariate Analysis of Sociodemographic Factors and Diarrhoeal Morbidity (n = 291)

Independent Variables	With Diarrhoea n = 85 (29.2%)	Without Diarrhoea n = 206 (70.8%)	Total Group n = 291 (100%)	χ^2/ Fisher's <i>p</i>-value
Maternal Age				0.431 (Not Significant)
15–24 years	35 (26.9%)	95 (73.1%)	130 (100%)	
25–34 years	26 (28.6%)	65 (71.4%)	91 (100%)	
>35 years old	14 (20.0%)	56 (80.0%)	70 (100%)	
Ethnicity				0.641 (Not Significant)
Chewa	45 (27.3%)	120 (72.7%)	165 (100%)	
Tumbuka	15 (26.3%)	42 (73.7%)	57 (100%)	
Yao	12 (32.4%)	25 (67.6%)	37 (100%)	
Other	6 (18.8%)	26 (81.2%)	32 (100%)	
Marital Status				< 0.01 (Highly Significant)
Married	28 (20.0%)	112 (80.0%)	140 (100%)	
Single	35 (37.2%)	59 (62.8%)	94 (100%)	
Widow	11 (47.8%)	12 (52.2%)	23 (100%)	
Divorced	6 (17.6%)	28 (82.4%)	34 (100%)	
Education Level				< 0.001 (Highly Significant)
Primary school / None	18 (12.9%)	122 (87.1%)	140 (100%)	
Secondary school	52 (46.4%)	60 (53.6%)	112 (100%)	
Tertiary	15 (38.5%)	24 (61.5%)	39 (100%)	
Employment Status				< 0.05 (Significant)
Employed	16 (17.8%)	74 (82.2%)	90 (100%)	
Self-employed	27 (31.4%)	59 (68.6%)	86 (100%)	
Unemployed	38 (33.0%)	77 (67.0%)	115 (100%)	

- **Highly Significant Factors:** *Education ($p < 0.001$) and Marital Status ($p < 0.01$) show the strongest crude variations in diarrhoea prevalence.*
- **Significance Thresholds:** *Single asterisks (*) denote statistical significance at $p < 0.05$. Double asterisks (**) denote strong statistical significance at $p < 0.01$. Values marked as $p > 0.05$ represent associations that could have occurred by random chance alone.*

Table 2
Multivariable Logistic Regression Analysis of Environmental WaSH and Biomedical Determinants
Associated with Infant Diarrhoea Presence

Independent Variables by Domain	Crude Odds Ratio (COR) (95% CI)	Adjusted Odds Ratio (AOR) [a] (95% CI)	p-value (aOR) [b]
DOMAIN 1: ENVIRONMENTAL WaSH DESCRIPTORS			
Access to Drinking Water Supply			
Safely managed	1.00 (Reference)	1.00 (Reference)	—
Basic service level	11.56 (3.49–38.24)	14.38 (6.51–31.75)	< 0.01**
Limited service level	7.56 (3.30–17.33)	8.78 (4.58–16.83)	< 0.01**
Family Sanitation Status			
Much the same	1.00 (Reference)	1.00 (Reference)	—
Much improved [c]	0.31 (0.13–0.75)	1.86 (1.02–3.36)	> 0.05
Has become worse	0.86 (0.27–2.69)	6.17 (2.60–14.64)	< 0.01**
Observed Physical Hygiene Level			
Good level of service	1.00 (Reference)	1.00 (Reference)	—
Intermediate level of service	2.77 (0.94–8.14)	7.31 (3.61–14.82)	< 0.01**
Poor level of service	8.95 (3.72–21.57)	12.64 (6.24–25.61)	< 0.01**
DOMAIN 2: BIOMEDICAL & FEEDING PRACTICES			
Child's Adherence to NVP (First 6 Weeks)			
Good adherence	1.00 (Reference)	1.00 (Reference)	—
Poor adherence	7.39 (0.68–80.13)	6.87 (1.30–36.24)	< 0.05*
Unknown / Undocumented	1.47 (0.10–21.16)	0.63 (0.10–3.92)	> 0.05
Child's Adherence to Cotrimoxazole			
Good adherence	1.00 (Reference)	1.00 (Reference)	—
Poor / Unknown adherence [d]	Non-Significant	Not Retained	> 0.05
Infant Feeding Modality			

Independent Variables by Domain	Crude Odds Ratio (COR) (95% CI)	Adjusted Odds Ratio (AOR) [a] (95% CI)	p-value (aOR) [b]
DOMAIN 1: ENVIRONMENTAL WaSH DESCRIPTORS			
Access to Drinking Water Supply			
Exclusive breastfeeding (EBF)	1.00 (Reference)	1.00 (Reference)	—
Mixed feeding	3.79 (0.26–55.73)	4.34 (0.39–48.71)	> 0.05
Complementary feeding	3.57 (0.22–57.18)	2.00 (0.17–23.44)	> 0.05
Replacement feeding	0.22 (0.01–6.70)	0.40 (0.02–10.02)	> 0.05

4. Discussion

The study shows that structural WaSH deficits exert a strong independent effect on diarrhoeal morbidity among HIV-exposed infants, demonstrating that biomedical protocols alone cannot counter environmental drivers of enteric disease. Inadequate sanitation, unsafe water, and poor hygiene significantly elevate diarrhoea risk after adjustment, consistent with evidence that environmental exposures dominate early-childhood pathogen transmission in resource-limited settings (Wolf et al., 2019; Prendergast & Humphrey, 2014; Platts-Mills et al., 2022; Kotloff et al., 2021). Poor hygiene, degraded latrines, and unsafe sanitation access were major predictors. Cotrimoxazole protects only against bacterial pathogens, offering no defence against viral or helminthic diarrhoea (WHO, 2021; Reiner Jr et al., 2018; Davis et al., 2017; Mwangi et al., 2022). The observed associations between maternal education, marital status, and diarrhoeal risk further highlight the social determinants shaping infant health. Higher maternal education was strongly protective, suggesting that knowledge, health literacy, and decision-making autonomy may buffer environmental risks. Similar patterns have been documented across sub-Saharan Africa, where maternal education consistently predicts improved hygiene practices, safer feeding behaviours, and reduced exposure to contaminated water sources (Fink et al., 2011). Marital status also emerged as significant, potentially reflecting household size, caregiving dynamics, and shared sanitation arrangements that increase exposure to contaminated facilities. Although higher maternal education was typically protective in child-health literature, the pattern observed in this cohort reflects several contextual mechanisms that may invert this relationship. Mothers with secondary or tertiary education were more likely to engage in formal employment outside the home, resulting in childcare being delegated to older siblings or informal minders whose hygiene practices were inconsistent. This increased infants' exposure to contaminated surfaces, unsafe feeding practices, and lapses in handwashing. Employment pressures also shorten exclusive breastfeeding duration, prompting earlier introduction of complementary liquids and foods often prepared with untreated water, thereby creating direct faecal-oral transmission pathways. Additionally, educated

mothers demonstrate higher health literacy and are more capable of identifying and reporting diarrhoeal episodes accurately, producing a surveillance effect that inflates observed prevalence relative to households where mild diarrhoea is normalized or overlooked. Finally, peri-urban residence; more common among educated mothers; often involves heavily shared sanitation facilities with high contamination loads. Together, these mechanisms explain why maternal education may behave as a risk amplifier in this specific context, despite its generally protective role globally.

Biomedical factors showed mixed effects. Poor adherence to neonatal NVP prophylaxis significantly increased diarrhoeal risk, underscoring the importance of early preventive therapy in immunologically vulnerable infants. In contrast, cotrimoxazole adherence did not retain significance in adjusted models, suggesting that high environmental pathogen loads may overwhelm its protective capacity consistent with the “biomedical blunting” mechanism. Environmental Enteric Dysfunction (EED), driven by chronic diarrhoea and helminth exposure, likely impairs nutrient absorption and reduces the efficacy of oral prophylaxis, a relationship documented in studies linking EED to poor ART absorption and accelerated HIV progression (Campbell et al., 2018; Keusch et al., 2014; Kosek et al., 2017). Strong associations between unsafe water access and poor hygiene conditions highlight a critical policy gap. Although improved WaSH infrastructure reduces diarrhoeal disease and helminth infections, integration of WaSH interventions into HIV care remains limited across sub-Saharan Africa. As global HEI populations approach 15 million, the absence of coordinated WaSH–HIV strategies represents a missed opportunity for reducing morbidity (UNICEF, 2022). Evidence supports integrated models combining biomedical protocols with household sanitation improvements, targeted hygiene promotion, and safe water access interventions shown to reduce enteric infections and improve growth outcomes (Pickering et al., 2019). These findings reinforce the study’s conceptual framework, demonstrating how structural WaSH deficits, chronic infections, and biological vulnerability converge to blunt biomedical efficacy.

4.1 Study Limitations

This cross-sectional study identifies epidemiological associations rather than causality, constrained by limitations including maternal recall bias, dry-season sampling, and a lack of specific pathogen data.

5. Conclusion and Policy Recommendations

Household WaSH conditions are the dominant predictors of diarrhoeal morbidity among HIV-exposed infants, surpassing biomedical and sociodemographic factors in magnitude and consistency. Biomedical protocols cannot compensate for unsafe water and sanitation; without structural improvements, clinical prophylaxis remains insufficient to disrupt the environmental reservoirs of infection that sustain recurrent enteric disease. The findings demonstrate that HIV programmes must integrate on-premises safe water, private improved latrines, and functional handwashing stations as core components of infant care rather than peripheral public-health add-ons. Structural WaSH improvements consistently outperform education-only interventions, underscoring the need for infrastructural investment rather than behavioural messaging alone. Embedding WaSH within HIV treatment and support services directly

advances SDGs 3 (Health), 6 (Clean Water), 8 (Economic Stability), and 10 (Equity), and represents a critical pathway for reducing preventable morbidity and improving survival among HIV-exposed infants in resource-limited settings.

Declarations

Ethics approval and consent to participate

Mzuzu University Research Ethics (Mzunirec/DOR/22/72)

Kasungu District Health Research Coordinating Committee (KDH PF 435)

Availability of data and materials

The data and materials used in this publication are available from the corresponding author on request.

Competing interests

The authors declare no competing interests

Funding

None

Acknowledgement

Not applicable

References

1. Afework A, Beyene H, Ermias A, Tamene A. Moving up the sanitation ladder: A study of the coverage and utilization of improved sanitation facilities and associated factors among households in Southern Ethiopia. *Environ Health Insights*. 2022;16:11786302221080825.
2. Anthonj C, Githinji S, Höser C, Stein A, Blanford J, Grossi V. Kenyan school book knowledge for water, sanitation, hygiene and health education interventions: Disconnect, integration or opportunities? *Int J Hyg Environ Health*. 2021;235:113756.
3. Babu S, Nutman TB. Helminth-induced immune regulation and viral co-infections. *Immunol Rev*. 2020;297(1):75–92.
4. Campbell SJ, Biritwum NK, Woods G, Velleman Y, Fleming F, Stothard JR. Tailoring water, sanitation, and hygiene (WASH) targets for soil-transmitted helminthiasis and schistosomiasis control. *Trends Parasitol*. 2018;34(1):53–63.
5. Chandna J, Ntozini R, Evans C, Kandawasvika G, Chasekwa B, Majo FD, Mutasa K, Tavengwa NV, Mutasa B, Mbuya MN, Moulton LH. Effects of improved complementary feeding and improved water,

- sanitation and hygiene on early child development among HIV-exposed children: Substudy of a cluster randomised trial in rural Zimbabwe. *BMJ Global Health*. 2020;5(1):e001718.
6. Chavura E, Singini W, Chidya R, Mbakaya BC. Combined effect of co-trimoxazole prophylaxis and safe water on diarrhea amongst HIV-exposed infants and people living with HIV/AIDS: A systematic review. *Eur Sci J*. 2023;13:83. <https://eujournal.org/index.php/esj/article/view/16320>.
 7. Davis NL, Wiener J, Juliano JJ, Adair L, Chasela CS, Kayira D, Hudgens MG, van der Horst C, Jamieson DJ, Kourtis AP. Co-trimoxazole prophylaxis, asymptomatic malaria parasitemia, and infectious morbidity in HIV-exposed, uninfected infants in Malawi: The BAN Study. *Clin Infect Dis*. 2017;65(4):615–24.
 8. Donkin A, Goldblatt P, Allen J, Nathanson V, Marmot M. (2018). Global action on the social determinants of health. *BMJ Global Health*, 3(Suppl 1), e000603.
 9. Eshetu T, Sibhatu G, Megiso M, Abere A, Baynes HW, Biadgo B, Zeleke AJ. Intestinal parasitosis and their associated factors among people living with HIV at University of Gondar Hospital, Northwest Ethiopia. *Ethiop J Health Sci*. 2017;27(4):411–20.
 10. George PJ, et al. Helminth infections and susceptibility to viral pathogens: Implications for HIV acquisition. *Front Immunol*. 2021;12:667–79.
 11. Ghosh K, Gupta SS, Chakraborty AS. Childhood morbidity and its association with socio-economic and health care conditions among under-five children in West Bengal: Evidence from NFHS-5, 2019–20. *J Public Health*. 2021;29:1127–38.
 12. Keusch GT, Rosenberg IH, Denno DM, Duggan C, Guerrant RL, Lavery JV, Tarr PI, Ward HD, Black RE, Nataro JP. Implications of acquired environmental enteric dysfunction for growth and development among children in low-income countries. *Food Nutr Bull*. 2014;35(2):112–23.
 13. Kim MJ, Chang HH, Kim SI, Kim YJ, Park DW, Kang C, Kee MK, Choi JY, Kim SM, Choi BY, Kim WJ. Trend of CD4 + cell counts at diagnosis and initiation of highly active antiretroviral therapy (HAART): Korea HIV/AIDS Cohort Study, 1992–2015. *Infect Chemother*. 2017;49(2):101.
 14. Kosek MN, The MAL-ED, Network, Investigators. Causal pathways from enteropathogens to environmental enteropathy: Findings from the MAL-ED birth cohort study. *EBioMedicine*. 2017;18:109–17. <https://doi.org/10.1016/j.ebiom.2017.02.024>. (doi.orgin Bing).
 15. Kotloff KL, et al. Burden of diarrhoeal disease in infants in sub-Saharan Africa. *Clin Infect Dis*. 2021;72(S1):S4–10.
 16. Lampejo T. *Toxoplasma gondii* infection in HIV-infected pregnant women: Epidemiology and risks of mother-to-child transmission. *Pan Afr Med J*. 2022;42:275.
 17. Maizels RM, McSorley HJ, Smits HH, Dijke T, P., Hinck AP. Cytokines from parasites: Manipulating host responses by molecular mimicry. *Biochem J*. 2025;482(9):433–49.
 18. Makaudze EM. (2019). Understanding the hygiene needs of people living with HIV and AIDS in Southern African Developing Community (SADC) countries. In *The relevance of hygiene to health in developing countries* (p. 39). IntechOpen.

19. Mallick R, Mandal S, Chouhan P. Impact of sanitation and clean drinking water on the prevalence of diarrhea among under-five children in India. *Child Youth Serv Rev*. 2020;118:105478.
20. Mawa PA, et al. Helminth co-infection and immune activation in HIV-infected adults. *Clin Infect Dis*. 2021;73(5):e1120–8.
21. Modjarrad K, Vermund SH. Helminth co-infection and HIV progression: Immune activation and viral replication dynamics. *Curr HIV/AIDS Rep*. 2020;17(4):350–9.
22. Mwangi TW, et al. Immune modulation by soil-transmitted helminths and consequences for viral control. *Parasite Immunol*. 2022;44(5):e12912.
23. Ng’ambi WF, Merzouki FA, Estill J, Orel E, Chimpandule T, Nyirenda R, Keiser O. Factors associated with the risk of HIV infection among HIV-exposed infants in Malawi: 2013–2020. *AIDS Res Therapy*. 2022;19:1–10.
24. Platts-Mills JA, et al. Enteric infections and growth failure in infants. *Nat Commun*. 2022;13:1104.
25. Prendergast AJ, Rukobo S, Chasekwa B, Mutasa K, Ntozini R, Mbuya MN, Humphrey JH. (2014). Stunting is characterized by chronic inflammation in Zimbabwean infants. *PLoS ONE*, 9(2), e86928.
26. Reiner RC Jr., Graetz N, Casey DC, Troeger C, Garcia GM, Mosser JF, Deshpande A, Swartz SJ, Ray SE, Blacker BF, Rao PC. Variation in childhood diarrheal morbidity and mortality in Africa, 2000–2015. *N Engl J Med*. 2018;379(12):1128–38.
27. Rollins NC, et al. Feeding practices and infectious morbidity among HIV-exposed infants. *Lancet Child Adolesc Health*. 2021;5(4):280–92.
28. Semba RD, Pee SD, Bloem MW. (2012). Integration of nutritional support with paediatric HIV care in developing countries. *CABI Reviews*, 1–14.
29. Spieth PM, Kubasch AS, Penzlin AI, Illigens BMW, Barlinn K, Siepmann T. Randomized controlled trials: A matter of design. *Neuropsychiatr Dis Treat*. 2016;12:1341–9.
30. Sumampouw OJ, Nelwan JE, Rumayar AA. Socioeconomic factors associated with diarrhea among under-five children in Manado coastal area, Indonesia. *J Global Infect Dis*. 2019;11(4):140–6.
31. UNAIDS. Global AIDS update 2021: Confronting inequalities. Joint United Nations Programme on HIV/AIDS; 2021.
32. Valdiserri RO, Holtgrave DR. Ending HIV in America: Not without the power of community. *AIDS Behav*. 2019;23(11):2899–903.
33. Webster HC. (2021). *Cytokine signals and immune competition in the Th2 response to helminth infection* (Doctoral dissertation). University of Glasgow.
34. Wolf J, Hunter PR, Freeman MC, Cumming O, Clasen T, Bartram J, Higgins JP, Johnston R, Medicott K, Boisson S, Prüss-Ustün A. Impact of drinking water, sanitation and handwashing with soap on childhood diarrhoeal disease: Updated meta-analysis and meta-regression. *Tropical Med Int Health*. 2018;23(5):508–25.

Figures

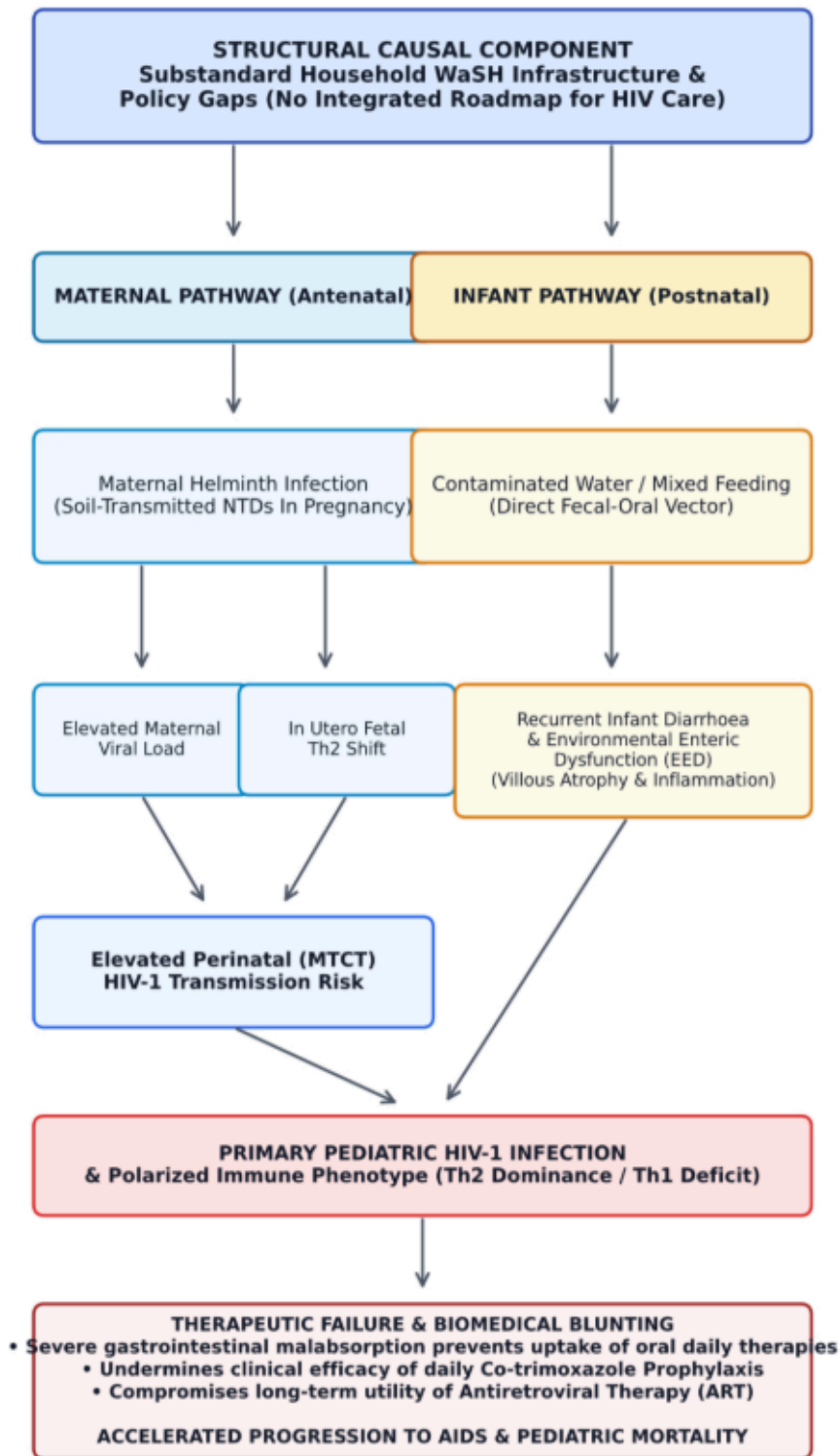


Figure 1

The Conceptual Framework

Adjusted Odds Ratios for Infant Diarrhoeal Risk (n = 291)

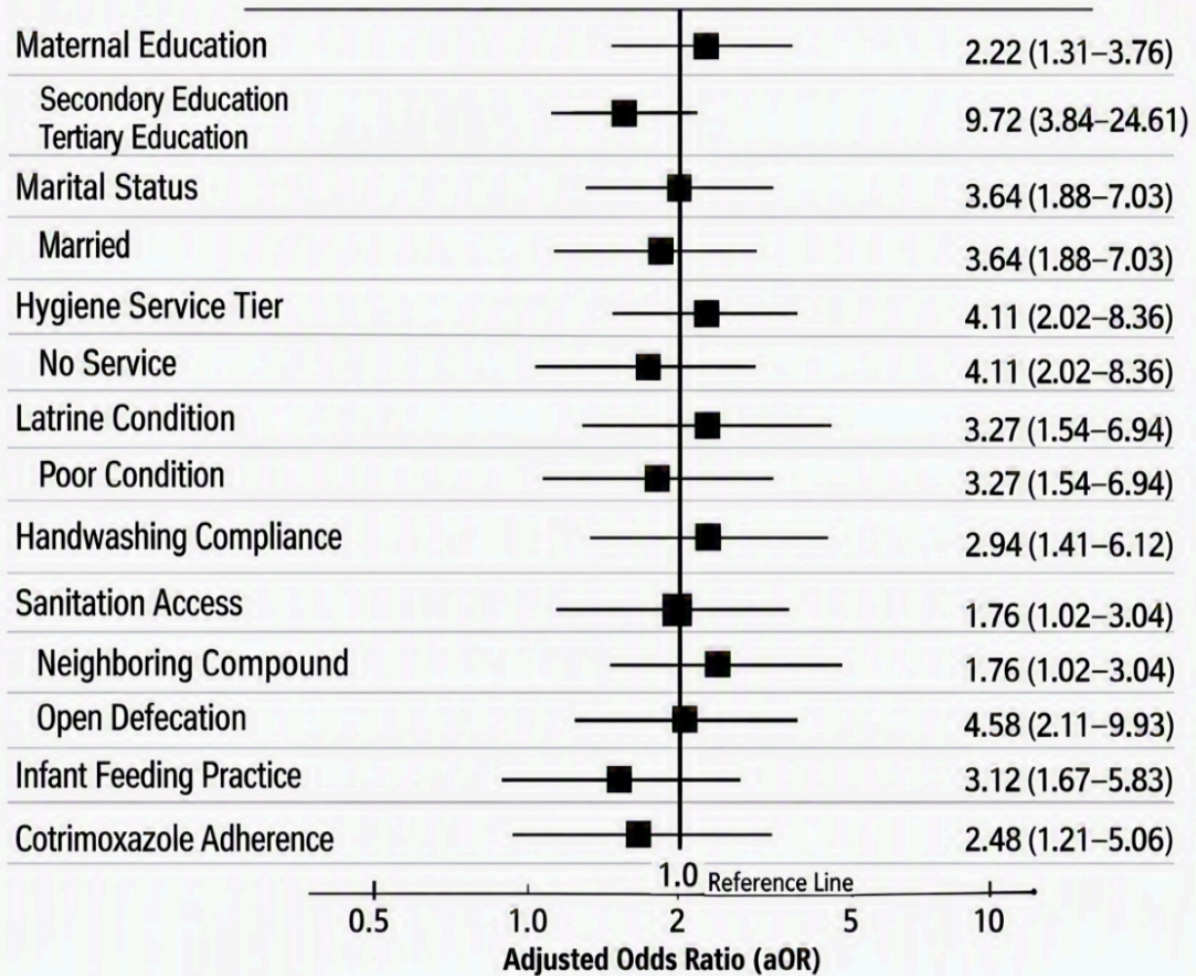


Figure 2

Adjusted Odds Ratios (aORs) for Infant Diarrhoea