

SYSTEMATIC REVIEW

Community-based interventions for preventing diarrhoea in people living with HIV in sub-Saharan Africa: A systematic review

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Abstract

Background

High prevalence rates of people living with HIV (PLHIV) are more predominant in sub-Saharan Africa compared to any region globally. Nonetheless, many people in the region have little access to safe water and live in poor sanitation environment. This region is, therefore, faced with a challenge in protecting PLHIV from infectious diseases that are transmitted through unhygienic conditions.

Aim

This systematic review was conducted to identify effective community-based interventions for the prevention of diarrhoea among PLHIV in sub-Saharan Africa.

Methods

Studies included in this systematic review were sought from PubMed, EMBASE, PsycINFO, AMED, CINAHL, DOAJ, Web of science, WHO Global Index Medicus Library, Cochrane and ProQuest (GeoRef). Articles were appraised using MMAT scale.

Results

From a search finding of 3,849 articles, only nine papers whose participants were people living with HIV and had incidence or prevalence of diarrhoea as an outcome met our inclusion criteria. Community-based interventions such as water treatment and safe storage were associated with 20% -53% reduction in diarrhoea episodes among PLHIV. The review has also demonstrated that the impact of hand hygiene and health education on the prevention of diarrhoeal infections is not adequately assessed.

Conclusion

Future studies are, therefore, warranted to assess the effect of hand hygiene and health education interventions on prevention and reduction of diarrhoea in PLHIV in Sub-Saharan Africa.

Keywords: PLHIV, effective interventions, water, hand-hygiene, sanitation.

Introduction

Human Immunodeficiency Virus (HIV) continues to be a major global public health issue, having claimed 35 million lives globally (since the initial cases), with one million deaths occurring in 2016 alone¹. According to the United Nations (UN), 36.7 million people are living with HIV globally and 25.5 million of these are in sub-Saharan Africa². Additionally, 2.1 million of the HIV infected people are children aged under 15 years². Diarrhoea and respiratory conditions are some of the main causes of death among people living with HIV (PLHIV)^{3,4}. Diarrhoea is defined as a passage of watery stools of more than 200ml per day⁵. According to the World Health Organisation (WHO), 644 000 people died due to diarrhoea related diseases in sub-Saharan Africa between 2000 and 2012, accounting for 67% of all the global deaths⁶. More than 88 per cent of these deaths were due to poor sanitation, unsafe water, and poor hygiene⁶. While there are many causes of diarrhoea in PLHIV, most of the cases are due to viral, bacterial and protozoal infections and

are spread through ingestion of contaminated food, water or objects^{6,7}. According to a joint report by WHO and the United Nations International Children's Emergency Funds (UNICEF), globally, sub-Saharan Africa has the highest number of people (319 million) without access to safe water⁷. Moreover, the number of people in sub-Saharan Africa without access to proper sanitation has increased since 1990 and is now pegged at 695 million⁷. In addition, places for hand washing where water and soap are available are only found in households with high income⁸. Improved water and sanitation can help reduce the number of deaths caused by diarrhoeal diseases⁷. Given the large proportion of PLHIV in the sub-Saharan region, where access to clean water and sanitation is limited and the compromised immunity that PLHIV have, it is important to identify suitable and cost-effective interventions to prevent diarrhoea in this group of people. The aim of this systematic review was to identify community-based interventions that prevent or reduce incidence of diarrhoea and their effectiveness

among PLHIV in sub-Saharan Africa. While the previous water, sanitation and hygiene (WASH) related systematic reviews focussed on interventions conducted in both low and high income countries,^{9,10} the current systematic review focused on community-based interventions conducted among PLHIV in sub-Saharan Africa. The findings of this study will, therefore, help to identify appropriate, suitable and cost-effective interventions for preventing diarrhoea in sub-Saharan African and other low-income countries. This review was conducted to answer the following question: how effective are the community-based interventions in reducing diarrhoea among PLHIV of all age groups in sub-Saharan Africa?

Methodology

Protocol

This review was guided by the proposed guidelines developed by the PROSPERO for systematic search and selection. PROSPERO is an international database for registering systematic reviews in various professions including the health sector¹¹. The protocol was published in the PROSPERO database with registration number CRD42016037835. Details about the protocol have been published elsewhere¹². In addition, a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram was used in this study to illustrate the number of articles retrieved, retained, excluded and reasons for every action. A PRISMA is a set of items founded on research evidence that improves and supports the reporting clarity of the systematic reviews and meta-analyses¹³. Lastly, a Mixed Method Appraisal Tool (MMAT) was used to appraise the studies included.

Inclusion criteria

Studies were eligible for inclusion in this systematic review if they reported on (1) an interventional or prospective cohort study; (2) participants who were living with HIV; (3) studies conducted in sub-Saharan Africa; (4) studies whose outcome was the incidence or prevalence of diarrhoea; and (5) studies that were conducted in a community setting.

Exclusion criteria

Articles were excluded from this study if they were: (1) retrospective cohort studies, case-control studies, qualitative studies, and analytical cross-sectional studies; and (2) written in languages other than English.

Information source /search strategy

The following database sources were used to gather the required information: PubMed, EMBASE, PsycINFO, AMED, CINAHL, Web of Science, WHO Global Index Medicus Library, Cochrane, ProQuest (GeoRef) and Directory of Open and Access Journals. MeSH database search in PubMed was conducted to identify search terms and keywords. These keywords combined with Boolean operations OR and AND were used to search and retrieve articles from the databases. The search strategy was confined to research articles published from 1983 to March 2016. The following key search terms were used: (HIV OR HIV OR HIV1 OR HIV2 OR human immunodeficiency virus OR AIDS OR acquired immunodeficiency syndrome) AND (interventions OR treatment OR strategy OR control OR prevention) AND (community OR family OR school

OR workplace OR neighbourhood OR household) AND (diarrhoea, OR dysentery OR waterborne disease OR bloody stool OR loose stool OR faeces). We also searched for key words related to WASH such as water, sanitation, and hygiene, WASH, water purification, water filtration, chlorinated water, clean water, safe water, water treatment, water quality, contaminated water, tap water, spring water, surface water, well, community based-care, and home based-care. Efforts were also made to identify both published and unpublished interventional studies by manually searching conference proceedings including the International AIDS Conference, IAS Conference on HIV Science, the Annual Conference on Retroviruses and Opportunistic Infections, Water Engineering and Development International Conference and the UNC Water and Health Conference. Additional searches to identify current and ongoing studies were made in the ClinicalTrials.gov website (<https://clinicaltrials.gov/>). We contacted seven researchers and experts who were working in the field of HIV and water to identify additional unpublished studies. Thereafter, identified studies were checked to determine their eligibility.

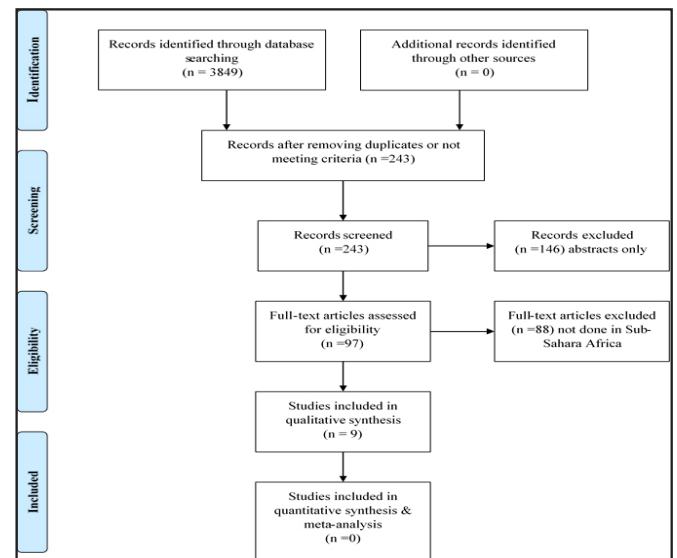


Figure 1: PRISMA Flow Diagram

Study selection

Articles identified from the databases were imported to Endnote X7 Reference Management System. Thereafter, the title, abstract and finally full articles were reviewed against the set inclusion criteria.

Data collection process

The process of data extraction started with a database search of relevant articles as described above and following the PRISMA guidelines (see Figure 1). Titles and/or abstracts of studies were retrieved and studies that potentially met the inclusion criteria as outlined above were identified. The full texts of potentially eligible studies were retrieved and independently assessed for eligibility by the two authors. The inconsistencies between the two authors over the eligibility of some studies were discussed and resolved with a third author. A table was used to extract data from the studies

Table 1: Characteristics of the studies included

| Author and year | Design | Location & setting | Interventions for control group | Interventions for study arm | Duration of follow up | Sample size | Objective |
|----------------------------|-----------------------------|-------------------------------|--|---|---|---|--|
| Peletz et al., 2012. | Randomized controlled trial | Community setting in Zambia | Instructed to continue usual practices throughout the study | LifeStraw Family Filter and two 5-litre safe storage (filtration technology) Training on use and maintenance | 7-12 months | Intervention: 61 households, 299 individuals Control: 59 households, 300 individuals | To assess the impact of the intervention on the longitudinal prevalence of diarrhoea among children < 2 years and all household members. |
| Walson et al., 2013 | Prospective cohort | Community setting in Kenya | Nothing was given | Water filtration device | 24 months | Intervention: 361 adults. Control: 228 adults. | To determine whether the use of simple point-of-use water filters can delay HIV-1 progression as indicated by CD4 count and incidence of diarrhoea. |
| Haris et al., 2009. | Cohort study | Community setting in Kenya | Nothing was given to the control group | Use of narrow-mouthed clay pot with lid and tap. Use of a sodium hypochlorite solution for water treatment. Instructions on food and water hygiene and on washing their hands with soap. | 1 year | Intervention: 252 infants. Control: 230 infants. | To determine whether safe water system reduces incidence of diarrhoea in HIV-exposed infants at the weaning period. |
| Lule et al., 2005 | Randomised clinical trial | Community setting in Uganda | Basic hygiene education | A 20-litre polyethylene vessel with a narrow mouth and a spigot One 500-mL bottle of 0.5% sodium hypochlorite solution, a cloth for water treatment. Cotrimoxazole prophylaxis. Basic hygiene education. | Median 547 days in the intervention and 556 days in the control | Intervention: 251 HIV positive and 761 HIV negative people. Control: 258 HIV positive and 760 HIV negative people. | To evaluate both the intervention and the potential for an additive effect on reducing the incidence of diarrhoea. |
| Barzilay et al., 2011. | Cohort study | Community setting in Nigeria | Nothing given (baseline survey) | A 25-litre jerry can with a narrow mouth Spigot and a comfortable handle. One 150ml bottle of 1.25% sodium hypochlorite. Instructions on the proper use of SWS. Basic hygiene and sanitation education. | 21 weeks | Intervention: 187 adult HIV positive women. Control: 242 adult HIV positive women | To evaluate the impact of a point-of-use water chlorination and storage intervention on diarrhoeal disease risk in a population of HIV-infected women. |
| O'Reilly et al., 2014. | Quasi-experimental design | Community setting in Ethiopia | Same interventions as study group, however, these interventions were provided at the end of the study. | 6 bottles of Wuha Agar, 24 sachets of PUR 20-litre Jerri can with a lid and tap, Bar of soap A health education booklet for appropriate water, treatment, sanitation and hygiene practices | 16 weeks | Intervention: 405 PLHIV Control: 344 PLHIV | To assess the use, acceptability, and health impact of the basic care packages on ART clients. |
| Pavlinac et al., 2014. | Prospective cohort | Community setting in Kenya | Nothing given (baseline survey) | Participants used a life straw family filtering device to prevent water contamination. | 24 months | Intervention: 361 adult females Control: 361 adult females | To evaluate the effectiveness of provision and home-based reinforcement of a point-of-use water filtration device to reduce diarrhoea among HIV-infected adults. |
| Mbori-Ngacha et al., 2001. | Randomized controlled trial | Community setting in Kenya | Infant feeding formula in another arm. All received health care when sick | Breastfeeding in one arm. All received health care when sick | 24 months | Intervention: 212 breastfeeding arm (197). Control: 213 formula-feeding arm (204) | To compare morbidity, nutritional status, mortality and cause of death among formula-fed and breast-fed infants of HIV-1 infected mothers. |

Table 2: Comparing main findings between studies

| Author & year | Outcome measure | Types of intervention | Effect of intervention in the intervention group | | |
|----------------------------|---------------------|---|--|--|--------------------------------|
| | | | Ratio | Confidence interval and p-value | Direction of effect |
| Peletz et al., 2012. | Diarrhoea incidence | -Filtered water -Safe water storage -Health education on use | LPR= 0.46, | 95% CI: 0.30–0.70; p=0.001 | Reduced incidence of diarrhoea |
| Walson et al., 2013. | Diarrhoea incidence | -Filtered water | RR= 0.65 | 95 % CI: 0.45-0.93 (p value not given) | Reduced incidence of diarrhoea |
| Haris et al., 2009. | Diarrhoea incidence | -Safe water storage -Water treatment -Health education -Hand washing | N/A (used mean) | (CI=N/A) (p <0.001) | Reduced incidence of diarrhoea |
| Lule et al., 2005 | Diarrhoea incidence | -Safe water storage -Water treatment -Health education | IRR= 0.75 | 95% CI: 0.59–0.94, p=0.015 | Reduced incidence of diarrhoea |
| Barzilay et al, 2011 | Diarrhoea incidence | -Safe water storage -Water treatment -Health education | N/A (used percentages) | (CI=N/A), p=0.04 | Reduced incidence of diarrhoea |
| O'Reilly et al., 2014. | Diarrhoea incidence | -Safe water storage -Water treatment -Health education -Hand washing -Bar of soap | N/A (used percentages) | CI=N/A, p=0.11). | Reduced incidence of diarrhoea |
| Pavlinac et al., 2014. | Diarrhoea incidence | -Filtered water | OR= 0.39 | 95% CI: 0.23–0.66, p<0.001 | Reduced incidence of diarrhoea |
| Mbori-Ngacha et al., 2001. | Diarrhoea incidence | -Breastfeeding in one arm -Standard healthcare | HR= 0.4 | 95% CI: 0.2-0.8, p=0.01. | Reduced incidence of diarrhoea |
| Abebe et al., 2014 | Diarrhoea incidence | -Filtered water -Safe water storage | ER= 0.23 | 95% CI: 0.19-0.27, p<0.0001. | Reduced incidence of diarrhoea |

CI= Confidence interval, HR=Hazard Ratio, OR= Odds Ratio, IRR= incidence rate ratio, RR= Relative Ratio, N/A= Not applicable, LPR=Longitudinal Prevalence Ratio, ER= Estimated Ratio

Table 3. MMAT scores for the included studies

| Type of study | Name of study | Methodological quality criteria | Criteria explained in the study? | Comments | Score |
|-----------------------------|---|---|----------------------------------|--|-------|
| Randomised controlled trial | Peletz et al., 2012. Assessing water filtration and safe storage in households with young children of HIV-positive mothers: a randomized, controlled trial in Zambia. | 2.1. Is there a clear description of the randomization (or an appropriate sequence generation)? | Yes | | 100% |
| | | 2.2. Is there a clear description of the allocation concealment (or blinding when applicable)? | Yes | No blinding of control participants. | |
| | | 2.3. Are there complete outcome data (80% or above)? | Yes | 84% completed follow up | |
| | | 2.4. Is there low withdrawal/drop-out (below 20%)? | Yes | 16% were lost to follow-up | |
| Prospective cohort | Walson et al., 2014. Evaluation of impact of long-lasting insecticide-treated bed nets and point-of-use water filters on HIV-1 disease progression in Kenya | 3.1. Are participants (organizations) recruited in a way that minimizes selection bias? | | Participants selected based on convenience | 75% |
| | | 3.2. Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes? | Yes | Used CD4 count machine, Malaria rapid test, Malaria film, Complete blood count. Reports of diarrhoea | |
| | | 3.3. In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups? | Yes | | |
| | | 3.4. Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)? | Yes | | |
| Cohort study | Haris et al., 2009. Effect of a point-of-use water treatment and safe water storage intervention on diarrhoea in infants of HIV-infected Mothers | 3.1. Are participants (organizations) recruited in a way that minimizes selection bias? | No | Two different time zones | 75% |
| | | 3.2. Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes? | Yes | | |
| | | 3.3. In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers consider (control for) the difference between these groups? | Yes | Cohort A (Aug 2003- March 2005). Cohort B (Aug 2005 – Jan 2007) | |
| | | 3.4. Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)? | Yes | Retained 77% in Cohort A and 85% in cohort B | |
| Randomised controlled trial | Lule et al., 2005. effect of home-based water chlorination and safe storage on diarrhoea among persons with human immunodeficiency virus in Uganda | 2.1. Is there a clear description of the randomization (or an appropriate sequence generation)? | No | | 50% |
| | | 2.2. Is there a clear description of the allocation concealment (or blinding when applicable)? | No | No concealment mentioned but tried to minimise confounding by exposure to health messages | |
| | | 2.3. Are there complete outcome data (80% or above)? | Yes | | |
| | | 2.4. Is there low withdrawal/drop-out (below 20%)? | Yes | | |

included for assessment of study quality and synthesis evidence. The details included; author, year of study, type of participants, age, setting, country, sample size, study design, methods, study purpose, study objectives, and study outcome measures. All relevant information was extracted from each study, summarized and documented.

Search outcome

An initial search of the databases and other sources yielded 3,849 articles. The titles of the identified articles were assessed, and 3,606 articles were removed because they were either duplicates or did not meet the inclusion criteria. Of the remaining 243 articles, 146 articles were excluded because they were abstracts only and 88 articles were removed because the studies were not conducted in sub-Saharan Africa or participants were not HIV positive. The remaining nine articles met our inclusion criteria (see Figure 1).

Quality appraisal

The MMAT tool¹⁴ was used to appraise nine studies included in the review. MMAT is a validated checklist used to appraise the quality of studies included in any systematic review with a quantitative, qualitative and mixed methods approach¹⁵⁻¹⁷. The MMAT has two general screening questions applicable to all study designs: (1) Are there clear qualitative and quantitative research questions or objectives, or is there a clear mixed methods question or objective?, and (2) Do the collected data address the research question or objective?

The MMAT appraises the following study methodologies and designs: qualitative, quantitative randomized controlled, quantitative non-randomized, quantitative descriptive and mixed methods study designs. The tool is divided into five sections, with each section used to appraise a specific study design or methodology (sections 1,2,3,4 and 5 are used to appraise qualitative, quantitative randomized controlled, quantitative non-randomized, quantitative descriptive, and mixed methods studies, respectively). Each section has numbered criteria for appraising studies as follows: four criteria for qualitative (1.1, 1.2, 1.3 & 1.4); four for quantitative randomized controlled trials (2.1, 2.2, 2.3 & 2.4); four for quantitative non-randomized studies (3.1, 3.2, 3.3 & 3.4); four for quantitative descriptive studies (4.1, 4.2, 4.3 & 4.4); and three for mixed study designs (5.1, 5.1 & 5.3) (see Table 3)¹⁴. All the criteria per entity sum up to 100% and each criterion has 25% power of quality except for the mixed methods study where the first 25% is given by default (as it has three criteria) followed by topping up with assessment scores per criteria. The total score per domain is a percentile and the higher the score, the better the quality¹⁴. The MMAT has a comparative advantage over other tools such as Jadad and MINORS (methodological index for non-randomized studies) because it is efficient and can concomitantly appraise different types of empirical studies¹⁴. Our systematic review included studies of different designs thus making MMAT a

Table 3 Cont.....

| | | | | | |
|-----------------------------|---|---|---------|---------------------------------------|------|
| Quasi-experiment | O'Reilly et al., 2014. Improved health among people living with HIV/AIDS who received packages of proven preventive health interventions, Amhara, Ethiopia | 3.1. Are participants (organizations) recruited in a way that minimizes selection bias? | No | Sample enrolled based on convenience. | 75% |
| | | 3.2. Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes? | Yes | | |
| | | 3.3. In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups? | Yes | | |
| | | 3.4. Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)? | Yes | | |
| Prospective cohort | Pavlinac et al., 2014. Water filter provision and home-based filter reinforcement reduce diarrhea in Kenyan HIV-infected adults and their household members | 3.1. Are participants (organizations) recruited in a way that minimizes selection bias? | Yes | | 100% |
| | | 3.2. Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes? | Yes | | |
| | | 3.3. In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups? | Yes | | |
| | | 3.4. Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)? | Yes | | |
| Randomised controlled Trial | Mbori-Ngacha et al., 2001. Morbidity and mortality in breastfed and formula-fed infants of HIV-1-infected women | 2.1. Is there a clear description of the randomization (or an appropriate sequence generation)? | Yes | | 75% |
| | | 2.2. Is there a clear description of the allocation concealment (or blinding when applicable)? | No | Not mentioned | |
| | | 2.3. Are there complete outcome data (80% or above)? | Yes | | |
| | | 2.4. Is there low withdrawal/drop-out (below 20%)? | Yes | | |
| Randomised Controlled Trial | Abebe et al. 2014. Evaluation of the use of ceramic water filter in improving the quality of drinking water and decreasing incidence of diarrhea among people living with HIV | 2.1. Is there a clear description of the randomization (or an appropriate sequence generation)? | Yes | | 75% |
| | | 2.2. Is there a clear description of the allocation concealment (or blinding when applicable)? | Unclear | | |
| | | 2.3. Are there complete outcome data (80% or above)? | Yes | | |
| | | 2.4. Is there low withdrawal/drop-out (below 20%)? | Yes | | |

Numbering system: The MMAT is divided into sections with numbered criteria for appraising different study methodology and designs as follows: four criteria for qualitative (1.1, 1.2, 1.3 & 1.4); four for quantitative randomized controlled trials (2.1, 2.2, 2.3 & 2.4); four for quantitative non-randomized studies (3.1, 3.2, 3.3 & 3.4); four for quantitative descriptive studies (4.1, 4.2, 4.3 & 4.4); and three for mixed study designs (5.1, 5.1 & 5.3). Qualitative and mixed methods criteria are missing in the table because the systematic review did not include any qualitative or mixed methods study.

Scoring metrics: Yes= stated item was done in the study (+25%); No= stated item was not done in the study (-25%) Unclear= not thorough appraising tool.

Synthesis of results

We identified community-based interventions used to reduce diarrhoea among PLHIV in sub-Saharan Africa. The meaning of community-based in this review refers to (1) a setting other than a health clinic or hospital where interventions were conducted (e.g. home, school, church, neighbourhoods, or workplace), and (2) community as a target (PLHIV found in the community setting). A subset analysis was done, categorized by type of intervention (water, hand hygiene, and sanitation) and type of community setting. A narrative synthesis was conducted based on the content analysis of the included articles. The papers were synthesized, rated and finally, the results were put in a table.

Results

Quality appraisal

Based on the score allocation as described in MMAT, three studies scored 100%, five studies scored 75% and one study scored 50%. Three review authors independently assessed the risk of bias in the studies included by considering the clarity of questions (objectives) in the articles and whether the data collected addressed the research questions. For all the non-RCT quantitative studies, the risk of bias was assessed by looking at the following: minimisation of selection bias during the process of recruiting participants for the

study; suitability of measurements against intervention and outcomes (clear origin or validity is known or standard instrument, and absence of contamination between groups when appropriate); and comparability of participants or taking into account the differences between groups being compared (exposed vs. non-exposed; with intervention vs. without). In addition, all non-RCT quantitative studies were assessed if there was complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above). The included studies are of moderate quality.

Study characteristics

The studies included in this review were conducted between 2001 and 2014. Six studies were more recent as they were conducted after 2010¹⁸⁻²³. Four studies were carried out in Kenya^{21, 23-25}. The remaining studies were each conducted in the following countries: Uganda²⁶; Nigeria¹⁹; Zambia²⁷, Ethiopia²⁰ and South Africa¹⁸. Six of the nine studies^{19, 21-24, 26} analysed in this study were also included in the previous WASH related systematic reviews by Peletz, et al.⁹ or Yates, et al.¹⁰, while the remaining three studies^{18, 20, 25} were reviewed neither by Peletz, et al.⁹ nor by Yates, et al.¹⁰.

Study participants

There was no age specification for the participants recruited in the studies included in this review. Articles reporting on studies conducted on participants of various ages were

included in the study if they met the inclusion criteria. The youngest participants were infants ≤ 5 months old in a study conducted by Harris, et al.²⁴. The oldest age was 69 years in a study by O'reilly, et al.²⁰. The number of participants in each study varied from 74 to 1,301.

Setting

All studies included in the review were conducted in sub-Saharan Africa, in the community setting. However, the recruitment of subjects was done in a clinic setting and then followed up in their homes in all the studies (9/9).

Types of interventions

Eleven interventions were identified in the studies included, namely: (1) use of sodium hypochlorite solution, a chemical used to decontaminate water to make it safe for drinking (4/9); (2) verbal or/plus booklet health education on proper handling of food, water hygiene and hand washing with soap (4/9); (3) a Life Straw Family Filter with a hollow-fibre cartridge used to remove pathogens from drinking water (3/9); (4) a 5-litre safe storage container used to prevent water contamination (1/9); (5) a narrow-mouthed clay pot used to prevent water contamination (1/9); (6) a 20-25 litre narrow-mouthed vessel with spigot used for dispensing water (3/9); (7) a ceramic water filters impregnated with silver nanoparticles used to remove pathogens from water (1/9); (8) bars of soap for hand washing (1/9); (9) breastfeeding infant (1/9); and (10) infant feeding formula (see Table 1). The studies assessed the effectiveness of these interventions in reducing incidences of diarrhoea among PLHIV. All the identified interventions had a positive effect in reducing the incidence of diarrhoea with rates ranging from 20% to 53% (see Tables 1& 2). The interventions were similar across the studies. However, they were different in terms of implementation duration, participants' characteristics, and material and financial resources. The common outcome measure among the reviewed articles was incidence of diarrhoea, either at primary or secondary level. The findings were further synthesised based on the type of intervention used and the study setting. The identified interventions were classified into three themes based on their similarity. The themes are; water, hand hygiene, and sanitation. (See detailed description below).

Water

Eight studies^{18-21, 23, 24, 26, 27} used interventions that preserved water through safe storage to prevent contamination or through treatment. The safe water storage interventions in the studies included 5-litre safe storage containers,²⁷ a narrow-mouthed clay pot with lid and tap,²⁴ a 20-litre polyethylene vessel with a narrow mouth and a spigot,²⁶ a 20-litre jerry can with a lid and tap²⁰ and a 25-litre jerry can with a narrow mouth, spigot, and a comfortable handle¹⁹. Three studies used a Life Straw water filter device^{21, 23, 27}. Another study conducted by Abebe, et al.¹⁸ used ceramic water filters impregnated with silver nanoparticles. Three studies decontaminated water through chlorination^{19, 24, 26}. In these studies, participants were given either a 500-mL bottle of 0.5% sodium hypochlorite, Water Guard, or a 150-mL bottle of 1.25% sodium hypochlorite solution and health education on how to use it.

The water treatment interventions were associated with

positive outcomes. For example, Pavlinac, et al.²¹ found that 8.7% of participants in an intervention group versus 17.2% in a control group reported diarrhoea three months after the provision of water filters²¹ (see Table 2). Peletz, et al.²², found that using the Life Straw Family Filter and two 5-litre safe storage containers was associated with a 53% reduction in the incidence of diarrhoea among PLHIV (see Table 2). Similarly, one study used a narrow-mouthed clay pot with a lid and tap, and Water Guard to treat and prevent water contamination²⁴. The authors reported significantly lower mean rates of clinic visits due to diarrhoea per infant-month in the intervention group during both the exclusive breastfeeding period ($p < 0.001$) and post weaning period ($p = 0.047$) in a study by Harris, et al.²⁴ (see Table 1). Lule, et al.²⁶ found a 20% reduction in diarrhoea episodes ($p = 0.047$) in an intervention group compared to those in a control group. In a study conducted by Barzilay, et al.¹⁹, water treatment and safe storage interventions resulted in a 36% decrease in reported episodes of diarrhoea between the pre- and post-intervention phases of the study ($p < 0.05$). Authors of the same study also reported an association of low-frequency use of Water Guard and higher episodes of diarrhoea compared to high-frequency use¹⁹. For example, the crude rate of diarrhoea episodes among low frequency users of Water Guard was 4.9 episodes per 100 person-days in pre-intervention phase compared to 4.2 episodes per 100 person-days in post-intervention phase, representing a 15% percent reduction in episodes of diarrhoea in post intervention phase from pre-intervention phase ($p = 0.47$). On the other hand, high-frequency use of Water Guard was associated with a pre-intervention crude rate of 6.6 episodes of diarrhoea per 100 person-days compared to 3.5 episodes per 100 person-days in post-intervention phase, representing a 46% percent reduction in episodes of diarrhoea in post-intervention phase from pre-intervention phase ($p = 0.04$)¹⁹. In a study conducted by Walson, et al.²³, lower self-reported episodes of diarrhoea among participants in the intervention group were observed (see Table 2). Abebe, et al.¹⁸, found that the mean rate of diarrhoea was 0.015 days/week in the intervention group compared to 0.064 days/week in the control group ($p < 0.001$), representing a 23% reduction in episodes of diarrhoea in the intervention group in comparison to the control group.

A randomized controlled trial by Mbori-Ngacha, et al.²⁵ compared breastfeeding to infant formula feeding in two study groups. Overall, there was no significant difference in the incidence of diarrhoea between formula and breastfeeding groups among HIV-infected infants. However, the incidence of diarrhoea was significantly higher in the formula group in the first three months compared to the breastfeeding group (HR = 2.1; 95% CI: 1.2-3.8)²⁵. On the other hand, the incidence of diarrhoea with more than five stools per day was significantly lower in the formula feeding group between ages 18 and 21 months (HR = 0.4; 95% CI: 0.2-0.8)²⁵ (see Table 2).

Hand hygiene

Five studies^{19-21, 24, 26} gave their subjects health education on basic hygiene. Participants in the intervention group of the study by O'reilly, et al.²⁰ were observed to have purchased

soap after two weeks of study commencement. However, it is not clear what the soap was being used for. Barzilay, et al.¹⁹ tried to assess the hand washing facility for either availability of soap or hand washing process. The authors later observed that participants in the intervention group started washing hands after defecating¹⁹. Lule, et al.²⁶ found that participants in the intervention group had water for hand washing and reported hand washing more frequently after defecation. These results, nonetheless, were not statistically significant. Most of the studies included in this review did not directly associate these interventions or observations with diarrhoea. A Kenyan study found a modest reduction in self-reported diarrhoea three months after education compared with three months before the home visit (7.7% versus 13.3%; OR=0.50, 95% CI: 0.20–0.99, $p=0.047$)²¹. However, they did not explain in detail the content of the health education messages given to participants.

Sanitation

Four studies^{19, 21, 24, 26} encouraged participants' sanitation and hygiene practices and gave health education to prevent diarrhoea. Lule, et al.²⁶ found that both the intervention and control groups had similar sanitary conditions, hygienic practices, and baseline *Escherichia coli* colony counts (in colony-forming units per 100 mL). Toilet facilities were assessed in a study by Barzilay, et al.¹⁹ and almost three-quarters of the participants had flush toilets, and very few individuals (6%) had no toilets. Toilet environments were also assessed for the presence of faeces. However, the authors neither further reported the association of these findings with any of their outcomes nor explicitly explained what information was included in their sanitation health education.

Discussion

This is the first systematic review aimed to identify effective community-based interventions to prevent and reduce diarrhoea among HIV-positive people, with a focus on sub-Saharan Africa. We searched for research articles that used diarrhoea prevention interventions among HIV-positive people published from January 1983 to March 2016. This systematic review identified nine interventional studies and synthesized the articles' findings based on the type of intervention used to prevent diarrhoea in PLHIV in sub-Saharan Africa. The review identified three main categories of findings, namely: water, hand hygiene, and sanitation. The methodology of the reviewed articles was appraised using the MMAT¹⁴. Three studies were of high quality and six studies were of moderate quality according to MMAT. As such, the outcome of this synthesis can be relied upon to inform education, practice, and policy regarding community-based interventions for reducing diarrhoea among people living with HIV in sub-Saharan Africa.

The results of this systematic review show that community-based interventions (see Table 2) are associated with 20%–53% reduction rate in diarrhoea episodes among PLHIV. The largest diarrhoea reduction rate resulted from using One Life Straw Family filter and two 5-L safe storage containers to prevent water contamination by participants²². On the other hand, the smallest reduction in the incidence of diarrhoea was reported in a study conducted by Lule, et al.²⁶ that used

a 20-liter polyethylene vessel with a narrow mouth and a spigot to prevent water contamination. Even though both studies were clinical randomized trials, the setting, sample size and duration of the study were different (see Table 1). Similarly, water treatment at point-of-use has been reported to be effective in studies conducted elsewhere^{28, 29}.

Results also show that very few studies used hand hygiene as a diarrhoea preventive measure, yet hand-washing is the single most important action and primary measure a person can take to reduce the spread of diarrhoea because it breaks the transmission cycle of many infectious diseases such as diarrhoea^{30–32}. Proper handwashing with soap can reduce contamination of hands and consequently reduce the risk of diarrhoea by 34 to 50%^{33–38}. Perhaps, authors of articles included in this review considered the fact that hand washing and soap usage can be difficult to measure since they are mostly self-reported and participants tend to over-report the frequency³⁹. Of the three main types of community-based interventions identified in this study, those that fall into the category of water were the most commonly used. All the identified interventions (aimed at hand washing, storage of water in safe containers and health education on hygiene and sanitation) can be affordable and readily accessible in sub-Saharan Africa and in other low-income regions. Given that two-thirds of PLHIV are in sub-Saharan Africa, where there is limited access to safe water and proper sanitation facilities, it is important that governments in this region consider including these eleven interventions in HIV/AIDS management guidelines. Health professionals working in antiretroviral therapy clinics and in communities should also educate the masses and promote the use of these interventions among PLHIV. Future studies should consider the use of all the three major categories identified in this review and evaluate their effectiveness.

This review builds on previous systematic reviews by Peletz, et al.⁹ and Yates, et al.¹⁰. There are similarities between the current review and those conducted by Peletz, et al.⁹ and Yates, et al.¹⁰. First, the prevention of diarrhoea diseases was the main outcome of the reviews. Second, both systematic reviews focused on WASH-related interventions such as hand washing, treatment of drinking water, and hygiene. Third, both reviews involved improving the quality of life of PLHIV. On the other hand, the current study analysed all community-based interventions some of which were not included in the previous two reviews, specifically, breastfeeding in a study by Mbori-Ngacha, et al.²⁵; ceramic water filters impregnated with silver nanoparticles by Abebe, et al.¹⁸; and a health education booklet for appropriate water, treatment, sanitation and hygiene practices in a study conducted by O'reilly, et al.²⁰. Finally, our review focused on studies conducted in sub-Saharan Africa unlike previous systematic reviews that included studies conducted globally. The findings of the current systematic review on household water treatment and safe storage are similar to those reported by Peletz, et al.⁹ and Yates, et al.¹⁰, despite these studies using different study quality evaluation tools. Peletz, et al.⁹ conducted a systematic review of 10 controlled studies. Seven studies, which had sufficient information, were included in a meta-analysis. The methodological quality of the studies was

measured using Cochrane EPOC risk of bias tool. On the other hand, the systematic review by Yates, et al.¹⁰ included 16 studies (both controlled and uncontrolled). There was no specific tool that was used to measure the methodological quality of the study. The quality of evidence was assessed through rating the studies as “strong,” “medium,” or “weak” by considering the quality of the study design, cohort population, and sample size.

Limitations

The limitations of this review are as follows: firstly, despite including quality studies in this review, all the RCT studies synthesized in this review had no adequate allocation concealment or blinding and this might have introduced selection bias⁴⁰. Inadequate concealment might have influenced some investigators to enrol or select study participants whom they thought might benefit more from the interventions resulting in selection bias⁴⁰. Secondly, the review was limited to studies written in English. This may have led to some bias because articles in languages other than English could have contributed significantly to this systematic review in terms of study outcomes. Thirdly, all the articles included in this review were conducted in sub-Saharan Africa. As such, the review may not be generalizable to other global settings. In addition, this review did not consider the age differences when comparing the impact of the interventions on diarrhoea among PLHIV considering that immunity levels differ between people of different age groups, for instance children and adults. Apart from these, some of the studies had no detailed explanation of how interventions were carried out. For instance, one of the interventions carried out in four of the nine studies was hygiene and sanitation health education although it was not clearly explained across the studies^{19, 21, 24, 26}. In another study by Harris, et al.²⁴, hand hygiene was promoted as one way of preventing diarrhoea among PLHIV. Nonetheless, no clear instructions on the hand washing procedure were given to participants. For hand washing to be effective, people need to know when, why and how to wash hands^{30, 31}. Despite these shortfalls, this review has identified effective interventions which, if promoted, could reduce the burden of diarrhoea among people living with HIV.

Conclusion

This review has demonstrated that water treatment and safe storage community-based interventions used in this study are effective in the prevention of diarrhoea among PLHIV in sub-Saharan Africa. The findings of the current review confirm the findings of previous WASH-related reviews^{9, 10} that demonstrated positive outcomes of household water treatment and safe storage in the prevention of diarrhoea among PLHIV. The current systematic review has also identified health education as an intervention despite being inadequately assessed in previous systematic reviews. Furthermore, there is limited research evaluating the effect of hand hygiene and sanitation on prevention and reduction of diarrhoea among PLHIV in sub-Saharan Africa. More studies are, therefore, required to assess the impact of health education, hand hygiene and sanitation interventions on the reduction of diarrhoea in PLHIV in sub-Saharan Africa. Future studies should also investigate the differences in the

impact of these interventions on reducing diarrhoea between children and adults living with HIV. In addition, future studies should consider assessing the impact of combining all categories of community-based interventions reported in this study on the prevention of diarrhoea and the related complications.

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