Received: 9 May 2023 | Revised: 29 January 2024 | Accepted: 31 January 2024

DOI: 10.1111/mcn.13634

REVIEW ARTICLE

Maternal & Child Nutrition WILEY

Household-level water, sanitation and hygiene factors and interventions and the prevention of relapse after severe acute malnutrition recovery: A systematic review

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Abstract

Severe acute malnutrition (SAM) is the most serious form of acute malnutrition and is associated with high mortality risk among children under 5. While the Community-based Management of Acute Malnutrition (CMAM) approach, recommended for treating cases of uncomplicated SAM, has increased treatment coverage and recovery outcomes, high relapse rates have been reported. Several risk factors for SAM relapse, such as insufficient food intake and high infectious disease burden in the community, have been identified. However, the role of household water, sanitation and hygiene (WASH) conditions remains unclear. This systematic review: (1) assesses the effectiveness of WASH interventions on preventing SAM relapse and (2) identifies WASH-related conditions associated with relapse to SAM among children aged 6–59 months discharged as recovered following SAM CMAM treatment. We performed electronic searches of six databases to identify relevant studies published between 1 January 2000 and 6 November 2023 and assessed their quality. After deduplication, 10,294 documents were screened by title and abstract, with 13 retrieved for full-text screening. We included three studies ranging from low- to medium-quality. One intervention study found that providing a WASH kit during SAM outpatient treatment did not reduce the risk of relapse to SAM. Two observational studies found inconsistent associations between household WASH conditions—unimproved sanitation and unsafe drinking water—and SAM relapse. Despite the paucity of evidence, the hypothesised causal pathways between WASH conditions and the risk of relapse remain plausible. Further evidence is needed to identify interventions for an integrated postdischarge approach to prevent relapse.

KEYWORDS
hygiene, relapse, sanitation, severe acute malnutrition, water

1 | INTRODUCTION

Acute malnutrition is a global public health problem affecting at least 45 million children under the age of five worldwide and contributing to nearly 1 million child deaths annually (UNICEF, World Health Organization [WHO], & World Bank, 2023). In 2020, approximately two-thirds of all children with acute malnutrition lived in Asia and more than one-quarter in sub-Saharan Africa (Ssentongo et al., 2021; UNICEF, WHO, & World Bank, 2020). Acute malnutrition is classified as either moderate acute malnutrition (MAM) or severe acute malnutrition (SAM) based on anthropometric indicators and/or the presence of oedema (WHO, 2023; WHO, & UNICEF, 2009). SAM is defined as having a weight-for-height *z*-score (WHZ) less than three standard deviations (SDs) from WHO child growth standards, a mid-upper arm circumference (MUAC) less than 115 millimetres (mm) and/or the presence of bilateral oedema (UNICEF, WHO, & World Bank, 2020; WHO, 2023; WHO & UNICEF, 2009). SAM represents the most life-threatening form of acute malnutrition and has been associated with low socioeconomic status, inadequate nutrient intake, lack of access to adequate health services and concurrent disease (WHO, 2021). Health consequences for children suffering from SAM include weakened immunity, susceptibility to disease and increased risk of mortality (UNICEF, WHO, & World Bank, 2020). The risk of all-cause mortality among children under five identified as SAM by low MUAC (<115 mm) and WHZ (*z*-score < −3) is eight times higher compared to children without SAM (Schwinger et al., 2019).

SAM has commonly been addressed through the WHO and UNICEF-recommended Community-based Management of Acute Malnutrition (CMAM) approach since its introduction in 2000 (WHO, 2013, 2023; WHO, WFP, & UNICEF, 2007). The approach includes inpatient treatment for children with complicated SAM and outpatient treatment for children with uncomplicated SAM (WHO, 2013, 2023). Children with complicated SAM, characterised by concurrent illness, severe oedema or poor appetite, require inpatient care to treat their acute illnesses while undergoing nutritional recovery. Children with uncomplicated SAM (i.e., no significant medical complications and sufficient appetite) are treated through the outpatient therapeutic programme (OTP) (WHO, 2013, 2023). The OTP includes ready-to-use therapeutic foods (RUTF) to be administered at home, a short course of antibiotics and regular visits to the closest health facility for up to 12 weeks. According to WHO recommendations, children admitted or readmitted to an OTP are discharged as cured when they have a WHZ ≥ −2 SD or MUAC ≥ 125 mm and no oedema for at least 2 weeks (WHO, 2013, 2023). Approximately 80 countries use the CMAM approach, though the specific admission and discharge criteria may differ according to national policies and guidelines (UNICEF, 2015).

CMAM programmes have been reported as effective at treating children with SAM to recovery (Alvarez Morán et al., 2018; Chang et al., 2013), but children remain at risk of relapsing, especially in the first 3 months following discharge (Stobaugh, Mayberry, et al., 2018; Stobaugh, Mayberry, et al., 2018). SAM relapse is defined as a new episode of SAM (i.e., MUAC < 115 mm or WHZ < −3 SD, and/or presence of bilateral oedema) after being discharged as cured from an OTP (O'Sullivan et al., 2018; WHO & UNICEF, 2009). However, evidence on SAM relapse is generally sparse and estimates have been highly variable due to contextual factors and methodological differences in SAM classification and reporting (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018). SAM relapse rates reported in the literature range from 9% to 37%. For example, 9% in Bangladesh (Banerjee et al., 2016), 10% and 37% in Malawi (Chang et al., 2013; Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018) and 15% and 34.6% in Ethiopia (Girma et al., 2022; Tadesse et al., 2018).

> **Key messages**
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> - This systematic review highlights a paucity of evidence on the relationship between household water, sanitation and hygiene (WASH) conditions and the prevention of severe acute malnutrition (SAM) relapse.
> - There are limited high-quality studies assessing the effectiveness of household-level WASH interventions in preventing uncomplicated SAM relapse among children 6–59 months discharged from outpatient programmes.
> - Equally, there are very few studies and of limited quality on household WASH risk factors associated with relapse to SAM.
> - While it is biologically plausible that household WASH conditions could influence the risk of SAM relapse, additional and high-quality research is needed to investigate if and how postdischarge WASH interventions might reduce this risk.

Many of the populations with inadequate access to safe drinking water and sanitation services also experience high levels of undernutrition (Prüss-Üstün et al., 2016, 2019; Ziegelbauer et al., 2012). Poor water, sanitation and hygiene (WASH) are estimated to account for 16% of the undernutrition burden in children under the age of five globally (Prüss-Üstün et al., 2016, 2019). Most responses to acute malnutrition are nutrition-specific, but there have been recent initiatives to address underlying determinants of undernutrition, such as water and sanitation, through nutrition-sensitive WASH interventions (ACF, 2017). Yet, there is mixed and limited evidence on whether and how WASH and nutrition interventions should be integrated for the prevention, treatment and long-term recovery of SAM (Patlán-Hernández et al., 2022).

Efforts have been made to understand the causal links between poor WASH conditions and malnutrition to develop interventions that target the specific underlying causes of SAM (ACF, 2017; Dangour et al., 2013; UNICEF, 2013). The conceptual framework linking poor water supply and quality, sanitation, and hygiene with the risk of SAM relapse identifies both direct and indirect hypothesised causal pathways (Figure 1 and Supporting Information S1: A1). Direct pathways

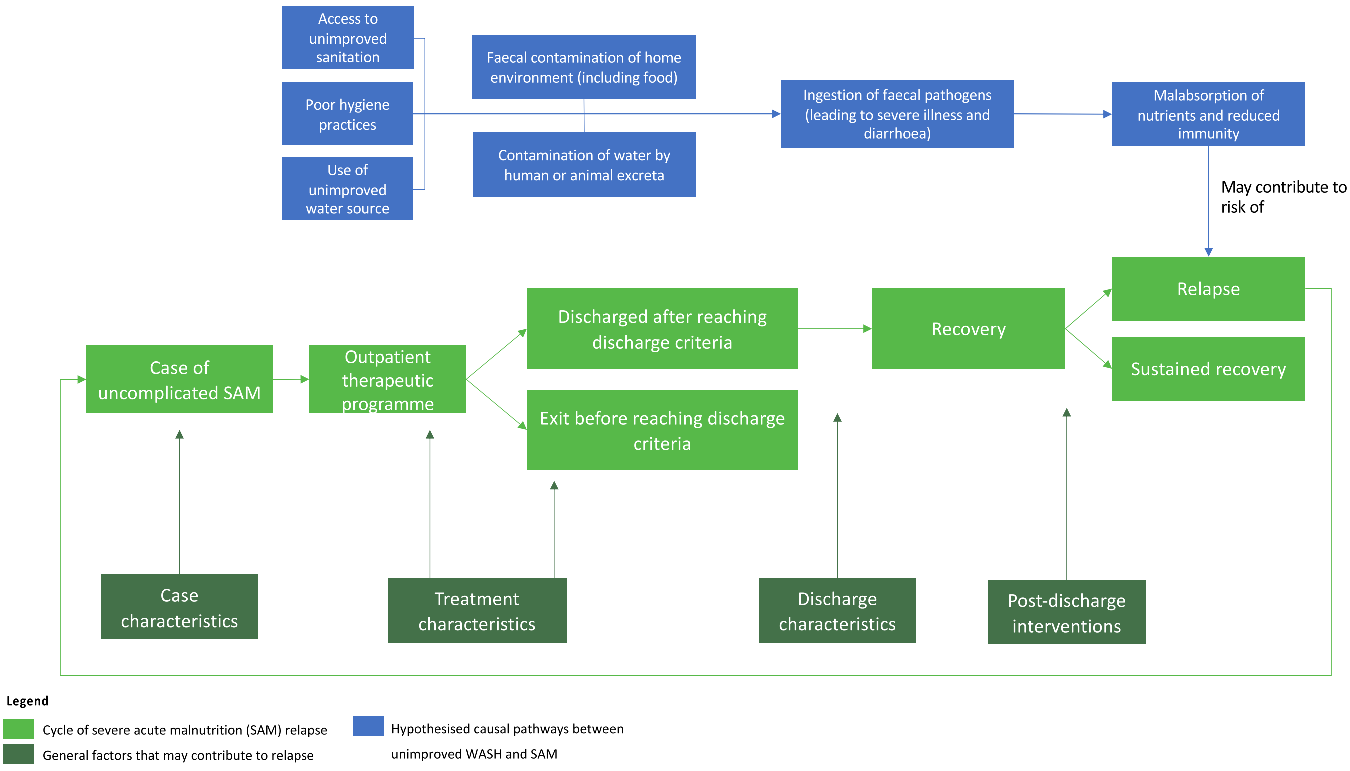

FIGURE 1 Conceptual framework developed for this systematic review linking WASH conditions and SAM and SAM relapse. SAM, severe acute malnutrition; WASH, water, sanitation, and hygiene.

relate to the body's ability to respond to infection and its related impact on nutritional status and health. The main direct biological mechanisms include repeated diarrhoea episodes, helminth infections and environmental enteric dysfunction (Cumming & Cairncross, 2016). These biological mechanisms are hypothesised to be caused by unsanitary living conditions and access to unimproved WASH services (Dangour et al., 2013). Access to adequate and reliable WASH services can therefore help to prevent infectious diseases, including enteric infections (Budge et al., 2019; Wolf et al., 2018). Indirect pathways relate to the household's ability and time to provide safe and clean living environments and adequate care to children. In addition, household water security (i.e., reliable availability, accessibility and quality) is critical for many nutrition-related behaviours and activities, such as food production and preparation and infant and young child feeding, that affect food intake (Miller et al., 2021; Schuster et al., 2020). Indirect causal pathways also include broader socioeconomic conditions, including available sanitation and hygiene services, education and income level (Budge et al., 2019; Cumming & Cairncross, 2016; Guerrant et al., 2008; Schaefer et al., 2020). Ultimately, these factors are embedded in the larger political and economic environment (Cumming & Cairncross, 2016; Schaefer et al., 2020). In the context of OTP, it is plausible that children discharged as recovered from OTP may be predisposed to relapse to SAM after returning to the same household environment with unimproved WASH conditions, which renders a higher risk of enteric infection and disease (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018). Understanding the association between household WASH conditions and the risk of SAM relapse can inform future postdischarge interventions.

The aim of this systematic review is to (1) assess the effectiveness of household-level WASH interventions on preventing relapse to SAM and (2) identify household-level WASH risk factors associated with relapse to SAM among children 6–59 months discharged from CMAM outpatient programmes.

2 | METHODS

Methods and results are reported in accordance with the Preferred Report Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2015) (Supporting Information S1: Table A1). The study protocol was registered with PROSPERO (CRD42022379839).

2.1 | Search terms

Electronic searches were conducted across six databases—PubMed including MEDLINE (general medicine), Cochrane Library, Global Health (public health), EMBASE (general medicine), Web of Science and WHO Global Index Medicus—on 9 January 2023 using keyword searches and Medical Subject Headings terms (Supporting Information S1: Table A2). The database searches were rerun on 6 November

2023 to identify new documents published since 9 January 2023. Each search term, with synonyms, variations and subject headings, was combined and truncated to capture all possible variations of relevant terms. The search was restricted to studies published after 1 January 2000 to reflect the introduction of the WHO-recommended CMAM guidelines for SAM treatment and prevention in 2000 (WHO, WFP, & UNICEF, 2007). Search terms were used to capture the relevant age group of 6–59 months.

2.2 | Study selection

Studies were included in the review if they met the following criteria: (i) published in English; (ii) published between 1 January 2000 and 6 November 2023, (iii) study design, as defined by the Cochrane guidelines (The Cochrane Collaboration, 2023), included individual- and cluster-randomised, quasi-randomised and nonrandomised controlled trials, case–control studies, cohort studies, cross-sectional studies and interrupted time series analyses; (iv) study population included children with uncomplicated SAM aged 6–59 months enroled in CMAM programmes and subsequently discharged as cured; (v) assessed household-level WASH interventions, either as stand-alone or in combination with other non-WASH interventions, and/or WASH conditions and (vi) outcomes included relapse to SAM up to 12 months postdischarge following recovery from outpatient treatment for intervention studies and WASH risk factors for relapse to SAM for nonintervention studies (WHO, 2021). The age group was selected based on WHO (2013) CMAM guidelines to target children in this age range who are most at risk of acute malnutrition. Peer-reviewed articles and preprints (Higgins et al., 2023) identified through the database search were eligible for inclusion.

Studies were excluded if: (i) SAM was defined differently than in WHO (2013) guidelines; (ii) children with SAM received health facility-based care due to differences in admission criteria, treatment guidelines and setting that limited the comparability of treatment outcomes; (iii) cases of complicated and uncomplicated SAM cases could not be analysed separately or children with uncomplicated SAM comprised <50% of study participants to limit overstating results from small sample sizes or (iv) SAM and MAM relapse cases that could not be analysed separately. The review did not consider WASH interventions in non-domestic settings, such as in health care facilities or at the community level (i.e., piped network water supplies).

2.3 | WASH interventions

Household-level WASH conditions and interventions are defined in accordance with those previously published in Cochrane reviews (Dangour et al., 2013) and by the WHO and UNICEF (2021) Joint Monitoring Programme. Based on these definitions, we considered the following four WASH categories: (1) water quantity: access to an improved drinking water source or any intervention aimed at increasing the amount of water available to a household (e.g., introducing a new safe and reliable water supply and/or improving distribution), (2) water quality: improved microbiological quality of drinking water, or any intervention that removes or inactivates microbiological pathogens (e.g., point-of-use chlorination and filtration) or protecting microbiological water quality before consumption (e.g., protected distribution and improved storage), (3) sanitation: access to an improved sanitation facility or any intervention aimed at introducing and/or expanding access to and use of improved sanitation facilities that hygienically separate excreta from human contact (e.g., pit latrine with slab, ventilated improved pit latrine, septic tank or piped sewer system) and (4) hygiene: access to a handwashing facility or any intervention that promotes the adoption or increased practice of handwashing with soap at key moments (e.g., after toilet use, disposal of child faeces, and before preparing and handling food) or food safety (i.e., hygienic food preparation and storage practices).

2.4 | Outcome definition

The primary outcomes of interest for this review are (1) relapse rates to SAM following recovery from outpatient treatment for intervention studies and (2) household-level WASH risk factors for relapse to SAM for non-intervention studies. For this review, SAM was defined as MUAC < 115 mm or WHZ < −3 SD and/or the presence of bilateral oedema (WHO, 2013). There is no standard follow-up period for measuring SAM relapse (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018). However, Schaefer et al. (2020) recommend defining SAM relapse as an episode of SAM within 6 months of being discharged as cured (WHZ ≥ −2 or MUAC ≥ 125 mm and no oedema for at least 2 weeks) from OTP. For this review, we specified a maximum 12-month postdischarge follow-up period to capture all possible studies related to SAM relapse. SAM, relapse, and relapse rate definitions are reported for each study as definitions typically vary across settings due to differences in national policies and guidelines. SAM relapse rates may be measured as a cumulative proportion (i.e., the proportion of children readmitted for SAM treatment postdischarge among all those admitted for treatment), incidence rate (i.e., number of children readmitted for SAM treatment throughout a certain time period), or point prevalence (i.e., percentage of children in the state of relapse at specific timepoint) (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018).

2.5 | Screening process, data extraction and analysis

All documents retrieved from electronic searches were transferred to Endnote for de-duplication. After removing duplicates, all titles and abstracts were screened independently by two reviewers (CM, LN). Full texts of all potentially eligible documents were retrieved and independently assessed for inclusion by two reviewers (CM, LN).

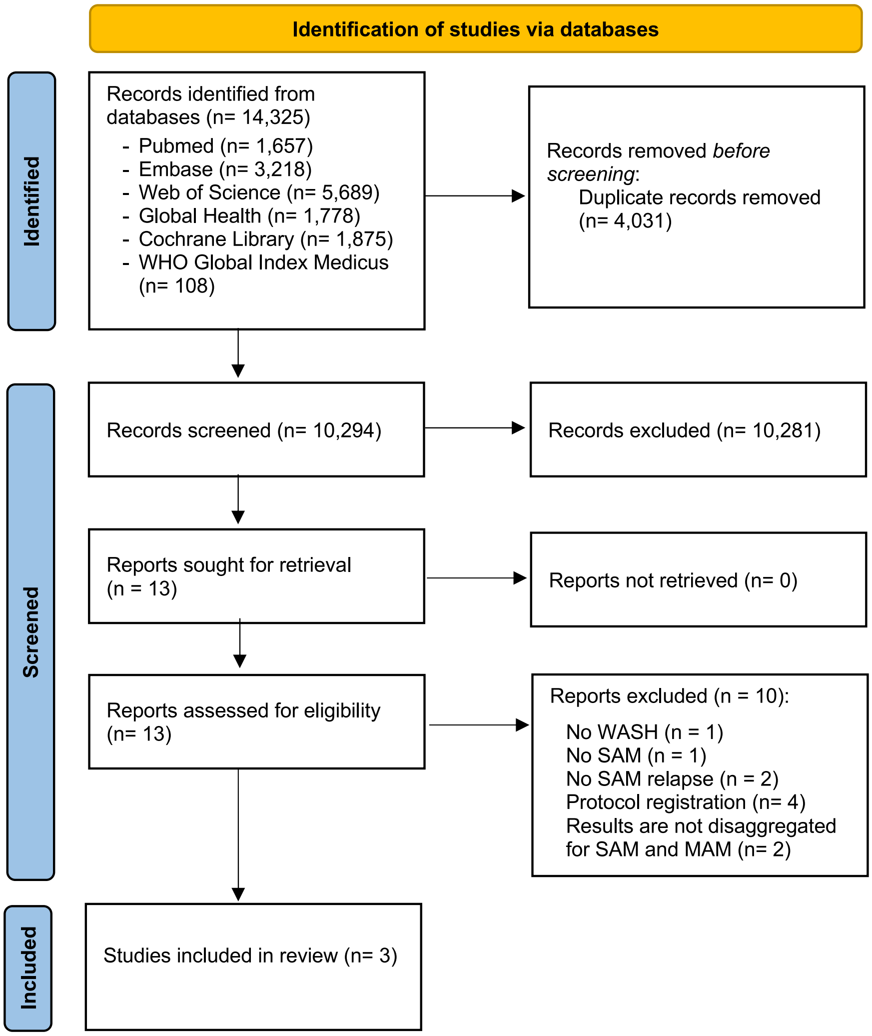

FIGURE 2 Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram. SAM, severe acute malnutrition; WASH, water, sanitation, and hygiene.

Any disagreement regarding the criteria was resolved between the two reviewers or resolved through arbitration by a third reviewer (OC). Reference lists of included studies and related systematic reviews identified during abstract and title screening were hand-searched for additional relevant studies. Study characteristics and results from included articles were double extracted by two reviewers (CM, LN) using a standardised data extraction template in MS Excel (Supporting Information S1: Table A3) and then cross-checked for accuracy. A third reviewer (OC) provided arbitration if the agreement on extraction was not met. Due to the limited number of studies included in the review, it was not possible to conduct a quantitative meta-analysis. A narrative synthesis of results was undertaken instead.

2.6 | Risk of bias assessment

The risk of bias for each included study was independently assessed by two reviewers (CM, LN), with discrepancies resolved by a third reviewer (OC). The Cochrane risk of bias assessment tool (i.e., risk of bias 2 [RoB2]) (Higgins et al., 2023) was used for intervention studies, the Newcastle–Ottawa Scale (NOS) (Wells et al., 2019) was used for cohort studies and the Joanna Briggs Institute (JBI, Joanna Briggs Institute, 2023) critical appraisal tool was used for cross-sectional studies. An overall study quality score was given to each included study based on RoB2, NOS and JBI assessment tools. The Cochrane Grading of Recommendations, Assessment, Development and Evaluations approach for assessing the overall quality of the evidence (Balshem et al., 2011; Guyatt et al., 2011) was considered but ultimately disregarded due to the limited number of included studies.

3 | RESULTS

3.1 | Search results

The search strategy identified 14,325 articles. After deduplication, a total of 10,294 records were screened by title and abstract and 13 documents were sought for retrieval for full-text screening. Ten studies were excluded after the full-text assessment. Only three studies met the inclusion criteria and are included in the review. The study selection process is presented in the PRISMA flow diagram (Figure 2). The 10 documents excluded during the full-text review are listed in the Supplementary Materials with exclusion reasons (Supporting Information S1: Table A4).

3.2 | Description of studies

The review includes three studies published between 2018 and 2023, consisting of two peer-reviewed studies and one preprint publication. Altmann et al. (2018) reported a cluster randomised controlled trial (cRCT), Adegoke et al. (2021) reported a prospective matched cohort study and Erkiso et al. (2023) reported a community-based cross-sectional study (Table 1). All three studies included participants between the ages of 6 and 59 months previously discharged as cured for less than 1 year from CMAM outpatient treatment programmes. The number of study participants ranged from 223 to 1,603 among the studies. The studies took place in two low-income countries (Chad, Ethiopia) and one lower middle-income country (Nigeria), as classified by the World Bank (2020). All three studies were in rural settings. Full details of included studies can be found in the Supplementary Materials (Supporting Information S1: Table A5).

The cRCT reported on the effectiveness of a WASH intervention in the prevention of SAM relapse. The two observational studies reported on the association between household-level WASH factors and the risk of relapse to SAM. The WASH intervention in the cRCT consisted of adding a WASH package, including a drinking water storage container with a fitted lid, chlorine tablets, a cup with a handle, handwashing soap and a leaflet with hygiene messages, to standard outpatient treatment for uncomplicated SAM in rural areas of the Kanem region in Chad (Altmann et al., 2018). The primary outcome was the difference in the proportion of postrecovery relapse cases between intervention and control groups. Both observational studies measured SAM incidence at various timepoints following discharge from OTP, as well as identified household factors associated with SAM relapse in rural areas of Sokoto State, Nigeria, and eastern Ethiopia (Adegoke et al., 2021; Erkiso et al., 2023). Adegoke et al. (2021) assessed whether WASH conditions, such as unimproved sanitation and unsafe drinking water sources, are risk factors for SAM relapse, whereas Erkiso et al. (2023) only assessed drinking water sources as a potential risk factor. These included piped water, dug wells and springs.

SAM definitions and measurement timepoints for SAM relapse varied across studies (Table 1). Altmann et al. (2018) defined relapse as a new SAM event (i.e., MUAC < 115 mm or WHZ < −3 SD or bilateral pitting oedema) during home visits at 2 or 6 months after successful discharge from OTP. Children that relapsed at 2 months follow-up were not followed up at the 6-month visit. The two observational studies measured incident rates of relapse. Erkiso et al. (2023) used the same anthropometric criteria for defining SAM as Altmann et al. (2018) but measured the incidence rate of relapse 3 months postdischarge. Adegoke et al. (2021) measured and compared the 6-month incidence rate of SAM among children discharged from OTP services and community control children. Adegoke et al. (2021) used MUAC as the only SAM anthropometric criteria, defining SAM as MUAC ≤ 112 mm at

TABLE 1 Description of included studies.

References	Study design	Sample size	Country (context)	Participant age range	Study dates	WASH intervention description	WASH factors assessed	Time of relapse measurement	SAM relapse definition	Study quality
Altmann et al. (2018)	Cluster randomised controlled trial	1603	Chad (rural)	6–59 months	April 2015 to May 2016	Water storage, water quality treatment, hygiene promotion during outpatient SAM treatment	n/a	2- and 6-months post-discharge	MUAC < 115 mm or WHZ < −3 SD or bilateral pitting oedema	Medium
Adegoke et al. (2021)	Matched cohort	1079	Nigeria (rural)	6–59 months	September 2018 to May 2019	Not applicable	Unimproved sanitation[a] and unsafe drinking water source[b]	6 months post-discharge	MUAC < 115 mm	Medium
Erkiso et al. (2023)	Community-based cross-sectional	223	Ethiopia (rural)	6–59 months	July 2021	Not applicable	Drinking water source (piped water, dug well, and water from spring)	3 months post-discharge	MUAC < 115 mm, or WHZ < −3 SD and/or bilateral pitting oedema	Low

Abbreviations: MUAC, midupper arm circumference; SAM, severe acute malnutrition; WHZ, weight-for-height z-score.

[a]Unimproved sanitation defined as no access to a flush toilet or latrine, ventilated improved pit latrine, pit latrine with slabs or composting toilet.

[b]Unsafe drinking water defined as no access to piped water, public taps, stand-pipes, tube wells, boreholes, protected dug wells and springs and rainwater, or safe drinking water more than a 30-min round-trip walk from home.

any visit or MUAC of 112–115 mm for two consecutive visits over the 6-month study period.

3.3 | Household WASH interventions and prevention of SAM relapse

Altmann et al. (2018) found that the provision of a household WASH kit during outpatient SAM treatment and postdischarge did not reduce relapse at both two- and 6-months postrecovery (Table 2). There was no statistical difference detected in relapse rates between the groups at both timepoints. This may be due to the household WASH kit which included supplies that lasted for 1 month post-OTP discharge. In addition, the study did not reach the required sample size at the 2-month follow-up due to operational challenges, including RUTF shortages, low recruitment rate and shortage of funds. In addition, the study was not powered to detect such a small absolute difference in relapse rates between the two groups. While relapse rates did not improve following the intervention, the intervention did demonstrate an increase in initial SAM recovery rates among children treated for uncomplicated SAM (Altmann et al., 2018). The study also demonstrated a reduction in time-to-recovery from SAM by 4.4 days in the intervention group compared to the control group (Altmann et al., 2018).

3.4 | Household WASH risk factors and SAM relapse

There are inconsistent results on the association between household WASH risk factors and relapse to SAM among children discharged from outpatient programmes (Table 3). Adegoke et al. (2021) did not find an association between household WASH conditions—unsafe drinking water sources and unimproved sanitation—and the likelihood of relapse. Erkiso et al. (2023) found that drinking spring water was associated with an increased risk of relapse to SAM.

3.5 | SAM relapse rate measurements

The percentage of children relapsing to SAM varied across the three studies. In the Altmann et al. (2018) intervention study, the relapse rate across the control and intervention groups was higher at 2 months postrecovery compared to 6 months, at 18% and 3%, respectively (Table 2). This is consistent with other studies that have found relapse rates decrease with time postdischarge (Ashraf et al., 2012). In Adegoke et al. (2021), 24% of the OTP-cured children relapsed within 6 months of initial SAM recovery (Table 3). This is the highest relapse rate across the three studies, and most relapse cases occurred within the first 2 months of discharge. This possibly indicates that OTP discharge criteria are not adequate to ensure full long-term recovery from SAM, especially as they were only based on MUAC. Erkiso et al. (2023) found that 11.3% of children relapsed to SAM

TABLE 2 Results of studies reporting the effect of WASH interventions on the prevention of SAM relapse.

Lead author (year)	Relapse measurement timepoint	Relapse rate	Statistical analysis	Measure of association	Intervention effect (95% confidence interval)	*p* Value	Study quality
Altmann et al. (2018)	2 months	Intervention = 17.6% (105/623) Control = 18.0% (91/484)	Multilevel mixed-effects linear regression model	The absolute difference in the proportion of relapse	−0.4 (−7.2, 6.4)	0.91	Medium
	6 months	Intervention = 2.6% (10/377) Control = 3.6% (10/293)			−1.0 (−4.0, 2.0)	0.53	

Abbreviations: SAM, severe acute malnutrition; WASH, water, sanitation, and hygiene.

TABLE 3 Results of studies reporting on household-level WASH factors and risk of SAM relapse.

Lead author (year)	Relapse follow-up period	SAM incidence rate	Statistical analysis	Measure of association	Results (95% confidence interval)	*p* Value	Study quality
Adegoke et al. (2021)	6 months	24.2% (134/553) (OTP-cured cohort[a])	Cox proportional hazards model	Hazard ratio (HR)	Unimproved sanitation: HR: 1.21 (0.64–2.26) Unsafe drinking water source: HR: 1.51 (0.89–2.56)	$p > 0.05$ $p > 0.05$	Medium
Erkiso et al. (2023)	3 months	11.2% (25/223)	Multivariate logistic regression	Adjusted odds ratio (aOR)[a]	Drinking water source - Piped water: reference - Water from spring: aOR: 15.9 (2.2–18.3)[b] - Dug well: aOR: 0.67 (0.06–7.6)	$p < 0.01$ $p = 0.75$	Low

Abbreviations: MUAC, mid-upper arm circumference; OTP, outpatient therapeutic programme; SAM, severe acute malnutrition; WASH, water, sanitation, and hygiene.

[a]A child was discharged as cured when their MUAC was >125 mm for 2 consecutive weeks with signs of sustained weight gain.

[b]Adjusted variables are not reported in the study.

within 3 months of discharge from OTP (Table 3). As neither of the other studies recorded SAM relapse at 3 months, it is not possible to compare these results. The variation in relapse rates across studies may be due to differences in anthropometric admission and discharge criteria, follow-up duration, frequency of follow-up and data collection methods (e.g., systematic tracking vs. passive readmissions).

3.6 | Risk of bias

The included studies ranged from low to medium risk of bias. The study by Altmann et al. was a cRCT but was not able to blind participants and the assessment team. The study also reported high loss to follow-up (34% in the intervention group and 28% in the control group). The Adegoke et al. (2021) cohort study had comparable cohorts and low loss to follow-up (6% in the OTP-cured intervention cohort and 6% in the community-level control cohort) but only conducted the risk factor analysis on a subset of children with nonmissing data. The Erkiso et al. (2023) retrospective cross-sectional study had clear inclusion criteria and used standard measurements for defining SAM but did not adjust for confounding variables at the analysis stage. Detailed information on the risk of bias in each study is available in the Supplementary Materials (Supporting Information S1: Table A6).

4 | DISCUSSION

There are very few studies and of limited quality on the relationship between household WASH interventions and conditions and the prevention of SAM relapse among children discharged as cured from outpatient programmes. All three included studies were published after 2018, highlighting a recent focus on SAM relapse. Overall, the findings are inconsistent, and the evidence relies on three studies only of low- to medium-quality. The WASH intervention examined the effect of a household WASH intervention on preventing SAM relapse but did not find an effect (Altmann et al., 2018). However, Altmann et al. (2018) did not achieve the required sample size to detect small differences in SAM relapse rates between the intervention and control groups and experienced operational challenges in intervention delivery, which may have impacted results. The observational studies examined the association between household WASH conditions and SAM relapse and reported inconsistent results. Adegoke et al. (2021) did not find an association between unimproved sanitation and unimproved drinking water sources and SAM relapse, while Erkiso et al. (2023) found that drinking spring water was associated with SAM relapse. This may be because unprotected springs may be subject to faecal contamination, which is associated with child diarrhoea (Goddard et al., 2020). Also, WASH conditions vary from one setting to another, which may limit the generalisability of WASH-related risk factors for SAM relapse. WASH interventions should therefore be adapted to each context to maximise effective implementation and sustainability (Anderson et al., 2022). In addition, all three included studies were conducted in rural settings in sub-Saharan Africa. Future studies should consider other geographic regions and urban settings where SAM may equally be prevalent.

Despite the paucity of evidence, the hypothesised causal pathways between WASH conditions and the risk of SAM relapse remain plausible. Two other studies have identified WASH risk factors associated with relapse to AM following recovery from SAM. For example, Kangas et al. (2023) found the use of an unimproved water source as a risk factor for relapse to MAM within 6 months postdischarge in Mali. In Ethiopia, Abitew et al. (2020) found distance to water sources as a risk factor for relapse to AM within 6 months of initial recovery. However, the two studies were excluded from the review as risk factor results could not be disaggregated for cases of relapse to SAM and MAM. It is possible that children admitted to a CMAM programme with SAM have different predictive relapse factors compared to children with MAM (Kangas et al., 2023). One multi-country prospective cohort study in Chad, South Sudan, and Somalia aims to identify WASH-related risk factors for relapse to SAM within 6 months of initial SAM recovery (King et al., 2022). Further research on WASH-related risk factors specifically for relapse to SAM is essential for developing postdischarge interventions to sustain recovery, particularly in high-burden SAM areas. Identified risk factors could also be used to target sub-groups of children that may benefit from additional postdischarge treatment (Bliznashka et al., 2023).

High-quality trials are needed to determine which WASH interventions are effective at reducing the risk of SAM relapse. Such findings can be leveraged to inform nutrition-sensitive services delivered post-discharge. In addition, other outcomes, such as direct measurement of enteropathogenic infection, may be considered in future studies to capture a broader range of health benefits produced by WASH interventions, in line with the 'transformative WASH' approach (Pickering et al., 2019; Stoler et al., 2023). The WASH Benefits and Sanitation Hygiene Infant Nutrition Efficacy trials found that basic household-level WASH interventions had no effect on childhood linear growth and mixed effects on childhood diarrhoea (Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018). In response to these findings, researchers have called for more 'transformative' WASH interventions that are locally adapted to sufficiently reduce household environmental faecal contamination (Pickering et al., 2019). Nonetheless, when carried out effectively, household WASH interventions, such as those aimed at improving water quality and promoting handwashing with soap at critical times, have the potential to interrupt pathogen ingestion and transmission pathways (Cumming & Cairncross, 2016). This can reduce diarrhoea incidence and thereby improve nutrient absorption (Cairncross et al., 2010; Clasen et al., 2015; Freeman et al., 2014).

Furthermore, the relapse rates reported by Altmann et al. (2018) and Adegoke et al. (2021) suggest that children are most vulnerable to relapsing shortly after discharge, which is consistent with other studies (Burza et al., 2015; Girma et al., 2022). The relapse rates also suggest that CMAM alone is insufficient to address SAM, indicating that postdischarge interventions are necessary to support long-term recovery from SAM. Future trials could focus on implementing WASH interventions during the first 3 months following discharge when risk of relapse is highest (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018). Finally, there is no published operational research on the cost and feasibility of integrating WASH interventions into CMAM and postdischarge interventions. Understanding the costs and feasibility of integrating postdischarge WASH and nutrition interventions can help to maximise their impact and cost-effectiveness.

The review also found variations in definitions of SAM relapse and timepoints for measuring relapse, thereby limiting the comparability and generalisability of the results across the studies. These results highlight differences in national protocol, as well as a current lack of a standardised definition of relapse, as also reported in another study (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018). For example, all three studies used WHO-recommended anthropometric measurements to define SAM but used different anthropometric criteria for calculating relapse (e.g., Adegoke et al. [2021] used MUAC only and Altmann et al. [2018] and Erkiso et al. [2023] used MUAC, WHZ and oedema). Although applied in recent years to simplify MAM and SAM treatment guidance, the use of MUAC as the only criterion for SAM identification and admission to OTP may lead to under-reporting of SAM (Guesdon et al., 2020) and thereby SAM relapse. The use of a standardised definition is needed to accurately understand the burden of relapse and determine appropriate postdischarge interventions to improve sustained recovery. Furthermore, there was a variation in measurement timepoints for SAM relapse, ranging from 2 to 6 months following outpatient recovery. Given that the review found the highest risk for relapse between 2- and 6-months following discharge, routine follow-up during the first 3 months may be ideal for preventing relapse.

No previous need assessments have targeted this research gap. We propose the following research agenda to guide WASH interventions implemented following recovery from SAM OTP:

1. Standardised definition for SAM relapse and reporting
   (a) Determine a standardised definition for SAM relapse, considering SAM discharge and admission criteria, outcome definition (i.e., WHZ, MUAC and/or oedema), period of follow-up and data collection methods (Stobaugh, Mayberry, et al., 2018; Stobaugh, Rogers, et al., 2018).
   (b) Identify the appropriate frequency of data collection within the recommended follow-up period
2. WASH for the prevention of SAM relapse
   (a) First, undertake longitudinal studies to better understand if and how WASH access influences the risk of relapse.
   (b) Second, identify household- and community-level WASH risk factors for SAM relapse.
   (c) Third, identify appropriate WASH interventions—standalone and combined—to include in SAM treatment programmes to improve the sustainability of SAM recovery and prevention and target causal pathways.
   (d) Based on findings from (a) to (b), conduct high-quality and adequately powered randomised controlled trials to assess the

(Continues)

effect of WASH access on SAM prevention, treatment and relapse.
(e) Assess the effect of household-level WASH interventions on SAM relapse compared to community-level interventions.
3. Operational research
(a) Undertake cost-effectiveness studies to understand the financial costs and benefits to households and implementers for integrating WASH into postdischarge services.
(b) Evaluate the acceptability, affordability, feasibility and sustainability of household- and community-level WASH interventions for the prevention of SAM relapse.
(c) Assess the feasibility (i.e., cost and logistics implications) of scaling up interventions identified above to national and regional levels.
(d) Conduct process evaluations of interventions and operational research studies to optimise future interventions and reduce publication bias.
4. Multi-sectoral approaches
(a) Leverage findings from research agenda items 1–3 to promote and implement nutrition-sensitive approaches for the prevention of malnutrition.
(b) Integrate WASH into nutrition monitoring and evaluation frameworks, strategies, plans and policies based on findings from research agenda items 1–3.

4.1 | Limitations

This review has several limitations. First, only three studies met our predefined criteria. Therefore, a meta-analysis was not possible. Second, each study was heterogeneous in study design, intervention, WASH assessment and outcome ascertainment, limiting the comparability of results among the included studies. The search was restricted to articles published in English, which could have excluded other relevant articles published and bias findings. Third, studies were of low to medium quality. Of the three included studies, only one was a randomised controlled trial and two were observational studies, which are prone to bias due to study design and do not allow an assessment of causality. In addition, one observational study is a preprint (Erkiso et al., 2023), which may also be prone to bias as it has not been peer-reviewed at the time of publication. Fourth, as WASH interventions are typically implemented together, such as through a WASH kit, it is difficult to discern the individual impact of specific WASH activities. In addition, it was not possible to disaggregate results by type of WASH intervention due to the inclusion of only one cRCT. More broadly, WASH interventions alone are not likely to improve malnutrition outcomes (Bekele et al., 2020), pointing to the complex need for integrating interventions that address the various determinants of SAM and SAM relapse (Bliznashka et al., 2023). Fifth, the review only considered SAM relapse rates as the primary outcome for intervention studies and may have excluded other relevant outcomes on the hypothesised causal pathway between WASH conditions and risk of relapse, such as mortality, duration of treatment, and diarrhoea. Finally, the review only considered relapse to SAM, as opposed to relapse to acute malnutrition (i.e., MAM or SAM). This limited the number of studies eligible for inclusion in our review. Expanding the relapse definition to include MAM may facilitate the early identification of relapse cases and thereby decrease SAM relapse rates if children receive treatment before experiencing SAM again.

5 | CONCLUSION

This systematic review highlights mixed and limited evidence on the effectiveness of WASH interventions in preventing SAM relapse, as well as risk factors. Nonetheless, the relapse rates across the three included studies suggest that children exhibit sustained vulnerability even after recovering from SAM through outpatient treatment. Future research investigating WASH risk factors for relapse, particularly in the first 3 months after discharge, provides an opportunity to identify children who are at the highest risk of relapse. Other rigorous studies on the effectiveness, feasibility and cost-effectiveness of postdischarge WASH interventions are essential to inform both policy and practice to globally reduce the burden of malnutrition.

AUTHOR CONTRIBUTIONS

Clara MacLeod and Oliver Cumming conceived the research project. Clara MacLeod, Dieynaba S. N'Diaye and Oliver Cumming developed the search strategy. Clara MacLeod and Laure Ngabirano searched the databases, participated in study selection and performed data extraction. Clara MacLeod, Laure Ngabirano and Laura Braun interpreted the results. Clara MacLeod wrote the first draft and revised subsequent drafts. Laure Ngabirano, Laura Braun, Dieynaba S. N'Diaye and Oliver Cumming provided regular contributions to the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: MacLeod, C., Ngabirano, L., N'Diaye, D. S., Braun, L., & Cumming, O. (2024). Household-level water, sanitation and hygiene factors and interventions and the prevention of relapse after severe acute malnutrition recovery: A systematic review. *Maternal & Child Nutrition*, *20*, e13634. https://doi.org/10.1111/mcn.13634