WATER SANITATION AND HYGIENE BEHAVIORS AND PRACTICES IN RURAL SOUTH AFRICA: A CASE STUDY OF INGWAVUMA AREA IN UMKHANYAKUDE DISTRICT OF KWAZULU-NATAL PROVINCE, SOUTH AFRICA.

By

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A thesis by manuscript submitted in fulfillment of the requirements for the degree of Doctor of Philosophy in the School of Nursing and Public Health, University of KwaZulu-Natal.

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Preface

The Ph.D. journey has been a journey of growth faced with many challenges. I'm very grateful for having been able to complete my studies. It has been a journey full of grace, healing, and perseverance, and a constant reminder of my purpose and destiny. I'm very grateful to all the people that I met during this journey. Every one of you played an important role in assisting me to achieve this amazing goal. My sincere gratitude goes to Professor Moses John Chimbari and his management team as well as Professor Zilungile Lynette Mkhize-Kwitshana for the guidance and mentorship afforded to me in facilitating the progress of my Ph.D.

The studies described in this thesis were conducted in the uMkhanyakude district, in the KwaZulu-Natal province of South Africa. The work described and the manuscripts that compose this thesis are original. The work was done as reported by the corresponding author and the supervisor guided the process.

These studies have not been done by any person in any form nor submitted to any tertiary institution for the award of a degree or diploma. Some of the work has been submitted for publication to accredited journals in line with the thesis by manuscript guidelines of the University of KwaZulu-Natal, College of Health Sciences. Duly acknowledgment has been accorded where other people's work has been used in the text.

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Declaration 1: plagiarism

I, **Chanelle Mulopo**, declare that:

i. The studies reported in this thesis, unless indicated otherwise are my original research work.

ii. This thesis has not been submitted to any University for any degree award or examination.

iii. This thesis contains my original data, tables, and graphs. Unless specifically acknowledged, no other person's data has been used.

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v. For every manuscript, the contributions for each co-author are indicated.

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vii. There are no competing interests amongst the authors of the manuscripts submitted for publication.

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Declaration 2: publications

The manuscripts (published/accepted or submitted/under review) that constitute the current thesis and author contributions are presented below.

Mulopo, C., Kalinda, C., and Chimbari, M. J. Water sanitation and hygiene (WASH) interventions for schistosomiasis control in Africa: A systematic review. *Under review: Infectious diseases of poverty*.

Authors contributions: Conceptualization, C.M. Literature search, C.M, and C.K formal analysis C.M, Supervision M.J.C, and C.K, writing original manuscript CM, Writing-review & editing C.M; CK; and M.J.C. All the authors have read and approved this version of the manuscript.

Mulopo, C., Mbereko, A., & Chimbari, M. J. (2020). Community mapping and transect walks to determine schistosomiasis risk factors related to WASH practices in KwaZulu-Natal. *International Journal of Waterlines*, *39*(4), 253-276.

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Mulopo, C., Kalinda, C., & Chimbari, M. J. (2020). Contextual and Psychosocial Factors Influencing the Use of Safe Water Sources: A Case of Madeya Village, uMkhanyakude District, South Africa. *International Journal of Environmental Research and Public Health*, *17*(4), 1349.

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Authors contributions: Conceptualization, C.M.; Data curation, C.M.; Formal analysis, C.M.; Funding acquisition, M.J.C.; Methodology, C.M, and T.M.; Project administration, C.M.; Supervision, M.J.C.; Writing—original draft, C.M.; Writing—review & editing, C.M., T.M. and M.J.C. All authors have read and approved the accepted version of the manuscript.

Name……Chanelle Mulopo…….. Signature……[redacted]……. Date……15-May-2021…..

Dedication

This thesis is dedicated to the future generation and my unborn child Maweja Amani Mulopo.

Revelations 21 vs 3-4

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My sincere gratitude goes to my supervisor Professor Zilungile Lynette Mkhize-Kwitshana and Professor Moses Chimbari and his management team (Nokwanda Majola and Sambulo Ntombela) for the role they have played in assisting me to complete my doctoral degree. I would also like to thank my mentors and co-authors of my manuscripts; Dr. Alexio Mbereko, Dr.Tinashe Mutero, and Dr. Chester Kalinda for their mentorship and guidance throughout my manuscript writing.

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I acknowledge my father Mr. Ambrose Maweja Mulopo for his support, financially, emotionally, and spiritually throughout my studies. I acknowledge the young water professionals (YWP) family for their love, support, and mentorship during the most challenging times of my studies, Prof. Chris Buckley, Dr. Rebecca Sindall, and the rest of my YWP family and colleagues. I also acknowledge all the Tackling infections to benefit Africa (TIBA) students for the journey traveled together during my Ph.D.

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List of abbreviations and acronyms

CCG: Community Care Giver

CTLS: Community-Led Total Sanitation

IBM-WASH: Integrated Behavioral Model for Water Sanitation and Hygiene

OD: Open Defecation

PHAST: Participatory Hygiene and Sanitation Transformation

RANAS: Risk, Attitude, Norms, Ability, Self-efficacy

VIP: Ventilated Improved Pit-Latrine

WASH: Water Sanitation and Hygiene

Abstract

Background: Water Sanitation and Hygiene (WASH) is a necessary but undervalued tool for helminth prevention and control, aiming to provide long-term improvements in people's wellbeing. Interventions that include WASH have been shown to be highly effective in reducing the environmental exposure to, and transmission of, eggs and larvae for STH and *schistosomes*. Due to limited resources and human psycho-social factors, the desired level of WASH has not been realized in many developing countries. There are limited studies that have been conducted on WASH behaviors and practices in poorly resourced communities such as the rural KwaZulu-Natal where this study was conducted despite the evidence that WASH interventions have the potential to reduce waterborne diseases. The proposed study seeks to explore WASH behaviors and practices in the Ingwavuma area in South Africa which is endemic to schistosomiasis.

Methods: A mixed-methods research design was carried out to illicit data from research subjects. An adapted WHO/UNICEF WASH questionnaire was administered to 57 households in Madeya Village. We conducted 4 focus group discussions with members of the community and 8 in-depth interviews with key informants in the study area. Before this, transect walks and community mapping were conducted. Data was analyzed using SPSS version 25 for quantitative findings while thematic analysis and grounded theory were the methods of analysis for qualitative data.

Results: There are no WASH intervention guidelines that guide the implementation of WASH interventions in the prevention of schistosomiasis. Hence there is a lack of standardized procedures or systematic practices that guide this process. Therefore, challenges are faced when WASH intervention projects need to be evaluated and their impact measured in the context of schistosomiasis prevention. Schistosomiasis risk factors were identified by members of the community. These risk factors included water scarcity, village proximity to the river, prolonged contact with open water bodies for domestic and recreational purposes as well as irrigation practices. Psychosocial factors found to influence risky behaviour for schistosomiasis included Vulnerability, Attitudinal, and Ability factors scoring high on intervention potential meaning that WASH interventions aiming to bring about behavioral change in the study area need to focus on these psychosocial factors. Stakeholders play a vital role in promoting WASH, although, effective implementation, promotion, and adoption of WASH can only be fully achieved with the involvement of various stakeholders, we found that there was a limited collaboration with various WASH stakeholders. However, the role being played by the Department of Health through community caregivers (CCG's) to promote WASH was evident. The evidence provided by the

study was then applied to develop a Schistosomiasis behavioral change prevention strategy. The strategy considers the unique characteristics of the population, both psychological and contextual; and is aligned with an existing behavioral change theory.

Conclusion: WASH plays a critical role in the prevention of schistosomiasis but has not received much attention. The current study provided evidence-based information using a bottom-up approach to understand the risk factors for schistosomiasis in Madeya by exploring the contextual, (access) psychosocial (behavioral) and structural (stakeholders) factors. The study highlights the gaps and recommends a strategy that can be implemented step by step to prevent schistosomiasis. Prolonged contact with open water bodies for domestic and recreational purposes as well as irrigation practices predispose the community to endemic schistosomiasis.

Keywords: Water, Sanitation, and Hygiene (WASH), Schistosomiasis, Psychosocial and behavioral risk factors, Community-based interventions.

CHAPTER 1

GENERAL INTRODUCTION, REVIEW PAPER, RESEARCH PROBLEM, QUESTIONS, OBJECTIVES, AND THESIS STRUCTURE

1.1 Background

Access to water and sanitation is one of the major challenges in Sub-Saharan Africa. Many African governments are facing challenges in providing potable water and sanitation services to their citizens (1). Water sanitation and hygiene are critical components in improving health and education outcomes as well as reduce gender disparities (2). The rapid population growth in developing countries may result in access to water and sanitation lagging (3). Even though environmental pollution affects the entire population, children are disproportionally affected by health risks associated with limited access to water and sanitation (4). An increase in the number of cases of gastrointestinal diseases such as soil transmitted helminths among school-going children has been reported in developing countries (5).

South Africa is one of the best performer countries in Sub-Saharan Africa with over 90% water supply and over 60% of sanitation coverage. However, disparities do exist between urban and rural communities, with rural areas characterized by limited access to water and sanitation. Currently, 19% of the South African rural communities do not have access to a reliable water supply.

Communities that have limited access to water and sanitation are susceptible to STH, Schistosomiasis and diarrheal diseases (6). Dreibelbis and colleagues (2014) (7), found that WASH interventions implemented in schools reduced diarrhea and gastrointestinal-related clinic visits for children under the age of five. Hands are the most common mode of transmission of gastrointestinal diseases (8), handwashing with soap is reported to reduce transmission of STH by 46% (9).

The distribution of schistosomiasis is high in sub-Saharan Africa due to the limited water resources, sanitation, and poor hygiene practices (10). Approximately 800 million people are infected with Schistosomiasis globally and over 90% of this population lives in sub-Saharan African countries with limited access to water and sanitation (11). Transmission occurs when urine or feaces from infected people contaminate fresh water that contains intermediate host snails. Individuals coming into contact with such water get infected through the skin, by schistosoma cercaria shed by infected snails (12). Water might be considered ‘safe’ concerning schistosomiasis if it is from a source defined as improved by the Joint Monitoring Program, or has not contained an intermediate host snail for at least 48 hours (12).

At present schistosomiasis control relies on preventative chemotherapy with praziquantel however, ***access to safe water and adequate sanitation are considered to be important components of complete schistosomiasis control*** (13). The provision of WASH services offers long-term control and has the potential to eliminate schistosomiasis (14). Treatment alone with praziquantel is not

sustainable for schistosomiasis control and will not break the cycle of transmission. **Improvements of WASH, infrastructure, and understanding people's behavior are essential to achieve sustained control of schistosomiasis** (15).

The literature on social aspects of WASH points to both intra-personal and inter-personal factors that influence behavior and practice as important components in WASH outcomes in a community (16). Considering the low coverage of water and sanitation in the study area Ingwavuma (a, town in UmKhanyakude District of KwaZulu-Natal,) with a population of 1303, understanding WASH practices and behavior in this area is of critical importance as it will highlight how limited access to water and sanitation has health implications for the community, in this case schistosomiasis. Ingwavuma is a poorly resourced community in rural KwaZulu-Natal province with limited access to water and sanitation, the community is also endemic to schistosomiasis. Only 20.8% of the population have piped water inside the dwelling and 20.2% have flush toilets connected to sewage. Previous studies in Ingwavuma, were largely influenced by biomedical models that mainly focused on screening and treatment for schistosomiasis (17-20). Although water and sanitation were reported as some of the risk factors for contracting schistosomiasis in Ingwavuma, the behavioral and practices aspects were not thoroughly interrogated. Understanding WASH practices and behaviours as risk factors for schistosomiasis contributes to knowledge on schistosomiasis prevention hence contributing to the sustainable development goal numbers three and six.

1.2 Literature Review

This section gives a review of the literature on the impact of WASH interventions that have been implemented in Sub-Saharan Africa to prevent schistosomiasis. It is presented in a form of a manuscript entitled *Water, sanitation, and hygiene (WASH) interventions for schistosomiasis control in Africa: A systematic review*. The systematic review is authored by Chanelle Mulopo, Chester Kalinda, and Moses, J Chimbari and is under review for publication in the *journal of infectious diseases of poverty*.

Title: Water, sanitation, and hygiene (WASH) interventions for schistosomiasis control in Africa: A systematic review.

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Abstract

Background: Schistosomiasis is one of the most prevalent parasitic infections worldwide and 93% of all cases are reported from Sub-Saharan Africa. Although the WHO advocates for chemotherapy as the cornerstone of schistosomiasis control, it has limitations such as the inability to kill immature worms and failure to prevent reinfection. Therefore, there is a need for integrated approaches and strategies to effectively interrupt schistosomiasis transmission, especially in endemic foci.

Objective: The objective of this review was to assess the impact of WASH interventions in the prevention of schistosomiasis, by assessing the types of interventions being implemented as well as the outcome on behaviour and practices in relation to schistosomiasis infection in low-income communities in sub-Saharan Africa.

Methods: A systematic search of primary studies published in peer-reviewed journals on WASH interventions in the control of schistosomiasis was conducted. The following databases were searched: MEDLINE, ScienceDirect, ProQuest Psychology Journals, JSTOR Health & General Sciences Collection, CINAHL with Full Text, Health Source: Nursing/Academic Edition, MEDLINE with Full Text, PsychINFO, Worldcat, and WorldCat.org. A data extract table was used to extract relevant information from the included articles. Mixed Method Appraisal Tool (MMAT) was used to evaluate the quality of all selected articles. Thematic analysis was applied to extract data and information from the selected papers.

Findings: Most interventions were integrative combined with preventive chemotherapy. Most studies indicated the value of WASH in the prevention of schistosomiasis especially in the context of maintaining low prevalence after chemotherapy. WASH was also highlighted as a key aspect in preventing the transmission of other diseases besides schistosomiasis. Behavioral interventions were effective in preventing open defecation and water contact activities hence interrupting schistosomiasis transmission. However, most published WASH interventions rely on the provision of infrastructure or just assess the impact of existing WASH infrastructure on schistosomiasis, and very few incorporate behavioral change interventions.

Conclusion:

Our study elaborated the importance of behavioral change in relation to use of safe and clean water, sanitation and hygiene to control schistosomiasis infection. Behavioral change interventions are possible if there is infrastructure to support it.

Keywords: Schistosomiasis control program, water sanitation, and hygiene (WASH), interventions, Africa.

Introduction

Schistosomiasis is the third most devastating tropical disease in the world after Malaria and intestinal helminthiasis (1, 2) and remains a major public health challenge in sub-Saharan Africa (3). Approximately 230 million people are infected, and 500 million people are at risk of contracting schistosomiasis (1, 4-6), with over 90% of the infections being in sub-Saharan Africa (7-9). In the fight against schistosomiasis and other neglected tropical diseases, Sustainable Development Goal 3 (SDG3) has a target to end neglected tropical diseases and waterborne diseases by 2030. Additionally, The World Health Organization (WHO) has recommended different strategies to prevent schistosomiasis. However, the focus has largely been on preventive chemotherapy with praziquantel while alternative methods such as water, sanitation, and hygiene (WASH), health education/communication, and snail control remain marginalized (10, 11).

The provision of water and sanitation contributes to the attainment of SDG 6 which aims at ensuring access to water and sanitation for all by 2030. Attainment of SDG 6 contributes to meeting SDG 3, target 3.3 which aims to combat epidemics including NTDs by 2030. Provision of clean water and sanitation are essential in the prevention of schistosomiasis as they lead to a reduction of contact with cercariae infested water thus interrupting schistosomiasis transmission (12). According to Grimes *et al.* (2014) (13), safe water supply was associated with lower odds of schistosomiasis infection. Currently, schistosomiasis control programs continue to place more emphasis on treatment with praziquantel despite its limitations in preventing reinfection and killing of immature worms (14, 15). This is despite the knowledge that access to improved water, sanitation, and hygiene; and behavioral change prevent reinfection after treatment (11, 14). It is well known that transmission of schistosomiasis takes place in snail infested freshwater bodies used by people for various activities while contaminated with schistosoma ova from human feces or urine (16).

Even though schistosomiasis is a problem in Africa, countries like Tunisia have successfully eliminated the disease while Morocco and Egypt have made significant progress towards elimination (17). School-aged children (SAC) are the most vulnerable when it comes to schistosomiasis transmission with infection being at its peak between 10 and 20 years of age (18). Also, preschool aged children (PreSAC) have also been observed to be at risk of infection (19). Approximately, 76% of the sub-Saharan Africa population live close to open water bodies such as rivers and lakes (20) and that increases the risk of contracting schistosome infections. Although mass drug administration (MDA) with praziquantel has successfully led to reduced morbidity due to schistosomiasis in many endemic communities, re-infection occurs rapidly due to people coming

into contact with cercariae infested water (21-23). Hence, there is great recognition that additional control measures are necessary to ensure that transmission is interrupted (24, 25).

For improved morbidity control, effective water-based interventions that reduce transmission may be operational adjuncts to treatment campaigns (21). There is a need for more comprehensive schistosomiasis control programs to support MDA initiatives. Previous reviews by Grimes *et al*. (2014) (13, 16) reported that an increase in access to safe water and adequate sanitation were important measures to reduce the odds of schistosome infection. These authors also reported that transmission of schistosomiasis is deeply entrenched in social-ecological systems whereby setting specific or contextual factors and environmental factors determine human behavior and snail population. Our review builds on this previous work to address identified gaps on demonstrating the effectiveness of WASH interventions in the prevention of schistosomiasis in low-income communities such as in many parts of Sub Saharan Africa Particularly assessing the effectiveness of "*software"* interventions that target the social and behavioral practices of schistosomiasis transmission. We did this by carrying out a systematic review and synthesis of the literature to assess the impact of WASH interventions and MDA-programs on reducing the prevalence of schistosomiasis. There are, limited studies that focus on the effectiveness of WASH behaviour and practices in the prevention of schistosomiasis, most studies focus on the provision of WASH infrastructure and MDA without really focusing on how WASH behaviour and practices contribute to schistosomiasis transmission (17-22). With most communities being in proximity with open water bodies in rural areas, coupled with limited access to improved water and sanitation. Areas endemic to schistosomiasis are likely to have a high prevalence of schistosomiasis. MDA has been reported to be successful in reducing the prevalence of schistosomiasis (23-25). However, reinfection is likely to take place within a 12-month period after MDA (26). This is due to the fact there is little or no focus on how behaviour and practices influence schistosomiasis transmission when it comes to how the MDA programmes are being designed and/or implemented.

Methods

Search strategy

A systematic search of primary studies published in peer-reviewed journals was done on MEDLINE, ScienceDirect, ProQuest Psychology Journals, JSTOR Health & General Sciences Collection, CINAHL with Full Text, Health Source: Nursing/Academic Edition, MEDLINE with Full Text, PsychINFO, Worldcat, and WorldCat.org. The search was carried out using the following keywords with Boolean terms: Water AND Sanitation AND Hygiene OR Water OR Sanitation OR Hygiene OR WASH OR Watsan OR WSH AND Schistosomiasis OR Schistosome

OR Bilharzia AND Control AND Intervention AND Western Africa OR Eastern Africa OR Southern Africa OR Central Africa OR Africa OR Nigeria; Ethiopia; Egypt; DR. Congo; Tanzania; South Africa; Kenya; Uganda; Algeria; Sudan, Morocco; Angola; Mozambique; Ghana; Madagascar; Cameroon; Cote d'lvoire, Niger; Burkina Faso; Mali; Zambia; Senegal; Chad; Somalia; Zimbabwe; Guinea; Rwanda; Benin; Burundi; Tunisia; South Sudan; Togo; Sierra Leone; Libya; Congo; Liberia; Central African Republic; Mauritania; Eritrea; Namibia; Gambia; Botswana; Gabon; Lesotho; Guinea-Bissau; Equatorial Guinea; Mauritius; Eswatini; Djibouti; Comoros; Cabo Verde; Sao Tome & pricipe; Seycheles. Articles that could not be accessed through the electronic search were sought through the University library. Articles retrieved from the searches were screened independently by two assessors (CM and CK), and any disagreements were discussed until consensus was reached. All references were managed using Endnote version 8. Furthermore, management of duplicates was done using Endnote version 8. The review included research articles from January 1981 to October 2020 and the search was conducted in December 2020. Articles were initially screened using titles followed by further screening using abstracts of selected articles for eligibility (Table 1). Articles that did not meet the eligibility criteria at the title and abstract screening were excluded and only those that fulfilled the inclusion criteria were considered for full article review.

Inclusion and Exclusion criteria used to select review papers

Table 1: Inclusion and exclusion criteria of studies included in the review

Inclusion criteria	Exclusion criteria
Primary studies on schistosomiasis control interventions with a WASH component conducted in Africa	Schistosomiasis control programs with no WASH component were excluded.
Studies conducted in the community and/or schools	KAP studies with no WASH aspect
Only studies published in English were considered	Studies that focused on prevalence and epidemiology
Studies conducted from January 1981 to December 2020	Studies with no clear intervention were excluded
Only studies that used praziquantel in the treatment component were included	Studies that used other medications besides praziquantel were excluded.

For quality assessment, the Mixed Methods Appraisal Tool (MMAT) 2011 version was used to guide the process. Individual studies were assessed based on the following domains: the clarity of the research question, if the data collected addressed the research question, the appropriateness of the study population, and the relevance of the outcome to the study objective. Each study included in the review was assigned a score and an overall quality percentage score was calculated. The studies were rated as low quality (1-4), moderate quality (5-7), and high-quality (8-10), respectively.

Data characterization and analysis

The steps preceding data analysis involved developing a data extraction form used to determine the relevance and/or quality of the study. Information on authors, date, the country where the study was conducted, study objectives, intervention package, outcome, and conclusion were extracted from each study. Data was compiled and thematic analysis was used to identify the themes emerging from the data.

Results

Literature search through databases WorldCat.org yielded the most articles in 1497. One hundred and fifty (150) articles were obtained from Worldcat, 129 from MEDLINE, 12 from Science Direct, 8 from ProQuest Psychology Journals, and 4 from JSTOR Health & General Sciences Collection. The total number of records obtained was 1800. Ninety-nine (99) duplicate articles were removed from the records. Thus, 1701 articles were subjected to title screening. One thousand five hundred and twenty-three (1523) articles were excluded during the title screening as they were deemed irrelevant to the study objectives. One hundred and seventy-eight (178) abstracts were screened leading to exclusion of 151 on the basis that they focused mainly on the epidemiology and prevalence of schistosomiasis in the context of WASH. The remaining total number of studies eligible for full-text screening was twenty-seven (27). Further studies were excluded based on not having a clear WASH intervention, KAP studies with no WASH aspects. Lastly, we excluded studies that administered other medication other than praziquantel in their intervention because WHO recommends praziquantel for the treatment of schistosomiasis. Eighteen studies (18) were retained in the actual review. Figure 1 shows the PRISMA diagram and the process of screening that was followed.

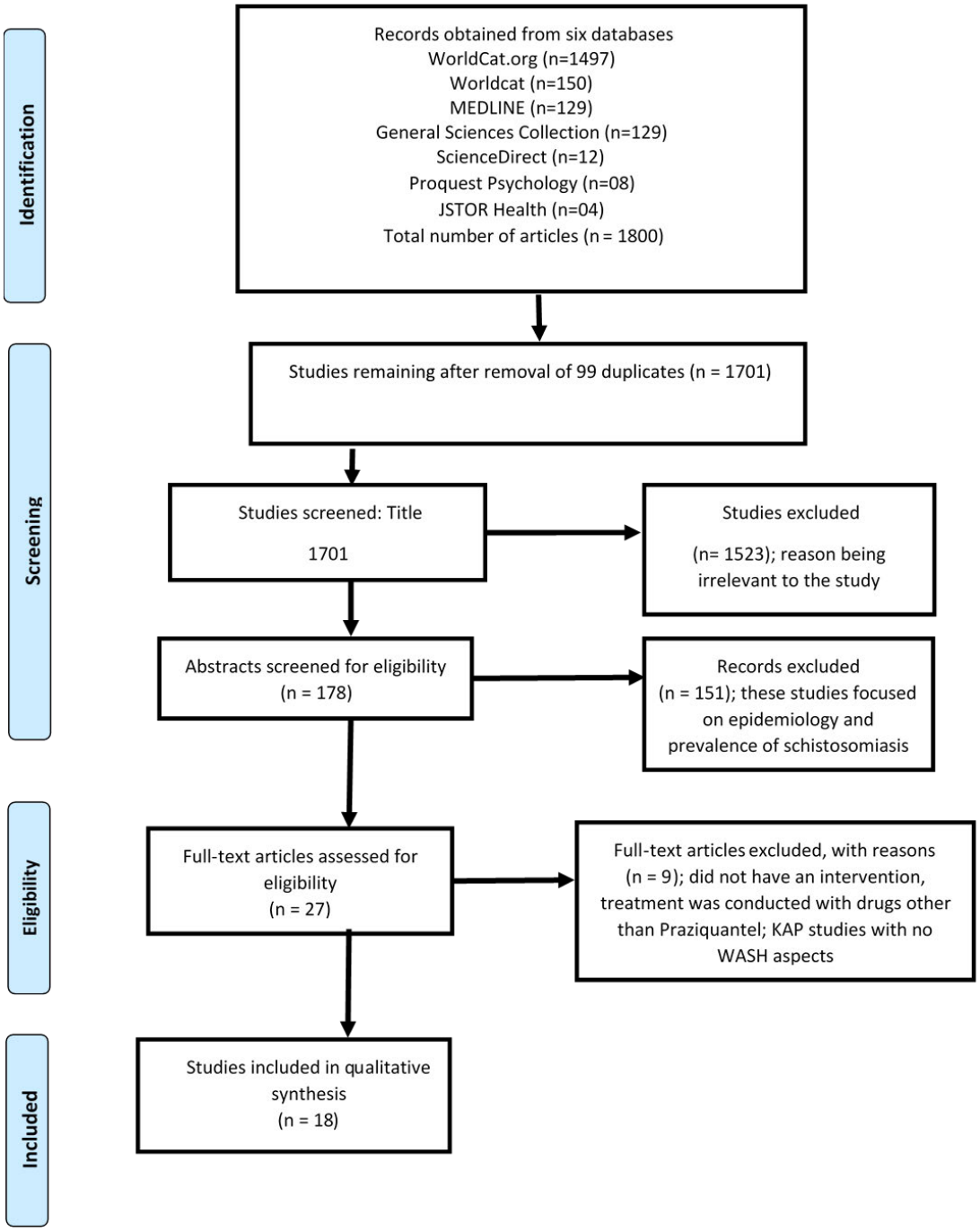

Figure 1: PRISMA flowchart of the study selection process

Characteristics of articles included

Table 2 shows the characteristics of the studies reviewed and provides a summary of the major findings included in the review. All the articles included in this review were community-based intervention studies including one conducted in both the community and a school setting. Among these studies, three community-based studies targeted school-going children. The studies reviewed were spread across Africa's regions; 4 from Kenya (36-39), 3 from Tanzania (40-42), 2 from Ethiopia (43, 44), another 2 from South Africa (45, 46) and 1 from each of the following countries: Cote d'Ivoire (11), Ghana (47), Uganda (48), Botswana (49), Zimbabwe (14), Nigeria (50) and 1 conducted in both Congo and Burundi (51). Five of the studies implemented community participatory WASH interventions for control of schistosomiasis (11, 40-42, 46). Among the remaining thirteen studies six provided WASH facilities (14, 36, 37, 48, 49, 51) and assessed the impact of WASH on the prevalence of Schistosomiasis while six studies assessed the existing WASH facilities with Schistosomiasis (38, 39, 43-45, 50) and lastly one study (47) installed a water recreational area as a measure to prevent schistosomiasis.

Table 2: Characteristics, strategies, and outcomes of Schistosomiasis control programs with a WASH component.

Author and Year	Country	Aims and objective	Type of study	# of participants	Type of intervention	Major outcomes of the study	Conclusion and comments
Ali *et al*. (1989) (49)	Botswana	To develop a national schistosomiasis control program through a combined approach of mobile teams and the primary health care system and to control *S. mansoni*.	Observational study	1st survey 15943 from 45 schools 2nd survey 17,00I school children enrolled in 45 schools	1. Health education 2. Provision of water and sanitation (latrine) 3. Diagnosis and treatment	The prevalence among the 15-24-year-old age group in the community was reduced.	- It was concluded that health education, water supply, and sanitation are considered to be the fundamental basis for maintenance of control.
Angelo *et al.* (2019) (42)	Tanzania	To complement the current chemotherapy-based schistosomiasis control interventions to reduce schistosomiasis.	Cross-sectional study	168 parent informants	Community knowledge, perceptions and water contact practices	1. Very few people identified schistosomiasis as a health problem in the community.	1. To have a successful schistosomiasis control program members of the community need to consider the disease a

						2. Poor knowledge of transmission routes of urinary schistosomiasis. 3. Common symptom of schistosomiasis mentioned were abdominal pain and passing blood in the urine 4. Participants agreed that schistosomiasis was preventable by avoiding random excreta disposal in or near water bodies and avoiding playing in the water or swimming in ponds.	public health problem. This can be achieved when members of the community have the relevant knowledge, correct perceptions and to apply the correct preventive and control measures. 2. Health education was reported to be a necessary means of schistosomiasis prevention.
Chandiwana *et al.* (1991) (14)	Zimbabwe	- To investigate the effectiveness of integrated control measures against	Observational study	Rural community of	1. Diagnosis and treatment with praziquantel.	1.Reduced prevalence of	1. In principle, improved hygiene and health education

		schistosomiasis at the community level.		30,000 people. targeted at school aged children between 7-15yrs	2. Provision of water supply and sanitation. 3. Health education. 4. A single application of the synthetic molluscicide Bayluscide in the main streams	schistosomiasis after chemotherapy 2. The rate of reinfection appeared high although infection intensities were generally low. Interventions aimed at reducing human water contact consolidated chemotherapy results. 3. Reinfections observed could be attributed to excluded groups from treatment. 4. Drama competitions showed great potential in communicating	should limit the risk of reinfection. This would reduce the need for frequent chemotherapy with consequent savings in the costs of drug procurement and delivery. 2. Improved sanitation would have a psychological effect on reinforcing health education messages and thereby encourage behavior patterns that result in less contamination. 3. The contribution of improved sanitation, safe water supplies, and health education in

						health education messages.	controlling schistosomiasis is difficult to evaluate
Gichuki *et al*. (2019) (38)	Kenya	This study aimed to describe the association between S. mansoni infection and household access to improved water sources and sanitation facilities in Kirinyaga County, central Kenya	Cross-sectional study	A total of 905 HHH interviewed and their stool samples screened for S. mansoni	Access to water	1. Households utilizing piped water had the lowest proportion of infections with S. mansoni. 2. Those who reported that they were satisfied with the water supply had a 38% reduction in odds of being found to be infected with S. mansoni.	Initiatives to ensure adequate provision of improved water sources should be a priority, and the inclusion of the adult community in schistosomiasis control programs is crucial.
Grimes *et al*. (2016) (43)	Ethiopia	The aim of this analysis was to quantitatively compare WASH (water practices and sanitation and hygiene facilities)	National mapping	1,645 Schools	Assessment of WASH against schistosomiasis	1. Schools with a high frequency of water collection from potentially Schistosome infected	1. The combined water and sanitation score was not significantly associated with the arithmetic mean

		with helminth infection rates.				water had significantly higher arithmetic mean S. mansoni infection intensities. 2. No significant differences were reported between *S. Mansoni* and sanitation.	intensity of *S. mansoni* infection.
Gryseels *et al.* (1992) (51)	Zaire and Burundi	A report on the experiences with population-based chemotherapy and other control methods.	Observational study	A population of 10,000 people in DRC and 140,000 in Burundi	**Maniema (DRC)** 1. Diagnosis and treatment. 2. Focal molluscicide **Rusazi (Burundi)** 3. Chemotherapy 4. Provision of piped water, the building of public laundry blocks,	**Maniema** 1. Most treated individuals, were re-infected to their initial intensity level, 12 to 20 months after treatment. 2. Repeated chemotherapeutic interventions had no or little impact on the	1.Chemotherapy is a valid tool for morbidity control but has no long-term impact on transmission.

					simple showers, footbridges. 5. Health education program (posters, meetings) and modern (video films, radio messages) techniques.	high prevalence of infection. **Burundi** 1. Rapid reinfection in children after the first chemotherapy. 2. Repeated selective treatment with praziquantel resulted in a reduction of the prevalence to about 25%.	
Hailu *et al*. (2020) (44)	Ethiopia	To determine the effect of water source, sanitation and hygiene on the prevalence of schistosomiasis among school-age children in Northwest Ethiopia.	Cross-sectional study	333 School age children	Assessment of WASH against schistosomiasis	1. Seven percent of children were infected with *Schistosoma mansoni* infection. 2. Using surface water for drinking, poor hand wash habit and latrine utilization were significantly	1. Absence of safe water for bathing, washing and swimming, poor sanitation and hygiene practices were major risk factors for schistosomiasis.

						associated with *Schistosoma mansoni* infection.	
Hürlimann *et al*. (2018) (11)	Côte d'Ivoire	To assess the effect of an integrated package of interventions consisting of preventive chemotherapy, community-led total sanitation (CLTS), and health education, on the prevalence of helminth and intestinal protozoa infections.	Cross-sectional study	Five communities	1.Chemotherapy 2.CLTS 3.Health education	1. Health education played a significant role in the construction of latrines. 2. After implementing CLTS, the use of latrines and reported handwashing after defecation was significantly high. 4. Children from households of intervention communities were reported to use latrines/toilets rather than open bushes.	1. Other than access to sanitation facilities, attitudes towards defecation and hygiene practices, acceptance and (appropriate) use of these infrastructures are key determinants for discontinuation of open defecation and thus successful interruption of fecal contamination of the environment. 2. CLTS triggering is one of the most important factors in triggering behavioral change.

Katsivo *et al.* (1993) (36)	Kenya	The project aimed to control Schistosomiasis through the provision of alternative water sources, chemotherapy, and health education.	Cross-sectional	203 HHH	1.Provision of water 2.Laundry and bath units 3. Chemotherapy 4. clearing of the canals and streams of their thick vegetation 5. Health education.	1. Less swimming in the canals due to bathrooms provided. 2. Defecation along the water contact sites decreased to almost zero. 3. Over 90% of the population showed improvement in knowledge of schistosomiasis.	1.The program would make a bigger impact on schistosomiasis infection if it was expanded to cover a wider area and if chemotherapy was carried out more frequently.
Katsivo *et al.* (1993) (37)	Kenya	To reduce the transmission of schistosomiasis in a rice scheme in Kenya	Observational and cross-sectional study	A community of 2,219	1.Health education (films) 2.Chemotherapy with praziquantel 3. Alternative water supply (wells) and sanitation (pit-latrines)	1. There was a reduction of schistosomiasis intensity in the age group 5-19 years.	Community participation was recognized as critical in ensuring that schistosomiasis control projects are successful.

					4.Laundry and bath units 5. Canals were cleared of thick vegetation		
Kosinski *et al.* (2012) (47)		The main objective of the study was to test the hypothesis (chi-squared analysis) that the annual cumulative incidence of S. haematobium infection among a population of schoolchildren would decrease in the presence of a WRA.	Cohort and observational study	3 Schools, 1 junior high and 2 primary schools	Water recreational area (WRA): A concrete swimming pool fed by rainwater and hand-pumped groundwater.	1. Annual cumulative infection incidence decreased significantly in girls and boys in the presence of a WRA 2. Risk factors for infection also changed significantly during the study.	The study shows a biologically-relevant and statistically-significant decrease in S. haematobium annual cumulative incidence in a community after installation of a WRA; this decrease was not achieved via MDA alone in the year before installing the WRA.
Means *et al.* (2018) (39)	Kenya	The study evaluated the impact of different potential helminth	Retrospective cohort study nested within	701 stool samples	Anthelmintic Chemotherapy and access to	1. Only treatment was associated with a reduced probability	1. There was no evidence of additional benefit (synergy)

		protective packages on infection prevalence, including repeated treatment with albendazole and praziquantel with and without WASH access.	a randomized trial		WASH (piped water and latrines).	of infection with Schistosoma. 2. Handwashing was associated with an elevated probability of *Schistosoma* infection. Consistent handwashing was associated with an increased risk of *Schistosoma* sp. infection in the absence of anthelmintic therapy	associated with access to more than one WASH resource when combined with chemotherapy. However, access to several WASH resources did appear to demonstrate benefit in reducing Schistosomiasis prevalence and intensity in adults who did not receive praziquantel.
Mulopo *et al*. (2020) (46)	South Africa	The study aim was to conduct a community diagnosis of WASH conditions by assessing water, sanitation, and hygiene practices and to identify risk factors for	Cross-sectional study	36 Adult participants	Community Mapping and transect walks	1.Water scarcity, village proximity to the river, prolonged contact with open water bodies for domestic and recreation purposes,	1. The study alluded to environmental changes that could be made to nudge people away from the rivers and contribute to the prevention of

		schistosomiasis using participatory research methodologies.				poor irrigation practices were reported as risk factors for schistosomiasis.	schistosomiasis, such as designated bathing and clothes washing areas.
Mwanga *et al*. (2015) (40)	Tanzania	To evaluate people's knowledge, attitudes, and practices (KAP) towards schistosomiasis and intestinal worm infections at the beginning of the project and 3 years after the implementation of locally adapted control interventions.	Quasi-experimental based on pre/post intervention	One community 82 individuals aged ≥15 years for the survey	Participatory Hygiene and sanitation transformation (PHAST) is an approach to health education/promotion that focuses on community participation and capacity development.	1. An increase in knowledge, symptoms, health consequences, and preventative measures of intestinal schistosomiasis.	1.PHAST intervention had a positive impact on the community's KAP concerning schistosome infections.
Mwanga and Lwambo (2013) (41)	Tanzania	A study on schistosomiasis-related perceptions and water contact behavior was undertaken in a	Quasi-experimental based on pre/post intervention	One community 157 individuals aged	PHAST	1. An increase in knowledge on causes of intestinal schistosomiasis.	There was a relatively successful transfer of biomedical knowledge on schistosomiasis through PHAST

		community where intestinal schistosomiasis is endemic before and 2 years after the implementation of a participatory hygiene and sanitation transformation (PHAST) intervention.		≥15 years for the survey		2. Increase in knowledge on symptoms of schistosomiasis. 3. Knowledge regarding the health consequences of intestinal schistosomiasis increased significantly. 4. Less water contact with the lake. 5. There was a significant reduction in the frequency, and duration of water contact activities.	intervention and this knowledge was still evident both theoretically and was translated into action by the study population in their local practices related to schistosomiasis 2 years after the intervention
Odongo-Aginya *et al*. (1996) (48)	Uganda	This study aimed to assess the inhabitants' Participation in the control of schistosomiasis.	Observational study	600 individuals	1.Chemotherapy 2.Health education	1. The treatment in combination with the aforementioned measures resulted in	1.The reduction of the snail population, the decrease in the number of infected people, and

					3.Sanitation (pit-latrines) 4.Environmental control (bush clearing)	a cure rate of 73.2% at the check-up after one year. 2. A tremendous reduction in all water contact activities was noted.	egg excretion as well as the decreased exposition by water contact, acted together to reduce the transmission of S. mansoni in the village. 2. Chemotherapy is well accepted but it is only a temporary control measure in endemic areas because the risk of reinfection remains.
Surakat *et al.* (2020) (50)	Nigeria	To evaluate the availability of WASH facilities and its impact on the prevalence of schistosomiasis among school-aged children.	Cross-sectional study	243 Participants	Assessment of WASH against schistosomiasis	1.The highest prevalence of schistosomiasis (46%) was reported in the community were 61% of the residents lacked access to toilets and	1. Frequent water contact activities including swimming and bathing are risk factors for infection

						64% were regularly involved in water contact activities such as swimming, bathing and washing of clothes by the river.	
Tanser *et al.* (2018) (45)	South Africa	To quantify the impact of safe water supplies on schistosomiasis.	Population based cohort	N=90000	Scale-up in pipe water	1. Participants living in communities with high coverage of piped water were eight times less likely to be infected in comparison to those living in communities with the lowest coverage. 2. Household access to piped water was associated with a 15.6% reduction in the risk of infection.	1. In this study, children living in communities with high coverage of piped water were eight times less likely to be infected relative to those living in areas with little or no access to piped water. Every 1% increase in the coverage of piped water in the surrounding local community was

							associated with a corresponding 2.5% decrease in the odds of infection.

A synthesis of findings from the studies included in the review

Although preventive chemotherapy remains the mainstream intervention for schistosomiasis prevention, WASH interventions ensure the sustainability of schistosomiasis control programs. Analysis of results from eight of the eighteen studies show that different WASH interventions were implemented to control schistosomiasis. Most of the interventions were integrated in nature (11, 14, 36, 37, 39, 48, 49, 51) and mainly constituted of preventive chemotherapy, health education, snail control, and environmental control (bush clearing). Community participation was also observed as one of the strong drivers of Schistosomiasis program sustainability and success (11, 40, 41, 46). All of the studies alluded to the importance of community participation in the success of the program either implicitly or explicitly. Community participation plays an important role in the success and sustainability of community interventions. Without community participation or engagement, interventions are not likely to be sustainable once the project comes to an end, resulting in project failure.

The different WASH strategies identified included; (i) Provision of water and sanitation (11, 14, 36-39, 45, 48, 49, 51) (ii) Health education (11, 14, 36, 37, 48, 51) (iii) Community-led total sanitation (CLTS) (11) (iv) Participatory hygiene and sanitation transformation intervention (PHAST) (40, 41) (v) Water recreational area (WRA) (47) and (vi) KAP with water contact practices (42, 46) (vii) Chemotherapy (11, 14, 36, 37, 39, 48, 49, 51) and (viii) Environmental control (36, 37, 48).

Interventions that provided access to water and sanitation and other related WASH infrastructure (*"hardware"* interventions)

The majority of the interventions (reported in 10 of the 18) (11, 14, 36-39, 42, 45, 47-49, 51) provided access to either water or sanitation, or both. Water supply was mainly in the form of piped water, wells, handpumps while sanitation was usually the provision of latrines. Some studies were specific on the type of latrine provided such as ventilated improved pit-latrines (VIP) while others were not (11, 14, 36, 37, 48). However, one study (47) was particularly unique in that it provided a Water Recreational Area (WRA). This particular study provided a swimming pool in the rural community for children. The swimming pool was meant to interrupt the transmission of schistosomiasis by limiting children's exposure to natural river water. Other technologies included in the interventions were washing slabs, laundry blocks, and bath units/showers/bathrooms by the well site and footbridges. No interventions provided handwashing facilities or any facility specifically for promoting hygiene.

Community members participated in the building of toilets and were tasked with the responsibility of maintenance of WASH technology at the end of the project to ensure project sustainability (11, 46). Community-led total sanitation intervention is community participation driven and all members of the community participated at every stage of the intervention.

Hardware interventions reported to result in reduced prevalence of Schistosomiasis

Eight of eleven studies (14, 36-39, 45, 48, 49) that provided either water or sanitation or both reported reduced prevalence of schistosomiasis following the intervention. One study reported a reduced prevalence of schistosomiasis after treatment; however, the rate of infection remained high but with low intensities (14). Furthermore, it was reported that reduced contact with infested water enhanced the benefits of chemotherapy. Treatment of certain age groups did not have a substantial impact on transmission as reinfection could be attributed to groups that did not receive treatment (14). The study by Gryseels *et al*. (1992) (51) observed that at 12 to 20 months after chemotherapy, reinfection was high in both adults and children with infection intensity returning to initial levels observed. The community-led total intervention was observed to have led to a 100% coverage of latrine in four intervention communities and 80% in one intervention community (11).

A study by Katsivo *et al.* (1993) (37) observed that having bathing facilities had a positive behavioral change among children as it led to the reduction in water contact activities and reduced open defecation on the riverbanks during swimming. Also, another study observed that implementation of WRA (swimming pool) as an intervention measure against schistosomiasis led to a reduction in the number of children swimming in potentially cercaria infested water (47). The same authors also observed a significant reduction in the annual cumulative infection incidence in girls and boys in areas where WRA was implemented.

A study by Gichuki *et al.* (2019) (38) and Tenser et al (2018) (45) found that the odds of contracting schistosomiasis among people with piped water were reduced compared to those living in communities with the lowest water coverage. Conversely, Tanser *et al.* (2018) (45) found that household access to piped water was associated with a 15.6% reduction in the risk of schistosomiasis infection. Another study by Means *et al*. 2018 (39) concluded that handwashing was associated with an elevated probability of *Schistosoma* infection in the absence of anthelmintic therapy.

Lastly studies that did not provide WASH facilities but assessed the impact of WASH on schistosomiasis reported higher prevalence of schistosomiasis in communities with poor access to WASH compared to communities that had access to WASH (38, 39, 43-45, 50).

The community-based approach in the prevention of schistosomiasis (*"software"* interventions)

Four (4/18) (40-42, 46) out of eighteen interventions did not supply a WASH technology or encourage members of the community to build latrines. These interventions mainly focused on behavioral change through community participation and hygiene education. The PHAST (Participatory Hygiene and Sanitation Transformation) approach was used in two of these studies while a type of KAP intervention focusing on knowledge, perceptions, and behavior was applied in one study. Lastly community mapping and transect walks participatory methodologies were implemented in one study (40-42, 46). These approaches did not include the provision of technology but focused on community participation and capacity development while inducing improvement in hygiene and behavioral change.

Behavioural change interventions reported increase in knowledge about Schistosomiasis

Two studies conducted by Mwanga *et al*. (2015) (40) and Mwanga and Lwambo (2013) (41) reported improvement in knowledge on the cause, symptoms, and health consequences of intestinal schistosomiasis (severe liver damage, poor cognitive performance); and knowledge on preventative measures such as avoiding contact with infected water after implementing the PHAST interventions. Similarly, a study by Katsivo *et al*. (1993) (37) reported over 90% improvement in knowledge on causes of schistosomiasis, transmission, treatment, prevention, and control. The study on knowledge perceptions and behavior reported health education as a necessary means of schistosomiasis prevention (42).

The community-led total sanitation intervention (CLTS) implemented by Hurlimann *et al*. (2018) (11) was focused on behavior change with emphasis on encouraging individuals to build their own toilets. In their intervention coupled with preventive chemotherapy they reported that the intervention was effective in reducing the prevalence of schistosomiasis. Since the CTLS approach is based on community participation and engagement, members of the community had a sense of ownership to the toilets that they built thus increasing the likelihood of the intervention to be sustained after the project ends.

Health education played an important role in the integrated interventions; Seven (7/11) integrated studies (11, 14, 36, 37, 48, 49, 51) had a health education component. All the studies reported on the value of health education in the interventions. Health education was initiated using different

strategies with one study not indicating how health education was conducted (49). However, the study by Chandiwana *et al.* (1991) (14) indicated that health education was done through annual school-based drama competitions. This study reported that drama competitions (edutainment) at schools showed great potential in communicating health education messages.

Additionally, the use of print, audio, and visual media were additional tools used to educate the community (14, 51). Health education was reported to complement the intervention by addressing the lack of knowledge of disease transmission and prevention (37). Health education was also reported to increase knowledge on the transmission, treatment, prevention, and control of schistosomiasis (37). Only one study indicated the health messages that were included in the study (48). They made the community aware of the disease and how water contact activities facilitate transmission. Housewives were also encouraged to boil water and avoid bathing children using untreated natural water. Additionally, Odongo-Aginya *et al*. (1996) (48) reported positive outcomes following a health education in Uganda; 95% of members of the community-built toilets.

On the other hand, health education was reported to have limited outcomes in some studies, for example in Zimbabwe (14) there were limited positive outcomes on the knowledge of schistosomiasis from household heads and children on the specific aspects of the life cycle of schistosomiasis. Furthermore, it was reported that health education executed by health staff created a challenge because health care workers did not always have enough time to visit the community to educate them about schistosomiasis. Furthermore, organizational and transport issues limited the number of visits health workers could make to the schools to conduct health education sessions. Also, the study (51) conducted in Congo and Burundi reported that the impact of health education combined with WASH on schistosomiasis could not be assessed.

To ensure community participation and ownership of the schistosomiasis control program, community members were involved in meetings from the beginning of the program in some of the studies. Leaders and councils were oriented on the aspects of the programs (52). Five (5/18) studies (11, 40-42, 46) used community-based interventions in the control of schistosomiasis. Community members were consulted, familiarized, and sensitized on the project and that made them have ownership of the project. In studies where members of the community were fully engaged (11, 40, 41, 47), they participated fully and built their toilets; they also participated in the construction of the swimming pool, and they contributed money needed to improve the facilities.

Discussion

There is a strong link between wash and schistosomiasis, many researchers have alluded to the benefits of WASH in the prevention of schistosomiasis (15). Hence studies have been conducted to assess the impact of WASH and schistosomiasis and others have provided WASH facilities in the fight to prevent schistosomiasis. We discuss the different types of WASH interventions implemented for schistosomiasis prevention and their outcomes.

Different types of WASH interventions and their outcome

The WASH interventions that we reviewed can be broadly grouped into two domains: *software* WASH interventions and *hardware* WASH interventions. *Hardware* interventions refer to interventions that focus solely on the provision of WASH technology such as the provision of toilets, hand pumps, and laundry blocks. On the other hand, *Software* interventions focus on behavioral change and this is mainly achieved through health education (52, 53).

Provision of water and sanitation was perceived as an improvement of health by members of the community (37). Most of the WASH interventions provided infrastructure indicating the emphasis on the provision of infrastructure and less focus on behavioral change interventions. Most of the studies were of high quality. There is a need to structure and design WASH interventions in a way that allows comparisons and reaching concrete conclusions.

When WASH technologies are provided in the community, the community needs to be educated on how to correctly use the technologies. In other words, to bring about effective change, for example, behavioral change, health education is imperative. We, therefore, discuss WASH interventions in conjunction with health education as strategies for controlling schistosomiasis. Most of the studies included in the review did not adequately indicate the additional value of WASH in integrated programs for schistosomiasis control. Although one study (39) found hand-washing to increase the risk of schistosomiasis, no intervention provided a safe alternative for handwashing.

Community-based interventions such as CLTS also promote behavioral change. Some studies (11, 41,) reported that the provision of technology does not guarantee its use. Consequently, interventions such as CLTS go beyond the provision of technology targeting behavior change

which results in the use of toilets and limits open defecation that contributes to schistosomiasis transmission. CTLS was found to be effective in behavioral change; members of the community were more likely to use the toilets following the CTLS intervention. PHAST interventions play an important role in community awareness as well as increasing knowledge about the disease (41). These are important steps to consider in the control of schistosomiasis. MDA projects ought to have strong components on knowledge about the disease and also perceive it as a public health problem.

Health education has positive outcomes in increasing knowledge but has been reported to not guarantee behavioral change (54, 55). Additionally, health education in the absence of WASH facilities has limited impact. To achieve sustainable outcomes from health education, the health education component has to be incorporated appropriately with WASH facilities being provided (56). It is also important to identify the appropriate health education communication channels tailored to a community as well as making sure that the material can be easily understood by the target population. Where possible members of the community should be trained to conduct health education. Ensuring that some members of the community are trained and are able to provide health education contributes to project sustainability.

Preventive chemotherapy alone was found to reduce morbidity and intensity of schistosomiasis (57); however, the WASH component played an important role in maintaining low prevalence by preventing reinfection. Most studies report reinfection after treatment, and that is attributed to continued contact with infested water by members of the community. Additionally, treatment is also not sustainable because it is usually targeted at high-risk groups. Thus, reinfection may occur as a result of systematically omitted groups such as adults who become the sources of infections to the previously targeted groups, (58) resulting in long-term morbidity for untreated groups. Age groups that are not targeted through preventive chemotherapy remain a reservoir for reinfection. Hence WASH sustains low prevalence after treatment.

Although WASH has been reported to sustain a low prevalence of schistosomiasis following treatment, some studies report the difficulty in evaluating the impact of WASH on schistosomiasis (59). Arguably provision of WASH technology is expensive (60) and many researchers have alluded to this. However, interventions should not only focus on the costs alone but also on the long-term benefits of WASH interventions. CTLS and PHAST interventions provide clear evidence that one can implement a WASH intervention at reasonable costs (61). The critical point is to have community buy-in; once the community is interested in the project, they are more likely to

contribute funds to improve their WASH facilities thus lowering the costs of the WASH project (62).

The role of community in preventing Schistosomiasis

Community participation was highlighted as an important factor in ensuring program sustainability (63). Studies on community engagement report that community engagement is effective in project acceptance and sustainability. Furthermore, our results show that studies in which interventions had a strong community participation component led to an increased number of toilets built and reduced open defecation as well as water contact activities. Only four studies took a community-based approach commonly referred to as a bottom-up approach. This approach locates the community at the center of the problem and is based on capacity building and empowerment (64). The involvement of local communities in the design and implementation of schistosome and intestinal worm control programs is increasingly being recognized as crucial for achieving cost-effective and long-term sustainability (4). Community participation in schistosomiasis control programs guarantees the sustainability of the project. The only limitation emanating from the current study was that they were a few studies that focused on implementing integrated schistosomiasis control programs with WASH components. Therefore, generalizations must be limited to the context of the current study.

WASH Coverage and Schistosome life cycle

WASH coverage in communities that require schistosomiasis control interventions is usually poor. Mulopo et al (46, 65) reported poor access to WASH in a community endemic to schistosomiasis in rural KwaZulu-Natal. Individuals infected with schistosomiasis release eggs through urine or faeces depending on the *schistosma* species. Eggs that enter freshwater bodies hatch and release miracidia (13) which then infect suitable intermediate host snails (4, 66) and infected snails later release infectious cercariae which penetrate skin of humans coming into contact with freshwater bodies infested with cercariae. However, provision of WASH infrastructure as part of WASH interventions to prevent schistosomiasis plays a role in reducing human water contact. For example, when toilets are provided and are used by members of the community, *schistosome* eggs are contained within the toilet and prevented from entering freshwater bodies. In this case sanitation would be effective in preventing schistosomiasis transmission through reduction of snail infections (68). It should however be noted that a given reduction in miracidia does not lead to a proportional reduction in cercariae and human infections. This is as a result of the exponential reproduction of the parasite within the intermediate host snail hence, the risk of human infection (13, 68). It should,

however, be noted that provision of safe water supplies may not completely prevent water contact with freshwater bodies because of other factors such as cultural, environmental and socio-economic differences which still may prompt individuals to get into contact with open water bodies (13).

The nature of studies conducted on WASH and schistosomiasis are usually observational. There is need for more cluster randomized control studies on WASH and schistosomiasis. This also needs to be accompanied by strict guidelines on how to implement WASH interventions in different contexts which can further give room to proper monitoring and evaluation of the WASH programs. In doing so, researchers and experts running these programs can obtain conclusive results on the effectiveness of WASH programs in the control of schistosomiasis.

This review builds on earlier studies by Grimes et al (13, 16). Our review focused on the effectiveness of WASH interventions in the prevention of schistosomiasis. Furthermore, we highlighted gaps in the failure of researching conclusive results with WASH interventions. The failures were attributed to a lack of focus on behavioral change interventions. Furthermore, there are no guidelines that exist on how to implement WASH interventions for different contexts.

Conclusion

WASH plays an important role in the prevention and control of schistosomiasis. However, WASH interventions should be executed carefully through the bottom-up approach by emphasizing community participation as this increases the likelihood of the success of the program. WASH projects also need to be carefully designed to evaluate their impact on health outcomes. Furthermore, we recommend that more studies with bottom-up approaches are needed to test their efficacy and which approaches work best.

List of Abbreviations

CLTS: Community-Led Total Sanitation

HHH: Household Head

MDA: Mass Drug Administration

PHAST: Participatory Hygiene and Sanitation Transformation

WASH: Water Sanitation and Hygiene

WHO: World Health Organisation

WRA: Water Recreational Area

Declaration

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1.3 Research Problem and significance

Of the 783 million people who are without access to clean water globally, 40% live in sub-Saharan Africa, and more than 320 million people lack access to safe drinking water. Poverty is a huge barrier to access to water and sanitation. Rural settings in this region experience challenges with the provision of WASH facilities. As a result of inadequate access to WASH, the population in these areas is vulnerable to NTD's such as schistosomiasis and diarrhea (21). Schistosomiasis and other NDTs cause enormous distress for the populations resulting in illness, long-term disability, and high morbidity and mortality (22). Provision of WASH and tackling human psychosocial factors can reduce the impact of these diseases and/or eradicate them. Figure 1 represents the underlying conceptual framework underpinning the current study. It highlights how different factors on the institutional, community, and personal level can contribute to improved public health.

The term WASH emphasizes the importance of a holistic approach to service delivery that focuses on health outcomes and encourages the involvement of communities (23).

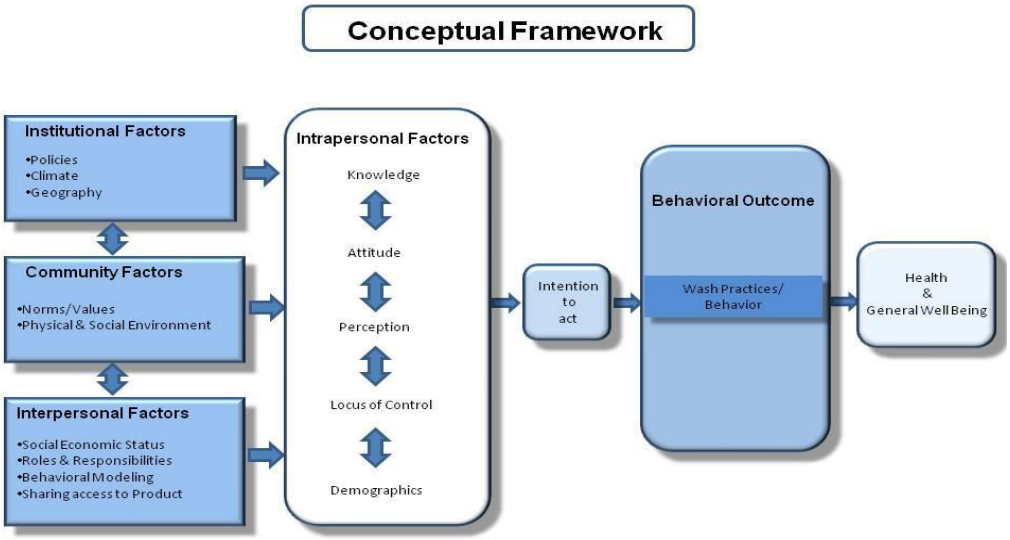

Figure 1: *Conceptual framework showing the interactions between psychosocial and contextual factors that influence behavior.*

Ensuring the availability of water and sanitation for all will contribute towards the prevention or eradication of diseases linked to inadequate access to water and sanitation such as schistosomiasis and diarrhea (24, 25).

This will result in improved health and general wellbeing for vulnerable populations in developing countries particularly in sub-Saharan Africa where coverage for water and sanitation is low.

Approximately 76% of the population in sub-Saharan Africa live near rivers, lakes, and other water bodies contaminated with snail intermediate hosts. The population living near dam reservoirs such as the one where the current study will be conducted are particularly at risk of schistosomiasis and there is high prevalence of the disease. Furthermore, schistosomiasis has been reported to rise as a result of irrigation projects construction (26-28). The highest prevalence and intensities of human schistosomiasis occur in school-aged children, adolescents, and young adults who also suffer from the highest morbidity and mortality (29). On the other hand, diarrhea is most prevalent among children under five claiming approximately 2200 lives per day and approximately 700 000 per year. These deaths are preventable through access to water and sanitation, hygiene promotion and education as well as by identifying psychosocial factors that may act as barriers to good WASH practice.

There are limited studies that have been conducted on WASH behaviors and practices in Sub-Saharan Africa despite the evidence that WASH interventions have the potential to reduce waterborne diseases (30). The proposed study seeks to explore WASH behaviors and practices in the Ingwavuma area of uMkhanyakude district, under Jozini Municipality, South Africa. Studies related to water and sanitation diseases that have been conducted in the Ingwavuma area have mainly been influenced by biomedical models and have looked at individual diseases such as schistosomiasis. Kabuyaya and colleagues (17,18) found a 37.5% prevalence of schistosomiasis haematobium among children within Ingwavuma. Identifying the psychosocial factors that put people at risk of contracting diseases such as schistosomiasis will help reduce reinfection after treatment. There is a paucity of literature on studies on the concept of WASH and psychosocial factors which is what the proposed study aims to investigate. The findings from this study will inform policy makers on the WASH practices, the psychosocial factors influencing WASH and the appropriate WASH intervention for Ingwavuma that will take into account the unique WASH needs of Ingwavuma.

1.4 Research questions

This thesis addressed the question of what role does WASH play or could play to prevent Schistosomiasis in a limited resourced setting. To address this broad question, the following specific questions were investigated;

1. What are the practices of WASH and how do these contribute to the risk of schistosomiasis transmission?
2. What role do stakeholders play in promoting WASH in the context of schistosomiasis prevention?

3. What behavioral (psychosocial) factors predispose members of the community to schistosomiasis?
4. What is the appropriate WASH intervention strategy for schistosomiasis prevention?

1.5 Research Objectives

In line with the research questions outlined above the following objectives were addressed.

General research objective

To determine the role of WASH in the prevention of Schistosomiasis.

Specific objectives

1. To determine the practices of WASH and how these contribute to the risk of Schistosomiasis transmission?
2. To determine the role that stakeholders play in promoting WASH in the context of Schistosomiasis prevention.
3. To determine behavioral (psychosocial) factors that predispose members of the community to Schistosomiasis.
4. To determine the appropriate WASH intervention strategy for Schistosomiasis prevention.

1.6 Study design and Methodology

1.6.1 Study setting and Context

A mixed method study design was conducted in the Northern part of the KwaZulu-Natal province in the uMkhanyakude district between November 2017 and November 2018 (Figure 2). The study area has a population of 1303, it has 587 households, overall, only 20.8 % of the population have access to piped water inside the dwelling and 20.2 % have flush toilets connected to sewerage. The study was part of a larger study taking place in wards 16 and 17. Madeya village in ward 17 was purposively selected because previous studies had shown that the village had a high prevalence of schistosomiasis and water was scarce in the area (19,20). At the time of the study, the number of households (HH) of Madeya village was approximately one hundred and sixty-five (165).

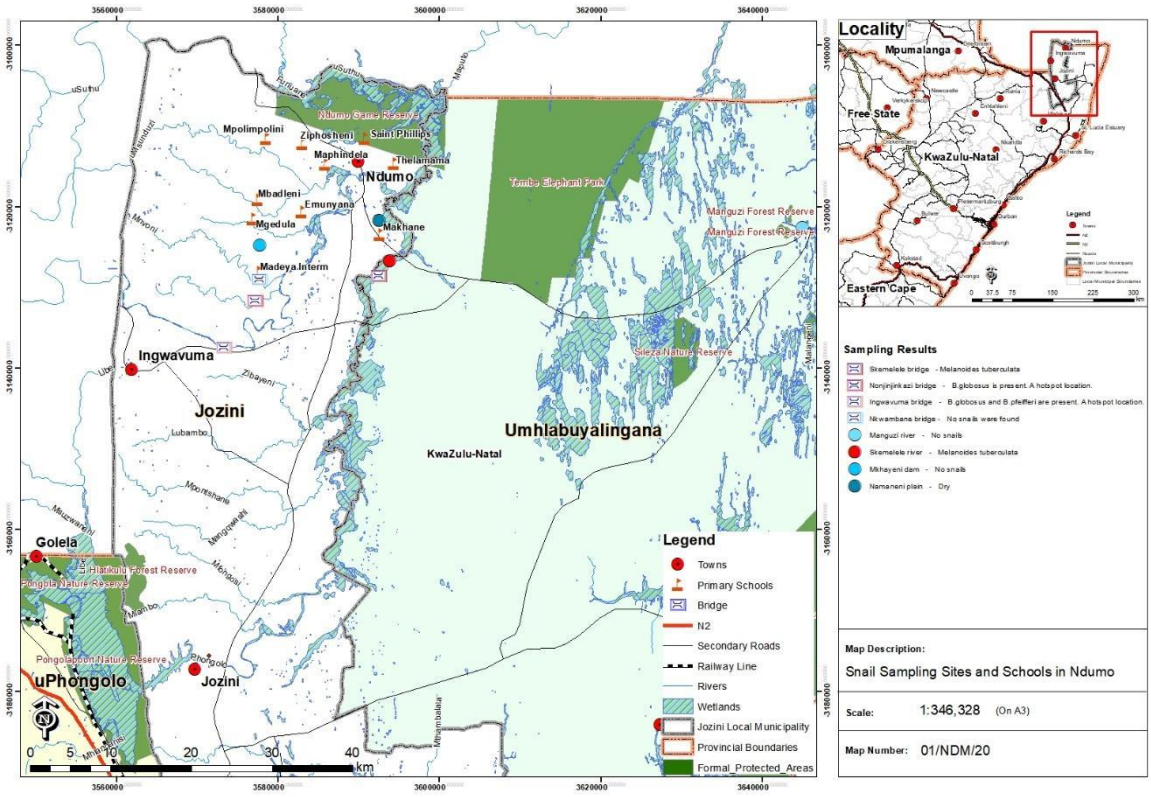

Figure 2: *Study Area: Madeya village in the uMkhanyakude district in KZN (The top right corner shows the location of where the study area is situated within KZN).*

1.6.2 Study participants and data collection methods

1.6.2.1 Qualitative data collection

1. 6.2.1.1 Community mapping and transect walks

Two participatory research methodologies were used to collect data: community mapping and transect walks. To ensure that voices of both men and women were well represented, there was a fair representation of both genders participating in the community mapping activity and transect walks. Research assistants and researchers encouraged both genders to express themselves and report their views before and during the data collection process. Eight participants, five men and three women, participated in the community mapping activity. Once the contents of the map were agreed, members of the community undertook a transect walk. The aim of the transect walk was to cross-check the accuracy of the map. Two transect walks were conducted in the village (Madeya), the first transect constituted of 10 participants, 4 women and 6 men. The second transect walk consisted of two researchers and six members of the community (2 men and 4 women). A total

number of 16 individuals participated in the transects walks. Researchers were listening carefully to the narratives provided by the community members during community mapping and transects walks activities; the narratives were recorded using an audio recorder. The conversations took place in IsiZulu. The researchers observed and recorded the conditions of water and sanitation facilities and took photographs while participating in the transect walk.

1.6.2.1.2 In-depth interviews

Furthermore, eight in-depth interviews with key informants were conducted; these included two teachers, two nurses, two village headmen, and two community caregivers (CCGs). Key informant interviews were used to extract information on WASH conditions, experiences of stakeholders with WASH within their various institutions as well as barriers to WASH promotion. A semi-structured interview guide with the following themes was used: provision of WASH services; role of the stakeholder; and local experiences with WASH issues. All data from key informants were captured on an audio recorder.

1.6.2.1.3 Focus group discussions

Members of the community were invited to participate in focus group discussions (FGDs). Four focus group discussions, (each comprising of approximately eight participants) were conducted with 32 participants: two FGDs were conducted with women and another two with males. FGDs were used to identify common practices in community regarding WASH as well as perceptions toward WASH. Each FGD comprised of 6–12 participants who were recruited purposively with the assistance of community research assistants to provide diversity in age, employment activities, and their location of residence within their neighbourhood.

All interviews and focus group discussions were conducted in isiZulu and recorded using an audio recorder. All participants had lived in the study area for more than 10 years. The researcher took detailed notes and kept a journal during all interviews. The notes included observation of objective facts such as nonverbal cues for instance; facial expressions, expression of emotions and objects in the environment where the interview was taking place and the description of the scene. The note taking started with the date, time, location and a brief sentence about the purpose of the interview/discussion. The researcher clearly stated the ages, sex and the number of people participating in the case of focus group discussions, community mapping and transect walks.

1.6.2.2 Quantitative data collection

Households were selected randomly using the modified random-route procedure which involves dropping off interviewers at different locations within the designed geographic coverage area using the GPS for diversified coordinates and letting them choose a starting point and direction for selecting households (31). A standardized questionnaire was administered face-to-face to 57 household heads selected by trained community research assistants.

Only households with at least one child under the age of five years were selected to participate in the study. As a result, 57 households were selected from a pool of 165 who are part of the larger study. The original questionnaire was in English but was translated to IsiZulu, the local language. The questionnaire was administered using an electronic form in the KoboCollect Toolbox, an open-source platform for collecting and analyzing data (32). To ensure uniformity in the understanding and evaluation of the data collection instrument, it was piloted in a non-study area using local research assistants and researchers. Core questions on drinking water and sanitation for household surveys from the WHO was adopted for this study. All interviews were conducted in IsiZulu and recorded using an audio recorder. All participants had lived in the study area for more than 10 years.

1.6.4 Eligibility criteria and choice of households

All households with a consenting member above the age of 18 were eligible to be part of the study. However, we only included households with children below the age of five years thus constituting a sample of 57 households out of 165 households. We targeted households with children under the age of five because they are a vulnerable group and the most susceptible to diarrheal diseases. Households were chosen using a modified random route procedure (31).

1.6.5 Data analysis

For qualitative data, the study adopted a grounded theory approach. Data were analyzed manually using the six steps of thematic analysis described by Braun and Clarke (2006) (33). Quantitative data were analyzed using SPSS version 25. A detailed description of the study designs, methods, and analysis of the data obtained has been described in the Methods and Material section of each manuscript.

1.6.6 Ethical considerations

Ethical approval was obtained from the Humanities and Social Science Research Ethics Committee at the University of KwaZulu-Natal. Protocol reference number: **HSS/0396/018D.** All participants gave informed consent to participate in the study. This study ensured anonymity and confidentiality of all research subjects that were interviewed and those that participated in FGDs. All information collected during the course of this study is kept on the UKZN online database. The data management was dealt with in the context of the bigger project – all data (raw and processed) are kept at a central repository and can be made available should that be needed. All hard copies were also handed over for storage in the department of public health. Only the

researcher and the supervisor have access to this information. All materials pertaining to this study will be stored at the University of KwaZulu-Natal (Howard College) for a period of 5 years as abiding with the University's ethical procedures.

1.6.6 Trustworthiness of the study

Rigor in this study was achieved through credibility, dependability, confirmability and transferability (34). Credibility, also known as the truth value, was achieved via the description of rich data which was substantiated with direct quotes from the interviews. To achieve dependability, I took careful consideration of the rules and conventions of qualitative methodology; for example, all my research questions were clear and in line with the purpose of the research. The concept of reflexivity was applied to achieve confirmability. This means that, as a co-participant of the qualitative aspect of the research, I was able to distinguish my own values from those of the participants by documenting my assumptions and biases that could influence the interpretation of data. Thus, I was able to accurately capture the participants' perspectives and experiences. Finally, transferability refers to the extent to which the findings can be transferred to other contexts or respondents (35). The results from this study reflect WASH behaviours and practices as risk factors of schistosomiasis in a low-income rural community at the time the study was conducted. This information was collected from various individuals (stakeholders and general members of the community). Additionally, different data collection methods were used to reach triangulation thus, the findings are an accurate representation of behavioural factors and practices that predispose members of the community to schistosomiasis. However, careful attention should be paid to contextual factors if the findings are to be transferred.

1.7 Thesis Overview

This thesis is divided into six chapters; a general introduction and a systematic review of literature, three data chapters, a conceptual framework and a synthesis of study findings, conclusion, and recommendations. Chapters 2, 3, 4 are data chapters and chapter 5 the conceptual framework have been formatted per the journal requirements to which they were sent for publication. Chapter 6 is the final chapter synthesizing the various components of the thesis. The full description is provided in the following sections:

Chapter 2: Community mapping and transect walk to determine schistosomiasis risk factors related to WASH practices in KwaZulu-Natal.

This is the first data chapter that explores a community diagnosis of WASH conditions by assessing water, sanitation, and hygiene practices and identified risk factors for schistosomiasis using participatory research

methodologies. This chapter demonstrates how members of the community through community mapping and transect walks were able to identify risk factors for schistosomiasis related to their WASH practices. The manuscript entitled "Community mapping and transect walks to determine schistosomiasis risk factors related to WASH practices in KwaZulu-Natal" was published in the *International Journal of Waterlines.*

Chapter 3: Water, Sanitation, and Hygiene for Schistosomiasis prevention: A Qualitative Analysis of Experiences of Stakeholders in Rural KwaZulu-Natal.

Many studies have linked improved WASH to decreased transmission and reinfection of schistosomiasis. However, very little is being done to involve stakeholders in the implementation of water, sanitation, and hygiene (WASH) strategies for schistosomiasis control. Hence this section explores the adoption of WASH through the involvement of a wide range of stakeholders and documents prevailing practices and experiences with WASH in the context of Schistosomiasis prevention. The manuscript entitled "Water, Sanitation, and Hygiene for Schistosomiasis prevention: A Qualitative Analysis of Experiences of Stakeholders in Rural KwaZulu-Natal" was accepted for publication in the *International Journal of Water, Sanitation and Hygiene for Development.*

Chapter 4: Contextual and Psychosocial Factors Influencing the Use of Safe Water Sources: A Case of Madeya Village, uMkhanyakude District, South Africa.

The risk of schistosomiasis transmission is associated with behavioral factors. However, there is a paucity of information on the behavioral (psychosocial) factors that influence risk for Schistosomiasis, hence we measured critical Psychosocial factors for behavior change to reduce the risk of Schistosomiasis transmission. The Risk, Attitude, Norm, Ability, and Self-regulation (RANAS) model to estimate the intervention potential for each factor was adapted for this study. By analyzing differences in means between groups of current performers (doers) and nonperformers (non-doers) we were able to determine which psychosocial factors were critical in the use of safe water sources. The Manuscript entitled: "Contextual and Psychosocial Factors Influencing the Use of Safe Water Sources: A Case of Madeya Village, uMkhanyakude District, South Africa" was published in the *International Journal of Environmental Research and Public Health.*

Chapter 5: A conceptual framework for an integrated behavioral change WASH Intervention strategy for schistosomiasis prevention in Madeya Village.

The most successful public health programs and initiatives are the ones that consider health behaviours in the context in which they occur. Considering the fact that there are multiple determinants and multiple levels of determinants of health and health behavior, a WASH conceptual framework for schistosomiasis prevention was proposed based on data from the above sub-studies. This framework takes into account the context in which behavior is taking place. Furthermore, three behavioural change theories were integrated in the framework. This resulted in a proposed framework in form of a manuscript entitled: "An integrated behavior change WASH intervention strategy for schistosomiasis prevention in Madeya Village: A conceptual framework. The manuscript is provisionally accepted in the *International Journal of Environmental Research and Public Health.*

Chapter 6: Synthesis

The final chapter of the thesis is a synthesis of all chapters to give a broad perspective of how these manuscripts interlink. This chapter also contains implications and possible application of the study as well as suggested areas of future research.

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CHAPTER 2

COMMUNITY MAPPING AND TRANSECT WALKS TO DETERMINE SCHISTOSOMIASIS RISK FACTORS RELATED TO WASH PRACTICES IN KWAZULU-NATAL

The introduction and the literature that has been reviewed suggests that there is a need for a bottom-up approach to WASH interventions to prevent schistosomiasis. Emphasizing community participation increases the likelihood of the success of the program. It is in this respect that the next chapter applied a participatory research design to identify WASH practices and schistosomiasis risk factors. This chapter addresses objective one of the study.

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Community mapping and transect walks to determine schistosomiasis risk factors related to WASH practices in KwaZulu-Natal

C. Mulopo, A. Mbereko, and M.J. Chimbari

A high prevalence of schistosomiasis has been reported among primary school-going children in KwaZulu-Natal. The study aim was to conduct a community diagnosis of WASH conditions by assessing water, sanitation, and hygiene practices and to identify risk factors for schistosomiasis using participatory research methodologies. Community mapping and transect walks were conducted in Madeya village within Ingwavuma area. Thirty-six participants, comprising 19 women and 17 men aged 22–68 years participated in the study. Data were analysed using the Braun and Clarke (2006) six steps of thematic analysis. Themes reported in relation to schistosomiasis risk factors included: 1) water scarcity as a risk factor for schistosomiasis; 2) village proximity to the river as a risk factor for schistosomiasis; 3) prolonged contact with open water bodies for domestic and recreational purposes as a risk factor for schistosomiasis; 4) poor irrigation practices as a risk factor for schistosomiasis; and 5) poor sanitation and hygiene practices. The river was the main source of water for domestic use and irrigation. Consequently, members of the community were exposed to the risk of schistosomiasis infection. Open defecation was observed in the case of children, and men confessed to doing it when in the field herding animals.

Keywords: schistosomiasis, water, sanitation and hygiene, risk factors, community mapping, transect walk

SCHISTOSOMIASIS IS A MAJOR PUBLIC HEALTH problem throughout the world, particularly in Africa (Hotez and Kamath, 2009). Schistosomiasis is endemic to most African countries and some countries in the Middle East (van der Werf et al., 2003). The disease causes substantial morbidity and mortality in many low- and middle-income countries (World Health Organization, 2006). Over 93 per cent of the world's schistosomiasis cases have been reported in sub-Saharan Africa (Hotez and Kamath, 2009). In 2014, schistosomiasis affected 230 million people including 40 million women of reproductive age (Colley et al., 2014).

Van der Werf et al. (2003) reported the prevalence of schistosomiasis in sub-Saharan Africa to be high. Approximately 70 million individuals out of 682 million in sub-Saharan Africa self-reported to experience haematuria associated with *Schistosoma haematobium* infection in the last two weeks prior to the study. An additional

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32 million also reported dysuria associated with *S. haematobium* (van der Werf et al., 2003). Schistosomiasis is caused by infection with flatworms belonging to the genus *Schistosoma*. Lack of basic sanitation infrastructure results in faecal contamination of aquatic environments, which may result in the infection of intermediate host snails with the schistosome parasite (Barbosa et al., 2010).

Globally, 2.1 billion people lack access to safe, readily available water at home, and approximately 4.5 billion lack safely managed sanitation. Furthermore, only 15 per cent of the population in sub-Saharan Africa has access to water and soap for handwashing (World Health Organization, 2017). Provision of safe water sources interrupts the transmission cycle by limiting contact with natural water potentially infested with snails carrying schistosome infections. The use of sanitation facilities limits contamination of surface water with urine or faeces that may carry schistosome eggs. On the other hand, health education plays an important role in stimulating health-seeking behaviour among people infected with schistosomiasis. Health education also informs the population at risk about the disease and informs them of various ways they can prevent disease transmission (van der Werf et al., 2003).

Schistosomiasis transmission thrives in the areas lacking water, sanitation, and hygiene (WASH) resources, as people in search of water come into contact with cercaria-infested water bodies (Grimes et al., 2015) while some others without sanitation facilities defecate in freshwater bodies inhabited by the snail intermediate host for the *Schistosoma* parasite (Gordon et al., 2019). Approximately 76 per cent (Steinmann et al., 2006) of the population in sub-Saharan Africa live near freshwater bodies and thus are at a high risk of contracting schistosomiasis. Moreover, surface irrigation systems are also a risk factor for schistosomiasis in Africa. They create favourable breeding conditions for snails that transmit schistosomiasis (Steinmann et al., 2006; Boelee and Madsen, 2006; Ekpo et al., 2008).

South Africa is classified as a water scarce country (Rijsberman, 2006) and has disparities in the distribution of water and sanitation resources. Rural areas have a lower coverage of water and sanitation compared to the urban areas (Pullan et al., 2014). Inadequate access to water supply and sanitation in rural communities results in people using unsafe water sources, such as rivers and dams, thus putting themselves at risk of contracting WASH-related diseases like schistosomiasis. In KwaZulu-Natal, one of the provinces in South Africa, schistosomiasis is endemic, with a high prevalence among primary school children (Thomassen Morgas et al., 2010).

This study, therefore, aims to understand the prevailing WASH conditions in Madeya village and to identify potential risk factors for schistosomiasis transmission using participatory action research (PAR). Findings from the study will contribute to the development of an appropriate intervention for schistosomiasis control in the study area.

Materials and methods

Study area and population

The study was conducted in Madeya village within ward 17 located in the district of uMkhanyakude situated in the northern part of KwaZulu-Natal province,

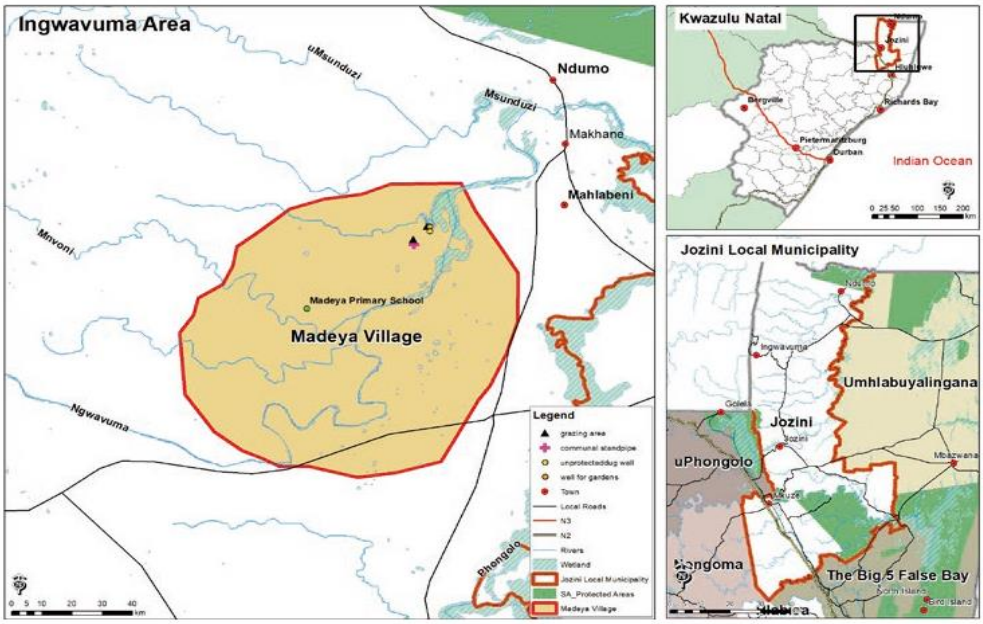

Figure 1 Study area (Madeya Village) located in KwaZulu-Natal Province within uMkhanyakude district

South Africa (Figure 1). The study was conducted between November 2017 and March 2018 as preliminary diagnosis of the WASH conditions in Madeya. There are approximately 328 households in the village; this information was collected from the *Induna* (village headman). The area is arid and has received below-average rainfall in the past four years, meaning precipitation has fallen below the seasonal average. IsiZulu is the main language spoken in the area. The study site was purposively sampled based on previous studies indicating a high prevalence of *S. haematobium* within the study area; prevalence was reported at 37.5 per cent of school-going children (Manyangadze et al., 2016; Kabuyaya et al., 2017). A recent study indicates that the prevalence of *S. mansoni* (0.9 per cent) is lower than that of *S. haematobium* (1 per cent) among preschool children in the study area (Sacolo-Gwebu et al., 2019). These findings are consistent with previous studies (Saathoff et al., 2004; Daniel, 2009). Generally, five schistosome species exist that cause schistosomiasis: namely, *Schistosoma haematobium (S. haematobium)*, *S. mansoni*, *S. japonicum*, *S. mekongi*, and *S. intercalatum* (Gryseels et al., 2006). The species present in the study area are *S. haematobium*, which is transmitted through contact with infested water, and *S. mansoni*, which is spread through poor sanitation practices, such as open defecation.

In this community, gender roles in the context of WASH are evident. Women are involved more in WASH activities than men. Women are responsible for collecting water for household purposes as well as watering the garden. While women were responsible for ensuring that toilets are clean, men were responsible for digging the

hole for the pit-latrine and also participated in building the toilet structures and making cement blocks for the toilet structure.

Selection of participants

Participants of the study were conveniently selected based on their availability and willingness to participate in the study. The recruitment of participants was done by word of mouth invitation of individuals that were very familiar with the study area. A member of the community was tasked to invite other members of the community. Moreover, to participate in the study, members of the community must have stayed in the village for at least 20 years. Gender dynamics were also considered to ensure that the diverse opinions and/or perceptions of both men and women were captured. Thirty-six participants, including 19 women and 17 men, participated in the study. Their age was between 22 years and 68 years. Most of the research participants have attended high school to a certain degree. All the men and women were unemployed except for one man who was an *Induna* (community headman) and one woman who was employed as a preschool teacher. Women with children received social grants from the government.

Informed consent was sought from all the participants before engaging them with the study. The *Indunas* (community headmen) of the villages provided the researchers with gatekeeper permission letters which were submitted to the University of KwaZulu-Natal ethics committee. The University of KwaZulu-Natal humanities and social science research ethics committee (HSSREC) granted ethical approval.

Data collection

Two participatory research methodologies were used to collect data: community mapping and transect walks; the study procedure is illustrated in Figure 2. To ensure that voices of both men and women were well represented and captured during the study, we ensured that there was a fair representation of both genders participating in the transect walk and discussions. Furthermore, research assistants and researchers encouraged both genders to express themselves and report their views before and during the data collection process. The research assistant prompted the women to speak by maintaining eye contact and also probing for their opinion in a polite and encouraging manner.

Community mapping. The first session of community mapping was conducted at Madeya Mobile Clinic in Madeya village. This is where the residents of the village normally meet for community meetings. The concept of community mapping was introduced and discussed as a tool for accessing information about access to WASH services in the community. Eight participants, five men and three women, participated in the community mapping activity. Community mapping has been used successfully in development planning and is also a key tool for community mobilization and empowerment. The technique has been applied successfully in many communities in Asia and Africa (Gloeckner et al., 2004). The process of community

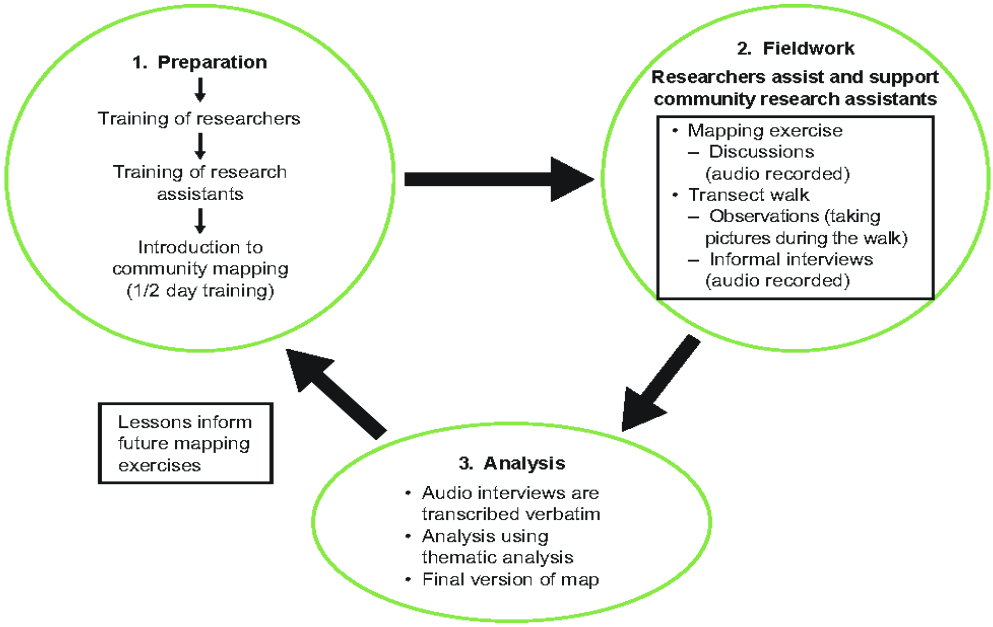

Figure 2 Study procedure: community mapping and transect walks

mapping helps members of the community to identify local problems and therefore results in co-production of knowledge by both researchers and communities.

The second community mapping took place at an early childhood development (ECD) centre. The ECD centre was a convenient place to conduct the activity because community meetings normally take place under a tree outside the ECD centre. A lot more people turned out for the second community mapping activity. There was a total of 24 participants, 10 men and 14 women. Both sessions of the community mapping were facilitated by a research assistant from Madeya village who was familiar with the village.

Participants in all groups were given markers and flip charts, and instructed to draw maps showing water sources in the community, places of defecation or sanitation in the community and water bodies. They were also asked to include housing, roads, churches, water sources, and sanitation facilities on the maps. Topics discussed during the community mapping exercise included the state of water and sanitation in the community, experiences of community members on access to water and sanitation, and water contact behaviours. Two participants in each group took the lead by assisting each other in the actual drawing of the map while the rest of the group contributed to the discussion while the drawing was taking place. Community members who participated in the community mapping exercise produced a map of their area, highlighting the challenges associated with water and sanitation that they experienced. Once the maps were completed, the two participants who led the groups presented the maps to the group. Additional contributions from group

members were added to the map during the plenary presentations. The community mapping activity lasted for approximately three hours. The maps included details on location of households, location of water sources, location of water bodies, and location of grazing areas.

Transect walks. Once the contents of the map were agreed, members of the community undertook a transect walk. The aim of the transect walk was to cross-check the accuracy of the map. Details that were still unclear were confirmed, and others that had been omitted were included in the maps during the transect walk. Two transect walks were conducted in the village (Madeya), the first transect constituted of 10 participants, 4 women and 6 men. The second transect walk consisted of two researchers and six members of the community (2 men and 4 women). Thus, 16 people participated in the transect walks. During the transect walk, the researchers and members of the community walked through the community from one point of the village to another. This was done while having conversational interviews on WASH practices by informally asking questions to members of the community that were walking with the researchers as well as members of the community we came across during the walk. Researchers were listening carefully to the narratives provided by the community members; the narratives were recorded using an audio recorder. The conversations took place in IsiZulu. The researchers observed and recorded the conditions of water and sanitation facilities and took photographs while participating in the transect walk. The first transect walk lasted one hour and nine minutes, whereas the second transect lasted for approximately two hours.

Data analysis

Audio recordings from the transect walks and mapping activities were transcribed verbatim and translated into English by a research assistant fluent in both IsiZulu and English languages. Transcripts, field notes, and observations were analysed for themes related to the conditions of WASH and risk factors for schistosomiasis. Braun and Clarke's (2006) six steps of analysis guided the analysis process. First, was the familiarization of data by reading and re-reading the transcripts. Second, initial codes were generated by coding interesting features in the data in a systematic way across the data set. Third, the initial codes were collated to develop themes. The fourth step involved reviewing the themes by checking if they relate to the coded extracts and the entire data set. Fifth, themes were defined and named by generating clear definitions and names for each theme and, sixth, a report was produced. We triangulated the data from the transect walks, community mapping, and observations to ensure credibility. Furthermore, dependability was achieved by having another researcher that was not part of the data collection process to examine the data collection and data analysis, as well as the findings of the study. Confirmability was achieved by reaching a consensus about the findings of the study between those who examined the data and the researcher, and transferability was achieved by the researchers' thorough description of the study context (Golafshani, 2003). Additionally, member checking and the confirmation of the

research findings was achieved with the participants by reporting the findings to them and confirming accurate representation. Five main themes emerged from the data.

Findings

Five main themes emerged from the data. All the themes reported were in relation to the risk factors that predispose people living in the village to schistosomiasis. The themes are: I) water scarcity as a risk factor for schistosomiasis; II) village proximity to the river as a risk factor for schistosomiasis; III) prolonged contact with open water bodies for domestic and recreational purposes as a risk factor for schistosomiasis; IV) poor irrigation practices as a risk factor for schistosomiasis; and V) sanitation and hygiene practices.

Theme I: Water scarcity as a risk factor for schistosomiasis

Availability of water source. The water sources observed during the transect walks are indicated on the map (Figure 3) and included: rivers, a borehole, communal tanks, communal taps and yard taps, rainwater harvesting (*jojo* tanks), and water tankers. Figure 3 shows the location of the water sources in Madeya village. Although there were quite a number of water sources, most of them were inadequate. The community had communal taps and yard taps; however, these were reported

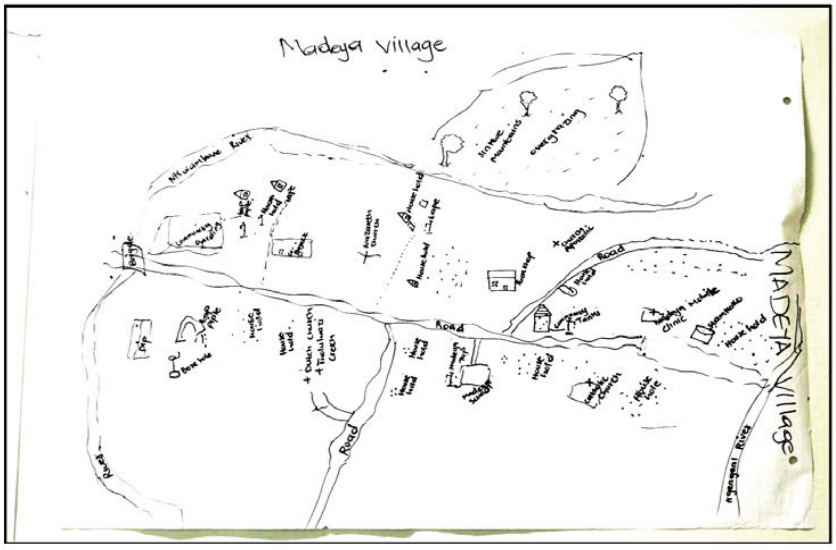

Figure 3 Community map drawn by community members during a community mapping activity in Madeya village, South Africa

Scale: 1cm = 100m

to have no running water. The community also had communal tanks and the municipality filled these up with municipal water. Municipal water which serves this community comes from Jozini dam. The water from the dam is pumped to a treatment plant for purification to reach a drinking water standard. This water is then piped to a reservoir where water tankers collect the water and distribute it to communal tanks so that members of the community can access it. However, the municipality was not consistent in filling up the communal tanks: *'The municipality brings water once in two or three months'* (unemployed woman, 40 yrs; community mapping). They would fill up the communal tanks occasionally, and members of the community collect water from that point for that period of time until the water runs out: *'The truck comes and sometimes it doesn't and they fill up this tank here and that is where members of the community will collect water'* (village headman, 50 yrs; transect walk one). The one borehole that was functional and the river was perceived as a more reliable source of water than the other water sources. However, people still preferred the river to avoid long queues at the borehole. However, during the dry season, some of the rivers would dry up. In such cases, members of the community would dig a waterhole in the riverbed and turn it into a water source (Photo 1).

Adequacy in terms of water source points and current population. Participants reported limited access to piped water in the village. The communal tanks had not had water in the past 5–10 years in the villages according to the research participants: *'We've had water problems for a long time now it's almost 10 years now since we've had water running from these communal tanks'* (unemployed woman, 37 yrs; transect walk one). There was only one communal tap functioning, and water was only available on Thursdays:

> *Even when we come here some days we don't get water, see now there hasn't been water in these taps since Thursday and today it's Sunday. The water comes out every Thursday, and you have to come in early in the morning because if you come late you won't get any* (unemployed man, 47 yrs; transect walk one).

Photo 1 Woman (left) fetching water from a waterhole dug next to Munyuwana River, and a man (right) demonstrating to researchers on how they fetch water from a waterhole dug in the riverbed during the transect walk. Members of the community put bushes around the water sources to prevent animals from accessing water sources reserved for drinking.

Only two yard taps were reported to occasionally have running water. However, supply of water by the taps was erratic and sometimes there would be no water for 3 months or longer: '*Ha!! It's been more than three months since water came out of the tap*' [high pitched tone] (unemployed woman, 34 yrs; community mapping). '*Yes, we have pipes, but water is not coming out of the taps … it's been a while since water has come out*' (unemployed man, 47 yrs; transect walk one). Some members in the community had installed taps at their homesteads; however, they still experienced challenges with running water: '*The next house which belongs to Mr Ndlazi, there's a tap which is not for the whole community, it belongs to him, but it doesn't work, there's no water*' (unemployed woman, 24 yrs; community mapping). Consequently, for the reasons mentioned above the river turns out to be a more reliable source of water: '*Sometimes, if maybe they couldn't get water from the pipe, because now we don't have water from the pipe they drink water from the river*' (unemployed woman, 40 yrs; transect walk one).

Functionality of water source and shared facilities with livestock. Members of the community were dissatisfied with the water conditions in the community. This was confirmed by one man in conversations that took place during community mapping (Figure 3). The community was not happy that they collected drinking water from the same spot used by livestock (Photo 1). '*This is a place where we all drink, even the cows*' (unemployed man, 28 yrs; community mapping). The above statement was made during the community mapping activity (Figure 3) when one of the men was marking the site of water collection.

Most of the water sources classified as improved water sources were not functional in the community; therefore that resulted in members of the community accessing water from unimproved water sources (Photo 1). However, because the unimproved water sources were usually not protected, livestock drink water from the same sources: '*We get to Munywana River where we all get our water, even the cows, yes. Here the cows graze, this is the river, and the cows graze below it*' (unemployed woman, 24 yrs; community mapping).

The water conditions in the area where the second transect walk took place were reported to be worse than in the area where the first transect walk took place. The area where the first transect walk took place had a tap that runs once a week as well as a communal borehole. It was reported that members of the community had to wait for a long time in the queue in order to fetch water from either the tap or the borehole. In addition to the long waiting time, water from the borehole trickled slowly such that it took a long time to fill up the buckets.

Theme II: Village proximity to the river as a risk factor for schistosomiasis

The entire village is in close proximity to the rivers (Figure 3), which serve as boundaries to the village. Limited access to water and the proximity to the river predispose members of the community to schistosomiasis. Women, young girls, and boys have the responsibility for fetching water for use in the household. During the second transect walk, we observed women, young girls, and boys collecting water at the river (Photo 1). In addition, it was reported that swimming

in the river by both adults and children was a common practice in the village and adults reported that children urinate in the river when swimming '*When it rains and the rivers are flowing we swim in the river and we enjoy it*' (unemployed man, 45 yrs; transect walk two).

Through the discussions at the borehole with women, it was established that people were usually exhausted by the time they got to the borehole because of the long distance that they had to walk. When women were asked why they were just seated at the borehole, they said they were tired and needed to regain their strength before they could start fetching water. '*We are resting; we walked a long distance to get here so we first need to rest and then we can start pumping the water*' (unemployed woman, 32 yrs; transect walk one). Consequently, women in that part of the village found it much more convenient to fetch water from the river than having to fetch water from the tap or borehole. In the second transect walk, the community reported to mainly rely on the river as their main source of water.

Theme III: Prolonged contact with open water bodies for domestic and recreational purposes as a risk factor for schistosomiasis

Due to the close proximity of the village to the river (Figure 3) and limited access to improved water sources, people have frequent, prolonged contact with water from the river. Snails that transmit schistosomiasis have been found at sites along the river (Photo 1) where local community members performed most of their water activities, such as water collection for domestic use, washing clothes, irrigation, and swimming or bathing. Washing clothes in the river and other surrounding freshwater bodies was common and was observed many times. '*There is no water, so we go to the river to wash our clothes from the river we do not have money to pay for water to wash our clothes*' (unemployed woman, 35 yrs; community mapping). In Madeya village, we observed women washing clothes in the river, and one of them had a child less than 5 years old who did not have clothes on and was playing on the banks of the river. We also observed women standing in the water while washing clothes. Collecting water from the river, swimming in the river, and doing laundry are water contact activities that were either reported or observed during the transect walk and community mapping.

Theme IV: Poor irrigation practices as a risk factor for schistosomiasis

Members of the community depended on rivers and rainfall for agricultural production. They depended on water from the river for irrigating community and personal gardens as well as for watering livestock. Personal and communal gardens were located near the rivers in both villages. Women were observed managing the gardens. The river was the main source of water for irrigation, and it was mostly women who came into contact with water when watering gardens. During the first transect walk, community members said in the last 10 years there had been a reduction in the amount of rainfall in the area. Hence, some of the gardens were abandoned. When we first did the transect walk in November 2017 the river, which

was the main source of water for irrigation for the gardens in the community, was dry and gardens had been abandoned.

> *This is a community garden but because it is like this now* [meaning there are no crops] *we don't have water, the river is dry, we were unable to cultivate in this garden. It is now dry, and they cannot plant anything until the rain comes again* (unemployed woman, 38 yrs; transect walk one).

However, during a subsequent visit, it had rained, and the rivers had water. We observed women working on previously abandoned garden plots. Thus, women had resumed their usual gardening activities and were coming into contact with water from the river.

Rainwater harvesting was noted as another water source for watering personal gardens. However, the use of rainwater is dependent on the amount of rainfall and on the nature of the roof at the homestead. Some households had *jojo* tanks, but they were generally empty because of limited rainfall. In some cases, it was reported that individuals fetched water from the river and stored it in the *jojo* tanks. *'I go to the river, early in the morning and collect water which I then use to fill up the jojo tank'*(preschool teacher, woman, 35 yrs; transect walk two). In addition to the water sources mentioned above, members of the community relied on water from the surrounding communities that had piped water. They paid individuals to transport water for them from the nearby communities with piped water. The water was transported using a *bakkie* (a light truck) for a fee between R100 and R350 (US$7.17–25.08) for thirty 25-L containers. *'If we are fetching the water from Mbabanani it's R250 ($17.91). If we are fetching the water from there (across the field) it's R100–150 ($7.17–10.75). It really depends on the owner of the car'* (unemployed woman, 60 yrs; transect walk two).

Theme V: Poor sanitation and hygiene practices

Non-availability of sanitation facilities at religious places, schools, and farmlands. On the community maps (Figure 3), members of the community did not indicate places of defecation. They reported that each household had a toilet and that the toilets were mostly used by adults (Photo 2). Several toilets observed during

Photo 2 The two types of VIP-toilets common in the community. The one on the left is made out of corrugated iron, and the one on the right is made out of bricks.

the transect walks were clean and did not have bad odour. However, upon probing, it became apparent that there was a non-availability of sanitation facilities at religious places (churches), during large gatherings, such as weddings, and at the farmlands. During these activities, individuals defecated in the bush, '*Well, we have toilets at home in every household, but the churches don't have toilets*'. The participant further alluded that they defecate in the open fields while at the farmland, '*So if you are out in the field or outside and need the toilet you just relieve yourself where the cows graze*' (unemployed man, 28 yrs; community mapping). Similar concerns were raised during the second community mapping activity '*If we are at church and need the toilet we go to the mountains or bushes*' (unemployed man, 55 yrs; community mapping).

Mainly men reported open defecation in the field. '*When we are in the field/farmland, and we need to relieve ourselves we just go to the bush*' (unemployed man, 57 yrs; transect walk two). During the transect walks, we observed that all the farmlands were next to the river. The farmlands are close to the river because the river is the main source of water for irrigation. Consequently, if members of the community are defecating on the farmlands, then there is a high possibility of faecal matter being washed into the river.

Limited access to water prevented handwashing at critical points such as after defecation. Members of the community knew that it was important to wash their hands after using the toilets; however, they were unable to practise this hygienic behaviour. '*No, there isn't water, and sometimes you don't even have the water to wash your hands after using the toilet because of the water shortage*' (unemployed man, 57 yrs; transect walk one).

Incompatibility of toilet holes at home for children. Although toilets were provided and community members reported to be satisfied with them, household members reported incompatibility of toilets holes at home for children. Open defecation at home was common among children. It was reported that at household level, the toilets provided by the municipality were not suitable for children (Photo 2). Consequently, children defecated in the yard: '*The toilet hole at home is too big for the child, so our children don't go there, we accompany the children and dig a hole for them to poo and then cover the poo*' (unemployed woman, 42 yrs; transect walk two). Similar observations were made at the crèche where teachers took children to the outskirts of the early childhood development centre (ECD) premises to defecate. '*We do not have a building for the crèche, we use the Dutch church, and since it's not our building, it doesn't have proper safe toilets appropriate for children*' (preschool teacher, woman, 32 yrs; transect walk two). This confirms open defecation occurs in some places around the villages.

Non-availability of a garbage collection system in the community. Lastly, there was no garbage collection system in the community. Diapers were dumped in the open environment; we observed many used diapers next to the pit-latrine at a crèche. The teacher reported that they had no garbage collection system in the community and they had nowhere else to dispose of the diapers except behind the toilet on the ground.

Photo 3 Picture of an unimproved pit-latrine

Adequate toilets at household level. At household level, the toilet facilities were found to be adequate. Every household had a ventilated improved pit-latrine (VIP) (Photo 2). The sanitation technologies observed in the community were simple pit-latrines (Photo 3) and ventilated improved pit-latrines (VIPs). The VIP toilets were provided by the municipality. We noted various types of VIP latrines built with different materials. Some toilets were built with iron sheets while others were constructed using bricks (Photo 2).

The government awards tenders to suppliers to supply building materials for the construction of the toilets in the community (Photo 2). The agreement is that the owner of the household ensures that a hole is dug where the toilet structure will be placed and the government provides all the material needed to build the toilet. The municipality outsources the work to individuals who build the toilet structure. All monetary costs incurred are settled by the municipality: '*I dug this hole for my house, they told me if I dig the hole they will come and build for me*' (unemployed man, 35 yrs; transect walk one).

Some households had two latrines on their premises; one they constructed on their own (old) and another constructed through the municipality subsidy (new) (Photo 3). In such situations, the new latrine was preferred.

Handwashing practices after using the toilet. We found no designated places for handwashing; however, members of the community said they used 2-L fizzy drinks plastic bottles for handwashing (Photo 4). They filled these bottles up with water and placed them next to the toilet and used them for handwashing after using the toilet.

> *No there are no handwashing facilities, but what we tell them is that they must use a 2-L bottle and put soap inside, and then hang it right outside the toilet so that they make sure they wash their hands before going into the house* (Induna, man, 50 yrs; transect walk two).

Photo 4 A 2L container hangs on the side of the toilet used for handwashing

This strategy was not very effective due to the scarcity of water in the area. Not all households observed had these bottles at the toilets; we also observed bottles that were empty. During the transect walk, the participants indicated that very few households had these containers. Furthermore, it was said that members of the community only put up these containers on the days that the community care givers (CCGs) visit to create an impression that they practise handwashing: '*There are very few houses with these containers; some households put these water bottles just on the days that CCGs visit*' (unemployed woman, 42 yrs; transect walk two). One of the roles of the CCGs is to educate the community about good hygiene practices, but they are not always there to ensure that households practise what they are taught.

Discussion

We were able to describe the conditions of WASH resources and identify predisposing risk factors to schistosomiasis in Madeya village. Madeya village is typical of many villages in sub-Saharan Africa. Most rural areas in sub-Saharan Africa are

characterized by limited access to water and sanitation, proximity to open water bodies, and dysfunctional water systems (Mackintosh and Colvin, 2003; Sutton, 2004; Haysom, 2006; Steinmann et al., 2006; Rodgers et al., 2007). Hence, our findings may be applicable to other similar settings. The study applied a novel way of assessing schistosomiasis risk by using community mapping and transect walks. Although community mapping and transect walks have been used successfully in development and planning of communities, these methods have not been fully explored as a rapid assessment tool for schistosomiasis transmission. In this study, community mapping enabled the community members to understand their problems more clearly. Hence, this participatory methodology is useful in empowering communities and enables them to identify problems and engage in the problem-solving process. This approach views research participants as co-constructors of knowledge and not subjects of research (Given, 2008). This study presented preliminary findings to WASH practices in uMkhanyakude.

Availability of resources: both water sources and sanitation facilities

We found that water was scarce in the village; this was a result of limited water resources. Although the municipality provided pipes for both communal and yard taps, the taps had no running water. There was limited access to piped water; consequently, members of the community relied on the river as a main source of water. This situation is typical of many poorly resourced communities in sub-Saharan Africa whereby limited access to WASH infrastructure results in members of the community having to depend on inadequate water sources, mainly surface water (Tumwine et al., 2002; Baumann, 2005; Mackintosh and Colvin, 2003; Lockwood and Smits, 2011). Grimes et al. (2015), in their review, found that there were significantly lower odds of contracting schistosomiasis with an increase in access to safe water and adequate sanitation. The prevention, control, and eventual elimination of schistosomiasis depends heavily on improvement (quantity, quality, and access) of WASH (Freeman et al., 2013). Madon et al. (2018), in Tanzania, reported on how WASH interventions sustained schistosomiasis control efforts.

We found that members of the community were satisfied with the toilets (ventilated improved toilets) that were provided to every household by the municipality. We found toilets to be adequate and clean at the household level. Access to adequate toilets is associated with lower odds of contracting schistosomiasis (Grimes et al., 2014). However, there were no toilets in public spaces such as at churches, at some crèches, and in the open fields. Consequently, this leaves room for open defecation during large gatherings, such as when people are at church and when men are in the field herding cattle. Most likely men defecated in the fields when they spent prolonged periods looking after domestic animals. Thys et al. (2015) reported in their study that men actually preferred open defecation. The acceptance of household VIP toilets by participants indicates that when good quality toilets are provided, members of the community are more likely to accept them.

Children defecated in the yard at household level because the toilets provided by the municipality were not suitable for child use; moreover, this has an impact

on open defecation. The same explanation holds for the observations made at the crèche and ECD centres. Open defecation has ramifications for schistosomiasis transmission. For as long as there is a practice of open defecation in Madeya village, there is a risk of schistosomiasis transmission. Faeces disposed in the environment may be washed into the river system when it rains. This contaminates the water, and if there are schistosome eggs in the faeces, they may hatch and penetrate intermediate host snails that might be present, thus making the water bodies potential transmission sites for schistosomiasis. Hence, to prevent schistosomiasis infection, provision of toilets is critical; this goes beyond providing infrastructure to providing infrastructure that is suitable for all populations both at household level and in public spaces. Additionally, when the infrastructure is appealing to members of the community, it increases the likelihood of acceptability.

Adequacy in terms of water source points and current population and functionality

The water resources described in the results section were mostly inadequate; hence there is a need to provide adequate water resources in the community and adequately manage these resources. There needs to be a discussion on how water and sanitation resources in the community should be managed, and by whom. According to Harvey and Reed (2006), implementing agencies, both government and non-government, must develop long-term strategies for ensuring that WASH services are managed in a sustainable manner. In the current study, only one borehole was operating in the community, consequently resulting in long queues at the water source. There were an additional two yard taps and a communal tap that occasionally had running water. The improved water sources that were available in the community are not sufficient to supply clean and safe water to the population. Inadequate water sources, such as rivers and dams, have become more reliable water sources for the community. However, during the dry season, some of the rivers dry up and unprotected dug wells in the river become the main source of water. These conditions can be avoided if implementing agencies engage and involve communities in the provision of WASH services by making sure that members of the community have a say on their preferred technology. Members of the community should be involved at all levels of decision-making; this will promote co-production through community participation and community management.

Functionality of water sources and shared facilities with livestock

The majority of community members collected water from unimproved water sources. The water sources were unprotected, allowing animals to access them; hence most water sources are shared with animals. Intermediate snail hosts for *Schistosoma* have previously been found along some of these water bodies; hence they pose a risk for schistosomiasis to both humans and animals. The livestock could also be contributing to the high prevalence of schistosomiasis as, according to research, schistosomiasis is a common parasitic infection in cattle (De Bont and Vercruysse, 1997). These experiences are similar across Africa. Community engagement and

involvement members of the community can work together to demarcate areas such that animals are kept away from sources where domestic water is collected. A study in Tanzania found that 71 per cent of study participants reported that they shared water sources with animals (Kusiluka et al., 2004).

The water resources in Madeya were not functional as only two taps were reported to have running water. The rest of the taps had no running water or had running water on a particular day, and the water would run at certain hours of the day. This made it difficult for the community. The water provided by the municipality through water tankers was inadequate in that it was not provided regularly, and it was not enough for the community. Due to the inadequate and unavailable water resources, open water bodies were the main source of water for this village.

Village proximity to the river as a risk factor for schistosomiasis

A lack of safe water sources and proximity of the village to the river lead women and young girls to perform domestic activities at the river. These contextual factors in Madeya village contribute to schistosomiasis transmission. Similarly, many communities in sub-Saharan Africa are in close proximity to open water bodies which expose them to schistosomiasis (Steinmann et al., 2006). Moreover, some studies have shown that children who attend schools close to open water sources are at a high risk of contracting schistosomiasis (Kapito-Tembo et al., 2009). The fact that the rivers are in close proximity within the study area, coupled with a lack of adequate water resources, compels individuals to use resources that are not adequate, consequently exposing them to many health risks, schistosomiasis being one of them. Since many communities in sub-Saharan Africa have similar contextual factors, findings from the study speak of the need for WASH behavioural change interventions that go beyond just educating individuals about WASH diseases and transmission routes to include other factors such as using emotions or motivation to influence behaviour change. Furthermore, it is critical to identify environmental barriers and opportunities that influence behaviour change as well as promote a sense of belonging among targeted individuals through engaging in a desired behaviour. The behavioural change approach is participatory in nature and takes a longer time to achieve; however, it is reported to be more effective (Dreibelbis et al., 2016; Mayne, 2018).

Our findings on the reason why women and young girls have contact with infected open water bodies are similar to those of Gazzinelli et al. (2001) where about 75 per cent of water contact activities were attributed to domestic activities. Although we did not quantify water contact, we observed that generally women in the study area had more contact with freshwater bodies compared with men.

Proximity to the river and a lack of recreational facilities contributes to individuals coming into contact with open water bodies. Kvalsvig and Schutte (1986) reported swimming to be the most important contact activity among young people in summer which exposes them to schistosome infections. Ekpo et al. (2010) reported similar findings of young people or older children being exposed to infection because of swimming. Our findings also show that children below

the age of five sometimes accompany their mothers to the river when they collect water and wash clothes. While at the river, the children come into contact with the water. Although we did not observe children being bathed in the river, Ekpo et al. (2010) indicated that exposure among children below the age of five was as a result of mothers bathing the children in the streams. According to Dalton (1976) bathing was more associated with prolonged contact with water than any other activity. A study conducted in Ghana reported a reduced incidence of schistosomiasis after a recreational water area (swimming pool) designed to reduce water contact was introduced in the community (Kosinski et al., 2012). A combination of swimming/bathing, washing clothes, watering the gardens, and collecting water from the river are likely to increase the risk of schistosomiasis infection in a poorly resourced community. Availability of water resources for recreational purposes was lacking in Madeya community, resulting in the population, especially young people, swimming in the river. In addition to providing behavioural change interventions, recreational interventions that reduce water contact are effective in reducing schistosomiasis.

Accessibility of water resources

We found that there were limited water resources in the community. For example, the taps had no running water, and the water tankers from the municipality were inconsistent in the provision of water. This made water resources inaccessible. The water resources available were either unimproved, or it took a long time to actually collect water from improved sources. Improved sources were few, and water was only available at certain hours of the day during the week. The water sources were very crowded, and people spent hours collecting water at improved water sources. When they had to fetch water from unimproved sources, they spent hours walking to and from the river. Women sometimes had to carry water on their heads, and it took them even longer when walking back from the river to the household. More than two-thirds of the population in Africa leave their household to collect water. Graham et al. (2016) reported that adult women and female children were the primary collectors of water in a study that was conducted across 24 countries in sub-Saharan Africa. Our findings show that safe water sources were not accessible; consequently, women and girl children carried the most burden since they are the ones mostly responsible for water collection.

Prolonged contact with open water bodies for domestic and recreational purposes as a risk factor for schistosomiasis

Aryeetey et al. (2000), reported high prevalence of *S. haematobium* among peasant farmers who use fertile land along the banks of the river. One can therefore argue that although the whole community is at risk of schistosomiasis infection, women are disproportionally at a higher risk of contracting schistosomiasis because of their daily domestic activities, such as washing clothes and collecting water for domestic activities and irrigation. In this study women and young girls collected water from the river for the major purpose of watering the gardens and thus were

exposed to cercariae-infested water bodies. The frequent contact with open water bodies is a result of inadequate water resources.

Limited access to piped water coupled with proximity of the villages to the river increases contact between individuals and the river where there might be infected snails. According to Atalabi et al. (2018), people who came into contact with open water sources, such as lakes, rivers, streams, and ponds, were two to three times more likely to be infected with *S. haematobium* than their counterparts who collected water from taps, boreholes, wells or any other forms of closed water source. Strategies aiming at preventing schistosomiasis in schistosomiasis-prone areas need to consider livelihood factors that may put certain groups of individuals at a higher risk of contracting the infection than others.

Poor irrigation practices as a risk factor for schistosomiasis

Women in Madeya village were disproportionally at a higher risk of schistosomiasis infection because they are the ones that actually irrigate the gardens in the community, whereas the men are responsible for herding cattle and ploughing the land. Some studies have shown that schistosomiasis is prevalent in large irrigation schemes (Brinkmann et al., 1988; Amankwa et al., 1994). Although Madeya did not have large irrigation schemes, women were involved in crop production in small gardens that they watered using river water. The gardens are in close proximity to the rivers where women actually collect water for irrigation. Sow et al. (2011) reported that women spent twice as much time as men in contact with water, thereby increasing their likelihood of contracting schistosomiasis. The risk factor of poor irrigation practices requires improved practices to draw river water for small-scale irrigation of community and personal gardens.

Poverty and its influence on schistosomiasis transmission

Schistosomiasis is a neglected tropical disease, and neglected tropical diseases are regarded as diseases of the poor. The disease is linked to poverty as it is found mostly in poverty-stricken areas in sub-Saharan Africa (Hotez et al., 2007). The study area is poverty stricken, and the majority of the community members are unemployed. Women mostly subsist on social grants which are only provided to women with children. Areas affected with schistosomiasis have limited access to water and sanitation resources as well as health care. These are some of the conditions experienced in the study area, where limited access to water and sanitation is contributing to members of the community coming into contact with open water bodies that may be infested with *Schistosoma*.

Conclusion

We conclude that transect walks provided an opportunity to observe households, sources of drinking water, and availability of toilets. Informal interviews during transect walks and community mapping provided an interesting set of data to

investigate access to WASH in Madeya. Interviews and transect walks illuminated how context and surroundings expose members of the community to WASH-related diseases. Madeya village has poor WASH conditions and practices. These conditions expose members of the community to the risk of contracting schistosomiasis and other diseases that we did not study. The study alluded to environmental changes that could be made to nudge people away from the rivers and contribute to the prevention of schistosomiasis, such as designated bathing and clothes washing areas. These facilities could be added to the WASH 'hardware' interventions.

Since the government is responsible for the provision of water and sanitation in South Africa, we recommend that the government should include behavioural change interventions as part of the WASH provision package. We place emphasis on behavioural change interventions because most of the WASH interventions rely solely on the provision of infrastructure (Montgomery et al., 2009). Interventions to improve health behaviour can be best designed with an understanding of relevant theories of behaviour change and the ability to use them skilfully (Glanz et al., 2008). A similar approach should be followed for any organization providing WASH across sub-Saharan Africa in communities similar to Madeya. If this approach is adopted, people living in villages like Madeya will be less at risk of contracting schistosomiasis and other WASH-related diseases. Unfortunately, interventions that focus on treatment are currently preferred over behavioural change WASH interventions in the control of schistosomiasis. Hence, this study advocates for WASH behavioural change interventions to be at the core of strategies to control schistosomiasis. Behavioural change interventions are guided by behavioural theory and frameworks and have been reported to result in improved behavioural outcome (Glanz and Bishop, 2010).

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CHAPTER 3

WATER, SANITATION, AND HYGIENE FOR SCHISTOSOMIASIS PREVENTION: A QUALITATIVE ANALYSIS OF EXPERIENCES OF STAKEHOLDERS IN RURAL KWAZULU-NATAL.

The previous chapter used participatory methodologies to explore and identify risk factors for schistosomiasis based on their WASH practices among community members. Though this was achieved by community participation, we needed to understand the role that stakeholders play to ensure that WASH is promoted for schistosomiasis control. Hence, Chapter 3 sought to document current WASH practices and explored how that can play a role in schistosomiasis prevention and control in Madeya Village through the engagement of different stakeholders. This Chapter focused on objective 2 of the study.

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Research Paper

Water, sanitation, and hygiene for schistosomiasis prevention: a qualitative analysis of experiences of stakeholders in rural KwaZulu-Natal

Chanelle Mulopo and Moses J. Chimbari

ABSTRACT

uMkhanyakude District in KwaZulu-Natal province is one of the districts in the six provinces in South Africa where schistosomiasis is endemic. While it is well established that schistosomiasis is a public health problem in the district and that efforts to prevent and control the disease have been made, very little has been done to involve stakeholders in the implementation of water, sanitation, and hygiene (WASH) strategies for schistosomiasis control. Hence, this study sought to document current WASH practices and explore how engaging diverse stakeholders can contribute to the prevention and control of schistosomiasis. Qualitative data were collected through eight key informant interviews with community leaders, nurses, community caregivers, and pre-school teachers; and four focus group discussions with community members during the dry season. The study adopted a grounded theory approach. Data were analyzed using the six steps of thematic analysis. Findings show that the key players in the promotion of water, sanitation, and hygiene were not clearly defined. Although effective implementation, promotion, and adoption of WASH can be fully achieved with the involvement of various stakeholders, we found that there was a limited collaboration among WASH stakeholders.

Key words | hygiene, knowledge, practices, schistosomiasis, water

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HIGHLIGHTS

- This paper informs the reader about the experiences of stakeholders in the adoption of WASH in a low-income community for schistosomiasis prevention.
- The paper uses qualitative methods with a grounded theory approach to understand the stakeholder's perspectives.
- Findings show that the key players for the promotion of WASH were not clearly defined.
- Effective implementation, promotion, and adoption of WASH for schistosomiasis prevention seemed to be the responsibility of various stakeholders with little coordination, thus indicating limited stakeholder collaboration.

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BACKGROUND

Sub-Saharan Africa is afflicted by a plethora of waterborne diseases including diarrheal disease and neglected tropical diseases (NTDs), commonly referred to as diseases of the poor (World Health Organization 2014; Campbell *et al.* 2018). Diarrheal outbreaks are common in poor countries that do not have access to adequate drinking water supplies. The outbreaks are usually severe, resulting in high morbidity and mortality (Cairncross *et al.* 2010). Schistosomiasis is the second most common NTD after hookworm with 93% of the world's estimated cases of schistosomiasis reported in Sub-Saharan Africa (Adenowo *et al.* 2015). Approximately 120 million people in Sub-Saharan Africa have schistosomiasis related symptoms and 20 million people experience hardship as a result of the chronic presentation of the disease (Utzinger *et al.* 2009). Limited access to water and sanitation is one of the contributing factors to the high prevalence of schistosomiasis in Sub-Saharan Africa. One-sixth of the world's population mostly in developing countries is infected with one or more NTDs (World Health Organization & UNICEF 2006; Mitra & Mawson 2017).

Transmission of schistosomiasis occurs when people suffering from schistosomiasis contaminate freshwater sources with their excreta or urine containing parasite eggs, which hatch in water to become larval forms called miracidia. Miracidia penetrate intermediate host snails where they undergo asexual reproduction transforming into another larval form called cercarium. Cercariae are shed from snails into water after at least 3 weeks from the time they enter the snails as miracidea. When people come into contact with water cercariae penetrate their skin, thereby infecting them (Anto *et al.* 2013). There are two forms of the disease, namely urogenital and intestinal schistosomiasis (World Health Organization 2020). Water, sanitation, and hygiene (WASH) is critical for prevention of schistosomiasis; yet such interventions have not been fully incorporated into schistosomiasis control programs (Campbell *et al.* 2014). Although mass drug administration (MDA) with praziquantel has clear benefits, people are easily re-infected after treatment if they come into contact with water containing infectious cercariae (Evan 2014).

The literature informs us that people with safe water and adequate sanitation have significantly lower odds of a *Schistosoma* infection (Grimes *et al.* 2015). Access to water and sanitation in Sub-Saharan Africa is interwoven with environment, culture, economics, and human behavior necessitating the need for interdisciplinary research and policy interventions (Armah *et al.* 2018). Similarly, schistosomiasis transmission is deeply entrenched in social-ecological behavior (Grimes *et al.* 2015). Mulopo *et al.* (2020) reported on the influence of psychosocial factors on behavior associated with the risk of contracting schistosomiasis. Improving WASH infrastructure and behavior is a primary prevention method for the elimination and eradication of NTDs including schistosomiasis (Waite *et al.* 2017). This can be achieved through health promotion which is defined as 'the process of enabling people to increase control over, and to improve their health, health promotion promotes a holistic approach of empowering individuals and communities to take action' (World Health Organization 1986; Kumar & Preetha 2012). Furthermore, intersectoral action is one component of this definition which focuses on building healthy public policies and a sustainable health system (Hussain *et al.* 2020).

A wide range of innovative health promotion approaches have been applied in low-income countries. These include the Participatory Hygiene and Sanitation Transformation tool (PHAST), Community-Led Total Sanitation (CLTS), and Community Health Clubs (Waterkeyn & Cairncross 2005; Wanga *et al.* 2015; Hürlimann *et al.* 2018). These approaches, which are usually implemented as part of the community- and/or school-based interventions, have improved hygiene behavior and encouraged use of toilets. The provision of adequate toilets and getting people to use the toilets contributes to greater public health (Odongo-Aginya *et al.* 1996; O'reilly & Louis 2014; Hürlimann *et al.* 2018; Gichuki *et al.* 2019). However, the motivation of households to use the toilet stems from comfort, convenience, privacy, and dignity (Peal *et al.* 2010) and not necessarily from a conscious effort to have health benefits. Consequently, for increased utilization of toilets in the community, WASH interventions need to take into account socio-cultural factors (Routray *et al.* 2015).

WASH interventions have resulted in the reduction of the prevalence of diarrhea (Prüss *et al.* 2002; Fewtrell *et al.* 2005; Mara *et al.* 2010) as well as that of schistosomiasis (Ali *et al.*

1989; Chandiwana *et al.* 1991; Katsivo *et al.* 1993a, 1993b; Tanser *et al.* 2018). WASH interventions have been shown to be highly effective in reducing contamination of the environment with schistosome eggs and larvae for STH (Esrey *et al.* 1991). Given that the route of transmission for schistosomiasis is water based, it is important to disrupt the aquatic life cycle by avoiding contamination of water with eggs (Evan 2014).

In South Africa, 19% of the rural population do not have access to reliable water supply and 25% do not have access to basic sanitation (WHO & UNICEF 2017). Countries that have successfully eliminated schistosomiasis have either done so as a result of economic development that increased access to clean water or because of the limited number of transmission sites (Evan 2014). Access to WASH interrupts numerous transmission routes of NTDs (Strunz *et al.* 2014; Stocks *et al.* 2015). For the sustainable promotion of WASH programs in the context of schistosomiasis prevention community, a participation (bottom-up approach) is crucial (Madon *et al.* 2018) but there are challenges related to collaboration among different stakeholders (Waite *et al.* 2017). We carried out this study in a schistosomiasis endemic area in rural KwaZulu-Natal province (Saathoff *et al.* 2004; Manyangadze *et al.* 2016a, 2016b; Kabuyaya *et al.* 2017a, 2017b) with limited access to water and sanitation (Msweli & Ngobese 2013). The objective of this study was to explore the adoption of WASH through the involvement of a wide range of stakeholders and document prevailing practices and experiences with WASH in the context of schistosomiasis prevention in Madeya Village. Our findings will contribute to the WASH knowledge gaps in stakeholder involvement in the prevention of schistosomiasis in rural KwaZulu-Natal where focus has primarily been biomedical (screening and treatment). This study uses a qualitative bottom-up approach which places the community at the center in a way that one can better understand the roles that different stakeholders can play in schistosomiasis prevention.

METHODS

Study design and area

A qualitative study (Ulin *et al.* 2012) was conducted in Madeya Village located in uMkhanyakude district situated in Northern KwaZulu-Natal. The province is located on the east coast of South Africa bordering three countries: Mozambique, Swaziland, and Lesotho. The district covers an area of 12,821 km^2 and has a population of over 600,000 people. Ingwavuma has a population of approximately 1,300 people. The area is arid and experiences water scarcity. It has limited infrastructure and experiences challenges with service delivery such as access to water. The area is surrounded by many water bodies including the Pongola and Ingwavuma Rivers, both major rivers in KwaZulu-Natal, as well as some ponds. IsiZulu is the primary language spoken in the area and the majority of the households are of a low socio-economic status (Leonard *et al.* 2017). Madeya village is part of Ingwavuma area in uMkhanyakude district, and has approximately 100–300 households. The area is serviced by one clinic and has two crèches (a nursery where babies and young children are cared for during the day) and one primary school. This study was part of a larger project, TIBA (Tackling Infections to Benefit Africa) that was being implemented in wards 16 and 17 of uMkhanyakude district (Manyangadze *et al.* 2016b; Chimbari *et al.* 2017). The aim of the larger project was to determine a baseline for prevalence, intensity and risk factors for schistosomiasis and soil-transmitted helminths (STH) in the study area. This study aimed to explore the experiences of stakeholders in the context of WASH promotion to prevent schistosomiasis transmission. Qualitative data were used to identify contextual and behavioral risk factors of schistosomiasis that may not be captured using quantitative methods, to inform the design of an intervention strategy for the prevention of schistosomiasis in poorly resourced communities.

Study participants and selection of participants of the study

Five categories of stakeholders were selected to participate in this study. The clinic that serviced the community had five nurses and we purposively selected two nurses who were familiar with the study area and had worked at the clinic for more than 10 years. Two community caregivers (CCGs) who work in the community also participated in this study. There were only two crèches in the community, and therefore, we included one teacher from each crèche in this study. Two village headmen responsible for the well-being of the community were included in this study. In addition, all households in the

study area with children below the age of five (we included children below the age of five because they are the most susceptible to WASH-related diseases) were invited to participate in focus group discussions (FGDs); we asked the CCGs that worked in the community to invite household heads to participate in FGDs and the response rate was at 32% out of just over a hundred households.

Inclusion and exclusion criteria

A consenting household member of 18 years and above whose household had a child below the age of five was eligible to participate in this study. We chose children below the age of 5 years because that age group is vulnerable to WASH-related diseases. The other stakeholders were identified for participation on the basis of their knowledge on WASH resources in the community and the strategic positions related to developmental issues in the community that they hold. We excluded households that had no children or that had children older than 5 years.

Data collection procedures

Data were collected through key informant interviews and FGDs with members of the community. Data from semi-structured key informant interviews were used to refine FGD instruments. Data were collected in IsiZulu (local language) by researchers with experience in conducting qualitative research and knowledgeable about schistosomiasis. This study received ethical approval from the University of KwaZulu-Natal Human Social Science Ethics committee (HSS/0396/018D). Data were collected during a dry season spanning from August 2018 to November 2018.

Key informant interviews

A total of eight key informant interviews were conducted with stakeholders. Stakeholders comprised of nurses, community health workers, village headmen, teachers, and the general members of the community. Key informant interviews were used to extract information on WASH conditions, experiences of stakeholders with WASH within their various institutions as well as barriers to WASH promotion. A semi-structured interview guide with the following themes was used: provision of WASH services; role of the stakeholder; and local experiences with WASH issues. All data from key informants were captured on an audio recorder.

Focus group discussions

Four FGDs were conducted with mothers (two groups) and fathers (two groups) of children aged below 5 years. FGDs were used to identify common practices in community regarding WASH as well as perceptions toward WASH. Each FGD comprised of 6–12 participants who were recruited purposively with the assistance of community research assistants to provide diversity in age, employment activities, and their location of residence within their neighborhood. A focus group guide was developed and refined using issues raised in the earlier key informant interviews, and covered the following topics: water sources and use, sanitation practice, and hygiene. All FGDs were recorded using a digital audio recorder with the consent of the participants.

Data analysis

All interviews and FGDs were transcribed verbatim and translated into English. Data were analyzed manually (Basit 2003). Guided by the grounded theory approach (Strauss & Corbin 1994), we identified core themes and grouped them into broader conceptual processes to understand schistosomiasis risk factors in Madeya Village. Transcripts were analyzed using the six steps of thematic analysis described by Braun & Clarke (2006). The first step (1) was familiarization of the data through reading and re-reading the transcripts. The second step (2) involved systematic coding of interesting features of the data. A codebook with both inductive codes from the data and deductive codes from the topics in the interview guides and concepts from the literature was developed (see Supplementary Material). For quality assurance, an inter-coder agreement was conducted between the researcher and the research assistant to assess and improve consistency in coding data. Thirdly (3), the initial codes were collated to develop themes. The fourth step (4) involved reviewing the themes by checking if they related to the coded extracts and the entire data set. Furthermore, themes were defined and named (step 5) and lastly, a report was produced (step 6).

FINDINGS

Table 1 summarizes the results into two broad themes and sub-themes. Theme I focused on access to facilities, sub-themes: water (sources and practices), sanitation (basic sanitation practices), and health care (access to primary health care). Theme II was on knowledge about diseases including schistosomiasis; this had the following sub-themes: health education and hygiene, handwashing practices among pre-school-going children, knowledge about WASH-related

Table 1 | Summary of themes and sub-themes

Broad themes	Sub-themes	Key questions	Issues	Stakeholders and responsibility
Access to facilities, experiences and current WASH practices	Water sources and practices	Is the use of safe water sources being promoted and who is responsible for promoting the use of safe water sources?	Members of the community were mainly using unsafe water sources.	No stakeholders were identified that promoted the safe use of water in the community.
	Basic sanitation practices in the community	Is sanitation accessible and who promotes the use of sanitation? What are the behaviors or general practice of sanitation?	Sanitation was reported to be accessible at the household level. However, some members of the community (mostly children) still practice open defecation.	
	Access to primary health care	Is primary health care accessible?	The clinic was reported to be inaccessible due to the distance.	Nurses
Knowledge about diseases, including schistosomiasis	Health education and hygiene	Who promotes health education and hygiene and what strategy is used to promote health education and hygiene?	Health education and promotion was carried out using pamphlets and posters at the clinic. Furthermore, nurses promoted handwashing at the clinic by informing the patients about the importance of handwashing when they are visiting the clinic.	Nurses and trained community health workers
	Handwashing practices among pre-school-going children		Community health workers also provided health education about the importance of handwashing and boiling water during home visits.	Teachers and parents could be potentially people to promote handwashing among pre-school-going children.
	Knowledge about WASH-related diseases in the community	What are the experiences of stakeholders with WASH?	WASH diseases in the community.	Members of the community – poor knowledge about schistosomiasis and transmission routes among both members of the community and healthcare workers.
	Knowledge on schistosomiasis	What role do stakeholders play in preventing these diseases?	Poor knowledge on transmission routes of WASH-related diseases by members of the community.	Very few cases of schistosomiasis were reported at the clinic; hence, healthcare workers did perceive the disease as a problem in the community.

diseases in the community, and knowledge on schistosomiasis. The broad themes are further described below supported by direct quotes from the participants.

THEME I: ACCESS TO FACILITIES

Water sources and practices

Community members reported that they could not easily access safe water because most of the safe water sources were not operational. Some of the safe water sources were working but could go for several months without discharging water. Consequently, in the months when water could not be accessed at safe water points, members of the community used unsafe alternative water sources:

> *'The clean water from the tap can go for 3 to 4 months without being available, that's why we have to dig at the river'*
>
> – (village headman, male, 55 yrs).

Alternative sources commonly used included unprotected dug wells, the spring, and the river. Members of the community dug wells in the riverbed when the river was dry as well as in areas close to the river. The two springs used by members of the community were unprotected.

When asked whether water was treated before consumption, respondents reported that water treatment was not a common practice. Furthermore, since the majority of water sources were not protected, the water sources were often shared with livestock. Some parents believed that their children got sick because of consuming water from sources shared with animals:

> *'the water which is available to us for consumption is often shared with other animals and our children get sick from drinking this water'*
>
> – (unemployed, male, 45 yrs).

Members of the community covered dug wells with dry tree branches and hence believed that the water that they collected from the dug wells was safer and better than the water collected directly from the river. These dug wells around the river were reserved for drinking water (Figure 1).

Figure 1 | Water source reserved for drinking water.

Basic sanitation practices in the community

For many years, there was limited access to improved sanitation in the community. However, since 2016 the government started providing households with improved pit-latrines (VIP). At the time of the study, coverage of the VIP latrines was at 100%, but the unimproved sanitation structures were still available at some households. Despite the availability of appropriate sanitation facilities, it was reported that some members of the community still preferred using the bush to defecate because they had been doing that for a very long time:

> *'sometimes we go out there in the bush to do our business (defecate) especially when we are out there in the fields, because it's something that we are used to'*
>
> – (unemployed, male, 28 yrs).

Members of the community also said that snakes found their way into the toilet structures; hence, they avoided using the toilets in some instances fearing that there could be snakes in the toilet. They encouraged children not to go to the toilets but to defecate in the yard and then adults would clean up after them. At a crèche, a teacher reported that sometimes a child would defecate on the premises and not inform them. In such cases, feces remained exposed in the environment.

Access to primary health care

The community is serviced by a clinic located 8 km away. According to the community members, access to the facility was limited because of the long distance, and hence, they preferred to use a mobile clinic that was made available every week. Members of the community that stayed far away from the mobile clinic station felt disadvantaged as it was difficult for them to access the services provided.

> *'The mobile clinic does not get close enough to us, we can conclude that we do not have a clinic'*
>
> – (unemployed, male, 43 yrs).

However, mothers reported that they took children to the clinic when they noticed symptoms of diarrhea or observed rash on the skin:

> *'We are struggling a lot in this area but when my child had a rash, I took him to the clinic for treatment'*
>
> – (community caregiver, female, 35 yrs).

THEME II: KNOWLEDGE ABOUT DISEASES INCLUDING SCHISTOSOMIASIS

Health education and hygiene

The responsibility of promoting handwashing in the community has mainly been placed on CCGs and nurses. CCGs (recently re-named Community Health Workers – CHWs) are part of the South African health system and are trained by the Department of Health (DoH) and Non-profit organizations (NPOs). When this system was first put in place, the CCG's roles and responsibilities tended to focus broadly on individuals experiencing health conditions related to poverty, social inequality, and lifestyle, which included TB, diarrhea in children and malnutrition, and sexually transmitted infections (STIs). However, as the HIV epidemic in South Africa worsened, CCGs started providing basic care and support for people living with HIV in their families. CCGs conduct their duties within the home environment of members of the community or their clients. CCGs are lay workers and usually do not have a formal, professional healthcare qualification. CCGs provide health education such as handwashing by going door-to-door in the community, whereas nurses provide health education at healthcare centers. Nurses provided healthcare services when the patients first arrived at the clinic. On a daily basis, nurses gave a talk on health promotion such as handwashing before consulting sessions with patients. They also provided brochures on handwashing and demonstrated to patients how to effectively wash their hands. However, nurses did not go into the community to promote handwashing:

> *'We can't go out into the community but we teach them when they are here at the clinic on how to wash their hands. We tell them that they should wash their hands with soap'*
>
> – (nurse, female, 50 yrs).

CCGs reached out to the community by going door-to-door to promote handwashing. However, they were not sure if members of the community practiced what they taught them:

> *'As a CCG all I do is deliver information, I go home at the end of the day so I cannot guarantee that they will use it'*
>
> – (community caregiver, female, 43 yrs).

CCGs taught the parents about handwashing when they went door-to-door and hoped that the messages they gave were used to protect children. They could not directly access the children because they were usually at school when they did their rounds:

> *'We work from Monday to Friday, the children are either at crèche or school so we cannot talk to them. I have never taught children'*
>
> – (community caregiver, female, 35 yrs).

CCGs said that they were not sure how much information on handwashing children were getting in schools:

> *'Maybe they can give us some other time with the children so we can also teach them'*
>
> – (community caregiver, female, 43 yrs).

CCGs expressed concern that not all children were taught about handwashing by their parents and they preferred that a handwashing intervention tailored for children

should be put in place to teach children about handwashing. CCGs argued that even though they provided information on handwashing, change on handwashing behavior could only be achieved through access to safe water.

During the FGDs, mothers indicated that they were responsible for teaching their children about handwashing; the fathers were not involved in promoting handwashing because they did not spend much time with the children:

'We are the ones that tend to always be at home, the children are taught by us mothers'

– (unemployed, woman, 28 yrs).

They indicated that whenever there is water available they help children to wash their hands making sure that the water was used sparingly:

'We teach the children to wash their hands and we teach them to use water sparingly so that they do not waste it'

– (unemployed, woman, 32 yrs).

Handwashing practices among pre-school-going children

We found that there were no designated handwashing facilities in the crèche. However, teachers improvised temporary handwashing stations. During break time at a crèche, the teacher placed a basin with water (occasionally soapy water was used) in a designated place where children washed their hands after using the toilet. During class times, the basin was not available; hence, children washed their hands at a nearby *jojo tank* (rainwater harvesting and water storage tank) when they stepped out during class times to go to the toilet. Some children were observed going back into class without washing their hands. Similarly, at the household level, household members washed their hands in a basin. The basin was only made available on demand:

'No there isn't a special place to wash your hands, you just take water and put it in a basin and wash your hands'

– (unemployed, male, 42 yrs).

In addition, people also washed their hands at a *jojo* tank (rainwater harvesting and water storage tank) whenever water was available in the tank. Availability of water in the *jojo* tank was dependent on rainfall. Consequently, people were only able to wash their hands at the *jojo* tank during periods of rainfall:

'I use the jojo tank after it rains and that's how I wash my hands'

– (unemployed, woman, 37 yrs).

Although children were taught about handwashing in school, handwashing behavior at the crèche was reported to be low. All the children at the crèche were on a feeding scheme. Some teachers reported that children ate food without washing their hands:

'Yes, they can get taught at crèche as well but because of the water shortage they sometimes will give the children food without making them wash their hands, and then you find children getting sick because of these unhygienic circumstances'

– (preschool teacher, female, 40 yrs).

'Sometimes the children eat their lunch without washing their hands'

– (preschool teacher, female, 40 yrs).

Sometimes water for handwashing was not available at the crèche if the person responsible for providing the water was either absent or forget to prepare water for the children to wash their hands during break time. When asked if children asked for water to wash their hands when it is not provided, the response was that they did not as they were not accustomed to washing their hands:

'Children do not ask us for water to wash their hands when the water is not provided because it's not something they practice even when they are at home'

– (preschool teacher, female, 40 yrs).

The teachers reported that most children washed their hands under supervision, so if there was no adult to tell them to wash their hands some of them would not do so:

'There are times when I'm not around so sometimes they don't wash their hands because I'm not there to tell them to do so'

– (preschool teacher, female, 45 yrs).

Furthermore, a teacher highlighted that handwashing is something that should be taught by parents at home.

Knowledge about WASH-related diseases in the community

Diarrhea, skin infection, and schistosomiasis were the WASH-related diseases that the participants from the FGD said were common in the study area. Members of the community were able to link some of these diseases with water but could not clearly explain the transmission routes of the diseases:

> *'We suspect that we get these diseases from water, especially schistosomiasis, it's definitely the water'*
>
> – (unemployed, male, 52 yrs).

Some of them had the misconception (in the case of schistosomiasis) that they contracted diarrhea and schistosomiasis through drinking dirty water:

> *'Diarrhea and schistosomiasis is caused by the dirty water that we drink'*
>
> – (unemployed, female, 23 yrs).

Schistosomiasis was reported to be prevalent in both girls and boys, with the latter being affected more because they swam in the river more often than the girls did. During the FGD, it was reported that boys usually swim in the river when they accompany other members of the households that go to the river to collect water:

> *'The children swim in the river because they go there to fetch water'*
>
> – (unemployed, male, 34 yrs).

Members of the community indicated that adults were also suffering from schistosomiasis but to a lesser extent compared with children.

Knowledge on schistosomiasis

Members of the community had poor knowledge on schistosomiasis transmission; they associated schistosomiasis with drinking dirty water:

> *'I know that if a child drinks contaminated water it is likely for them to get Bilharzia'*
>
> – (preschool teacher, female, 40 yrs).

Their knowledge of the symptoms of schistosomiasis was generally poor although some parents were able to identify symptoms such as the presence of blood in the urine:

> *'They usually have blood in the urine when they urinate and that's how we know that the child is infected with schistosomiasis'*
>
> – (village headman, female, 65 yrs).

The teachers seemed to know very little about schistosomiasis, claiming that no one had ever taught them about the disease. In contrast, they were very much aware of diarrhea. When asked what preventative measures they could take to prevent schistosomiasis, they said that they did not do anything because they had little knowledge about the disease:

> *'We don't know much about Bilharzia but we are more educated about Diarrhoea … We don't really do anything to prevent the disease because we are not really taught about it'*
>
> – (preschool teacher, 45 yrs).

An immunization and deworming program for schools had been operational in the area for 2 years. It involved nurses going into the schools to immunize and deworm the children. The nurses indicated that when they got into the schools or the crèche they focused on immunization and deworming. They did not screen for schistosomiasis or educate the children about schistosomiasis. It was also noted by the village headman that since the inception of our research project through which children were screened for schistosomiasis, many people had become aware of the disease:

> *'TIBA (research project) has come and taught us how to prevent schistosomiasis, so we now have an understanding on how people get schistosomiasis'*
>
> – (village headman, male, 55 yrs).

DISCUSSION

We found that the community did not have access to reliable safe water sources and that existing safe water sources were often not functional for prolonged periods. This resulted in community members collecting water from unprotected water sources which were usually contaminated. A study conducted in Uganda reported that consumption of raw water from unprotected water sources was the primary route of exposure to contaminated water (Agensi *et al.* 2019). Furthermore, members of the community shared water sources with livestock thus increasing the likelihood of using contaminated water. Similar results were reported in Ghana where ownership of livestock was significantly associated with drinking contaminated water (Wardrop *et al.* 2018).

The majority of the participants could not afford and were not knowledgeable about water treatment products; hence, they drank untreated water from the river, spring, and unprotected dug wells, putting themselves at a risk of contracting diarrheal diseases from drinking dirty water, or schistosomiasis through water contact. Previous studies have shown that covered water sources and treatment of water before consumption reduces the likelihood of diarrheal diseases (Grabow *et al.* 2000; Cairncross *et al.* 2010; Cha *et al.* 2015; Clasen 2015).

It was not clear to members of the community who was responsible for the provision of water. The use of safe water sources was not common, mainly because of the limited safe water sources. The provision of safe water sources can be promoted through a collaboration between the municipality (water service providers), and the DoH with the involvement of prominent members of the community. This approach can encourage members of the community to use safe water sources provided that the municipality provides the water sources. Bisung & Dickin (2019), in a study conducted in West Africa, emphasized the importance of ownership and the responsibilities of all actors/stakeholders to play their parts in the management of WASH.

Although toilets were provided in the community, some members of the community still practiced open defecation. Banda *et al.* (2007) found that 30% of the participants that had toilets were still practicing open defecation. A study by Coffey *et al.* (2014) conducted in India also reported a preference for open defecation among some community members. The sanitation program through which the municipality built toilets for communities did not have a health education component. Sara & Graham (2014) found that education may be an important factor in changing defecation practices; similar findings were reported in Tanzania (Mwanga & Lwambo 2013; Wanga *et al.* 2015). Moreover, other studies have also indicated that households that own livestock tend to practice open defecation because they travel long distances while tending to herds. This is because they could find themselves in places with no access to sanitation facilities (O'loughlin *et al.* 2006). Other studies (Sara & Graham 2014; Routray *et al.* 2015; Gupta *et al.* 2016) reported that households that still practiced open defecation even when they had a toilet were dissatisfied with their toilet. However, in the current study, the majority of participants indicated that they were happy with the toilets provided and that they were using them. They only encountered problems when they were out in the field or at church because places of worship did not have toilets.

Feces in the environment pose a public health threat to the members of the community but particularly to children who may come into contact with feces at crèche if the teachers do not notice when a child has defecated in the environment. Stakeholders such as the municipality can promote toilet ownership and use of sanitation facilities by including an education intervention to complement the infrastructure interventions. This means that while they are providing infrastructure they should also target behavioral change and work closely with the communities to understand their needs as well as promote acceptance of the infrastructure.

Although participants were able to link drinking untreated water and diseases, they had poor knowledge on transmission routes of schistosomiasis. The majority of individuals interviewed believed that one could contract diarrhea and schistosomiasis by drinking contaminated water. While this may be accurate for diarrhea, it is not so for schistosomiasis. Our findings are similar to those of a study on knowledge of waterborne diseases conducted in rural South Africa which reported good knowledge of waterborne diseases but poor knowledge on the

transmission routes of these diseases (Sibiya & Gumbo 2013). While the current study found that the majority of the participants associated drinking dirty water with diarrhea, Banda *et al.* (2007) in a study conducted in India found that only 12% of the participants in their study linked the two with the majority of the participants attributing diarrhea to heat, spicy food, ingesting hair mud, or mosquitos.

Our findings show that handwashing practice in the community was promoted using a knowledge-based intervention led by CCGs. However, CCGs had many responsibilities in addition to promoting handwashing. There was no structured handwashing intervention in the community. Furthermore, if members of the household do not visit the clinic, they are less likely to hear about handwashing. One CCG was allocated 60 households and they normally did not get to all the households. Therefore, there was a possibility that some people did not receive information on the importance of handwashing and why they should wash their hands.

The scarcity of water in the crèche resulted in children engaging in poor handwashing practices. Washing their hands in the same basin could expose some children to other pathogens washed into the basin by others. Furthermore, the handwashing basin was only available during break time. Hence, children that visited toilets during classes had limited opportunities to wash their hands. Parents and pre-school teachers can play an important role in promoting handwashing at the pre-school level. Our findings show that parents assumed that their children were taught about handwashing at school, while teachers felt that it was the responsibility of the parents to teach their children about handwashing. One way to overcome this issue is to ensure that handwashing is included in the pre-school curriculum. That way children would be taught about handwashing and their mothers could be involved by ensuring that children routinely washed their hands at home. This can be designed as part of homework in the school curriculum where mothers engage in activities with their children to remind them of the importance of handwashing.

Schistosomiasis prevention and screening programs tend to lean toward school-going children (Engels *et al.* 1996; Aagaard-Hansen *et al.* 2009; Brooker *et al.* 2009) since the prevalence of the disease is shown to be high in this age group. However, our findings show that due to limited access to improved water sources in the study area, women are often in contact with fresh water bodies as they go to the rivers accompanied by young children to collect water for their household needs. Consequently, children under 5 years old are exposed to a higher risk of contracting schistosomiasis.

RECOMMENDATIONS

Members of the community need to be taught about water safety and different low-cost water treatment methods that they can use. They also need to be aware that covering a dug well with branches does not make water safe for consumption. Strong collaborations are needed between the municipality, the DoH, and the community, for the provision of water sources and the use of these water sources to prevent diseases such as schistosomiasis. There is a need for a structured ongoing handwashing intervention that includes activities tailored for children. This can be built in the already existing system of using CCGs, but should also include teachers and parents in the handwashing promotion campaigns. Additionally, handwashing promotion needs to go beyond knowledge-based interventions to include behavior change and provision of infrastructure.

This study has also highlighted the importance of health education in the provision of sanitation facilities. Furthermore, the provision of sanitation facilities in rural settings should go beyond household provision but also include facilities being provided at places of worship as well as in the fields where men herd cattle and women cultivate their crops.

CONCLUSION

The findings from this research highlight the importance of collaboration among stakeholders in order to bring about the effective use of safe water sources, use of sanitation facilities, and promotion of handwashing. Access to facilities such as water, sanitation, and health care was a challenge

and members of the community were not aware of the stakeholders who were responsible for the provision of these facilities. In addition, health care was deemed inaccessible due to distance. Knowledge on WASH-related diseases and schistosomiasis was found to be poor.

LIMITATIONS OF THE STUDY

This study was a cross-sectional study and, therefore, may not have been able to provide data for other times, for seasons. Time constraints and limited resources did not permit the researchers to prolong their stay in the study area and conduct observations. Due to the sampling technique (purposive sampling) applied in this study, caution should be taken in generalizing the findings to other contexts. The findings are not statistically representative of the greater population at hand, but they are qualitatively generalizable.

Positionality statement (Chanelle Mulopo)

I view research from an interpretivism and constructivism paradigm. I believe the research subjects are co-constructors of knowledge in the research process. My research interest in water and sanitation stems from my own experience growing up in a developing country and having suffered from a waterborne disease early in my childhood. Access to water and sanitation is a huge problem in Sub-Saharan Africa and a cause of many preventable deaths. I have been studying the social and public health issues resulting from poor access to water and sanitation for the past 5 years. My study population of interest has been people living in poor communities (informal settlements and rural areas). I hope the findings of this research will highlight the water crisis in the study area and how this is impacting the community's health.

Positionality statement (Moses Chimbari)

I am an eco-health tenet and, therefore, view health challenges holistically. My more than 143 journal publications, mainly on NTDs, are testimony to this approach. My advocacy for WASH as a sustainable means for controlling schistosomiasis dates back to the 1990s when I was part of a research group that developed a model smallholder irrigation scheme (Mushandike Irrigation Scheme – Zimbabwe) which made safe water and appropriate sanitation a condition for the model irrigation scheme. In later years, I was able to demonstrate that the differences in schistosomiasis prevalence and intensity between Kariba (Zimbabwe) and Siavonga (Zambia) 10 km apart could be explained by improved WASH facilities for Kariba compared with Siavonga. It is this strong belief in the efficacy of WASH that motivated me to participate in Chanelle Mulopo's work.

ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Humanities and Social Science Research Ethics Committee at the University of KwaZulu-Natal. Protocol reference number: HSS/0396/018D. All participants gave informed consent to participate in this study. This study ensured anonymity and confidentiality of all research subjects that were interviewed and those that participated in FGDs. All information collected during the course of this study is kept on the UKZN online database. The data management was dealt with in the context of the bigger project – all data (raw and processed) are kept at a central repository and can be made available should that be needed. Only the researcher and the supervisor have access to this information. All materials pertaining to this study will be stored at the University of KwaZulu-Natal (Howard College) for a period of 5 years as abiding with the University's ethical procedures.

CONSENT FOR PUBLICATION

Consent was granted for publication of any personal information for the purpose of this study.

COMPETING INTERESTS

The authors have no conflicts of interest to disclose.

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AUTHOR CONTRIBUTIONS

Chanelle Mulopo conceived and designed this study, took part in the data collection process, developed the data collection tool, performed the analysis, and wrote all the first drafts of the paper. Prof. Moses Chimbari supervised the project and reviewed several drafts of the manuscript.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories (https://drive.google.com/drive/folders/1BdEqT5lw2TracHRIlrakfoWUMRMYWAca?usp=sharing).

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CHAPTER 4

CONTEXTUAL AND PSYCHOSOCIAL FACTORS INFLUENCING THE USE OF SAFE WATER SOURCES: A CASE OF MADEYA VILLAGE, UMKHANYAKUDE DISTRICT, SOUTH AFRICA.

Chapter 2 and 3 established WASH practices, WASH risk factors for schistosomiasis as well as the involvement of stakeholders in promoting WASH for Schistosomiasis control. Whilst these studies provided information that can contribute to understanding how schistosomiasis can be controlled in Madeya village, there is understanding and measuring psychosocial factors that are associated with the factors that have been identified in Chapters 2 and 3 is essential for the implementation of behavioral change. Thus chapter 4 addresses this by identifying critical psychosocial factors for behavior change, to reduce the risk of schistosomiasis transmission in Madeya Village.

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Article

Contextual and Psychosocial Factors Influencing the Use of Safe Water Sources: A Case of Madeya Village, uMkhanyakude District, South Africa

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Abstract: *Background*: Schistosomiasis is a public health problem that affects over 240 million people worldwide. It is mostly prevalent in tropical and sub-tropical areas among communities with limited access to clean water and adequate sanitation. This study was conducted in uMkhanyakude District in rural South Africa, where water resources are limited. In this community, individuals frequently come into contact with freshwater bodies for various reasons. The objective of the study was to identify critical contextual and psychosocial factors for behaviour change to reduce risk of schistosomiasis transmission in Madeya Village, uMkhanyakude district. *Methods*: Structured household interviewswere held with 57 primary caregivers to assess their thoughts and attitudes towards collecting waterfrom a safe source. We used the Risk, Attitude, Norm, Ability, and Self-regulation model (RANAS) to estimate the intervention potential for each factor by analysing differences in means between groups of current performers and nonperformers who use safe water sources. *Results*: The subscale vulnerability belonging to the risk factor on the RANAS was scored as low. Furthermore, attitudinal factors towards the use of safe water sources were found to be low. Ability factors (confidence in performance and confidence in recovery) towards the use of safe water sources were low as well, indicating that thesefactors should be the target of the intervention in the study area. *Discussion*: Based on this study, it is recommended that a community-based empowerment intervention strategy it appropriate. The strategy should prompt behavioural practice and public commitment, use persuasive language to boost self-efficacy and target younger low-income caregivers between 18 and 35 years of age.

Keywords: RANAS model; water; behaviour; psychosocial factors; rural

1. Background

Approximately 430 million people worldwide use unimproved water sources and 144 million people use surface water [1]. Lack of access to improved water sources contributes to the high burdenof diseases such as diarrhoea and schistosomiasis [2]. Schistosomiasis is a public health problem which affects over 240 million people worldwide with 500 million people at risk of infection [3,4]. Over 90% of cases of schistosomiasis reported are in sub-Saharan Africa [5]. It is mostly prevalent in tropical and sub-tropical areas among communities with limited access to clean water and adequate sanitation [6].Transmission of schistosomiasis is dependent on the presence of the intermediate host snail (IHS) andhuman contact with cercariae infested waters [7]. Since infection occurs during human contact with

water, it can be avoided through provision of safe water sources. The use of safe water sources is however dependent on sound understanding of psychosocial drivers of behaviour.

Understanding psychosocial factors is crucial for achieving a desired behaviour that can be sustained over time. There are a number of factors referred to as behavioural determinants, which influence the adoption of a specific behaviour and continuation of practicing the behaviour [8]. For successful and sustained behavioural change, the changes need to occur in psychosocial factors suchas attitudes, norms and belief systems that determine behaviour [8–10].

Although schistosomiasis is prevalent in uMkhanyakude [11–13], to our knowledge, no structured assessment of psychological determinants that influence the use of safe water sources as a means to reduce risk for schistosomiasis transmission has been conducted. Our study sought to identifythe psychosocial factors influencing the use of safe water sources in order to develop a behavioural change intervention for reducing schistosomiasis transmission in Madeya Village in uMkhanyakudedistrict. We used the Risk, Attitude, Norms, Ability and Self-regulation (RANAS) model to identify psychosocial factors that influence the use of safe water sources in Madeya. The RANAS model was developed for prediction of health behaviours in developing countries and is based on psychological health behaviour [10]. The model is an integration of psychological factors proposed by theories of behavioural change such as the health belief model, the health action process approach and the theoryof planned behaviour [8]. Additionally, the model also provides behavioural change techniques that tackles the factors that need to be changed. The model depicts five distinct components or "factor blocks" that have to be favourable for the new behaviour to be assimilated. These include risk factors, attitudinal factors, norm factors, ability factors and self-regulations. The first block comprises the risk factors which refers to the person's understanding and/or awareness of the health risk associated with contracting the disease. The second block is the attitudinal factors that refer to a person's negativeor positive feeling towards a particular behaviour. Normative factors which form the third block represent the perceived social pressure to engage in a specific behaviour. Ability factors constitute the fourth block and represents an individual's perceived confidence in their ability to perform a specific behaviour. Self-regulation, which forms the last block, represent a person's attempts to plan and self-monitor a behaviour and to manage conflicting goals and distracting cues [14,15]. We sought to address the contextual and psychosocial factors influencing the use of safe water sources inMadeya. Our findings may be used to design an intervention framework that can be applied to control schistosomiasis transmission in Madeya.

2. Materials and Methods

2.1. Study Area and Context

The study was performed in Madeya village, located in uMkhanyakude district of KwaZulu-Natal province, South Africa (Figure 1). Madeya is just one of the sites where the large study is being conducted. UMkhanyakude district is one of the poorest districts in KwaZulu-Natal and much of it is characterized by poor economic development. Most of the rural areas within the district are poor, have limited infrastructure and experience poor service delivery [16]. Water supply is poor and sanitation facilities are inadequate, thus creating a conducive environment for transmission of infectious diseases such as schistosomiasis and soil transmitted helminths [17,18].

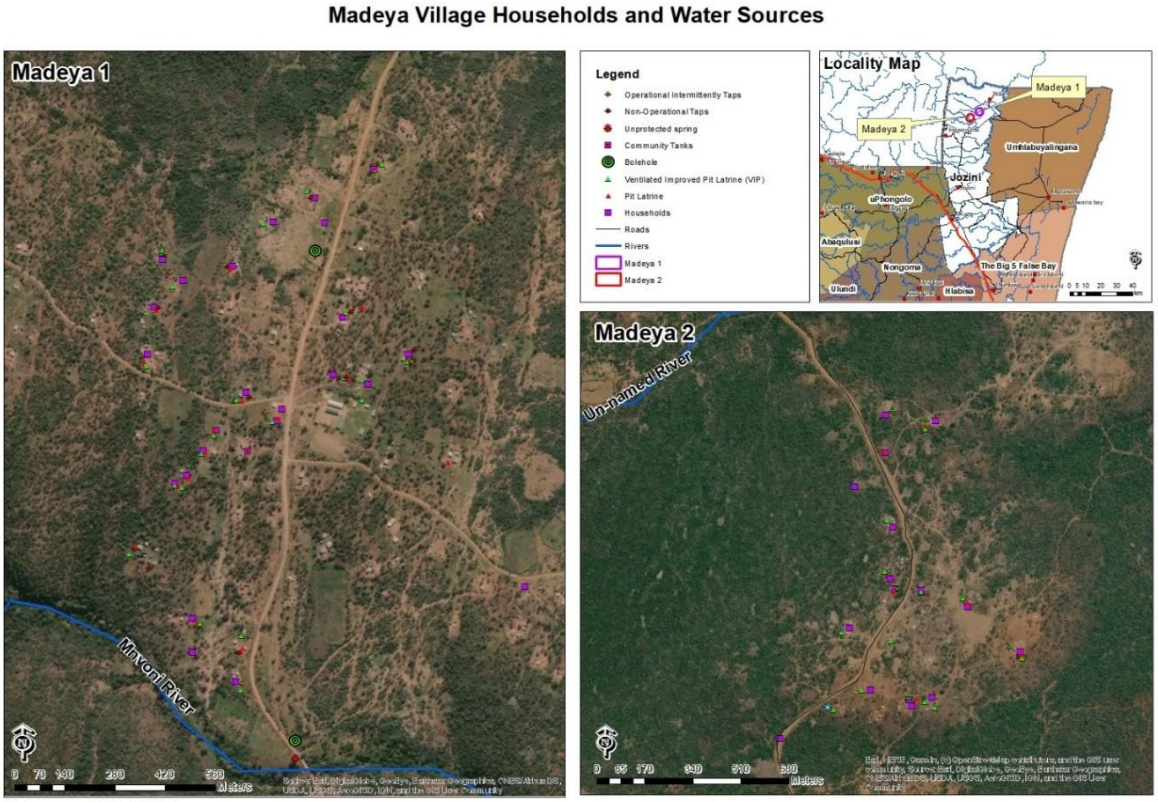

Figure 1. Aerial and coordinate map of the households included in the Madeya Village, the study area.

2.2. *Data Collection Methods, Study Participants and Inclusion Criteria*

A standardized questionnaire was administered face-to-face to 57 household heads selected randomly using the modified random-route procedure which involves dropping o*ff* interviewers at di*ff*erent locations within the designed geographic coverage area and letting them choose a starting point and direction for selecting households [19]. Only households with at least one child under the age of five years were selected to participate in the study. As a result, 57 households were selected from a pool of 165 who are part of the larger study.

The questionnaire was designed in English and translated to isiZulu, the local language used in the study area. Local research assistants who administered the questionnaire received intensive trainingover two days. To ensure uniformity in the understanding and evaluation of the data collection, the instrument was pre-tested in the Mgedula Village, which has similar socio-demographics and cultural characteristics to the study area. Further, modifications were made to the tool based on findings from pre-testing.

The questionnaire included questions on demographics such as age, gender and number of peoplein the households. To determine the use of safe water sources, respondents were asked to identify their main source of water. Several items were constructed for each psychological factor to address all theRANAS components in detail. The questions were arranged in a logical sequence and uploaded on KoboCollect, an online open source platform for collecting and analysing data [20]. The study took place between November 2017 and November 2018.

Ethical approval was obtained from the Humanities and Social Science Research Ethics Committee at the University of KwaZulu-Natal. Protocol reference number: HSS/0396/018D. All participants gave informed consent to participate in the study.

The RANAS model was the most applicable model because, contrary to other behavioural change models, the RANAS measures more behavioural factors [21]. Additionally, other approaches rely on provision of knowledge as a tool to change behaviour, yet psychological theories inform us that

behavioural knowledge alone is not sufficient to bring about behavioural change [21]. The RANAS model presents a systematic approach of behavioural change informed by psychological theory and behavioural interventions [8].

2.3. Data Analysis

The incidence of each factor targeted for change was measured and analysed for its intervention potential. To determine the intervention potential (IP) for each factor, the improvement reserve was first analysed and then its impact on behaviour. The improvement reserve (IR) is defined as the difference between the population mean (Mean) in a factor and the maximum possible value (Max) of this factor (IR = Max − Mean) [8]. To determine the impact of each factor compared to other factors on behaviour, regression analysis was calculated. In the regression analysis, the B-values express how the size of each factor influences the behaviour compared to the others, provided that the factors are transformed to the same range of values. Finally, to fix the behaviour improvement potential (IP) of each factor, the IR was multiplied by the B-value derived from the regression analysis (IP = IR × B). Furthermore,to determine what psychosocial factors are important behavioural drivers for the use of safe water sources in the study area, the intervention potential (IP) for each psychological factor of the five RANAS model components was estimated by comparing the means between groups of performers, (doers) individuals who collect water from safe water sources and nonperformers, (non-doers) individuals who collect water from unsafe water sources [8]. Total population means as well as differences in means (*t*-tests) between the groups of doers and non-doers were calculated for all psychological variables. The Guideline for Behaviour Change stipulates that the IP for psychological factor components and their subscales results from the distance of mean value to scale maximum [22]. In our study, all factors falling at or below the mid 3-point value on a scale of 1–5 were considered important for the design of the intervention, because of the remaining theoretical improvement reserve.

We therefore calculated the IP as a combination of the distance of the total mean from the desired scale maximum value (5-point scale end) as well as the difference between the group means [8]. T-tests were, run to confirm statistically significant differences of means between the groups of doers and non-doers for all five of the RANAS components. Values between 1 and 2 are considered as a low, 2–3 as a moderate, 3–4 as a high, and above 4 as a very high IP. Since questions about self-regulationcannot be answered by non-doers and because we had a small sample for doers, we did not measurethe self-regulatory component. All analyses were performed using SPSS version 25.

3. Results

Study Population

All the targeted 57 households consented to participate in the study. The mean age of the respondents was 37 years (standard deviation [SD] = 13.23). Most households (43.9%, n = 25) had 6–10 members. The majority (66.6%, n = 38) of the households had one child below the age offive. Most (29.8%, n = 17) of the participants earned ZAR201–500 (USD13.53–33.65) per month (1USD = ZAR14.86, https://www.bloomberg.com/quote/USDZAR:CUR, date accessed on 14 February2020). Table 1 presents results grouped into two categories: doers and non-doers. Doers are individuals who use safe water sources at least 60% of the time and non-doers are individuals who mostly use unsafe water sources. There were 8.8% (n = 5) male and 91.2% (n = 52) females. Half (50.9%; n = 29) of the participantswere not married. Close to half of the participants (42.1%, n = 24) had completed secondary school education and more than half the participants (77.2%, n = 44) were unemployed. Most of the participants (31.6%, n = 18) resided in dwellings made of traditional mud block and corrugated iron.

Table 1. Characteristics of the study participants separated into two groups: doers and non-doers.

Percentage		
	Doer (*n* = 10)	**Non-Doer (*n* = 47)**
Age		
	43.70 ± 16.51	35.85 ± 12.22
Marital status		
Married	10	19.15
Divorced	0	4.26
Single	30	55.32
Widowed	20	2.13
Cohabiting	40	19.15
Highest level of school completed		
No school completed	40	19.15
Primary school	30	29.79
Secondary school	30	44.63
College level	0	2.13
University	0	4.26
Occupation		
Student	0	4.26
Self-employed	10	10.65
Employed by Government	0	2.13
Employed by private company	0	4.26
Unemployed	90	74.47
Retired	0	4.26
Type of dwelling		
Mainly traditional mud block with thatch	10	17.02
Mainly traditional mud block with corrugated iron	30	31.91
Mud plastered with cement	0	21.28
Concrete or cinder block	30	21.28
Modern brick house	30	4.28
Temporary structure	0	0
Other	0	4.28

We asked the respondents where they collected water in order to identify the proportion of the population that had access to improved water sources and the proportion that had access to unimproved water sources. Bearing in mind that the proportion of the sample that had access to unimproved water sources were at a greater risk of contracting schistosomiasis. Primary water sources used in the supply of drinking water included the tap (10.53%) and pump/bore hole (7.02%), and themajority of the respondents collected water from freshwater bodies such as unprotected dug wells, rivers and dams [surface water (77.19%)]. The municipality also provided water using a water tanker(3.51%) (Table 2).

Table 2. Primary sources of water in the Madeya village.

Primary Source of Water	***n***	**%**
Tap	6	10.53
Pump	4	7.02
Surface	44	77.19
Tanker	2	3.51
Not classified	1	1.75
Total	57	100

In order to determine the psychosocial factors that influence where people collect water, the position of total means as well as di*ff*erences in means on the standard scale were used to estimate

the IPs for all psychological components of the RANAS model. Figure 2 shows the outcome of all psychosocial factors. For the targeted behaviour, perceived vulnerability was measured by asking how high or low the risk for contracting schistosomiasis from freshwater bodies was (scale range for all questionnaire items were rated from 1 = very low to 5 = very high). On average, perceived vulnerability was rated very low (M = 0; SD = 3.485). There was a moderate difference between doers and non-doers of 0.063 scale points, indicating no statistically significances between the two groups (t = 0.198, p = 0.422). Extent of the schistosomiasis problem was measured by asking how severe the respondents rated schistosomiasis. The average perceived severity was rated moderate (M = 2.543; SD = 1.637). There was a significant difference (t = −2.065, p = 0.021) of 1.15 scale points between doers and non-doers. The IP for the subscale vulnerability was high whereas that of severity was moderatebut when combined, the subscales produced a moderate IP.

To measure attitudes, feelings towards collecting water from a safe source were measured by asking the respondents how they felt about collecting water from a safe source. The outcome was moderate (M = 2.286; SD = 3.03) with a large difference of 2.04 scale points between the two groups of doers and non-doers. The difference (t = −1.978, p = 0.026) between doers and non-doers. The mean score for cost benefit was low (M = 1.825; SD = 2.399) with a moderate insignificant difference (t = −0.905, p = 0.184) between doers and non-doers of 0.76 scale points. Both attitudinal subscale scores were low, indicating that respondents had negative feelings towards collecting water from a safe source and found it very time consuming and effortful. The IP for all factors within the component attitude were therefore high.

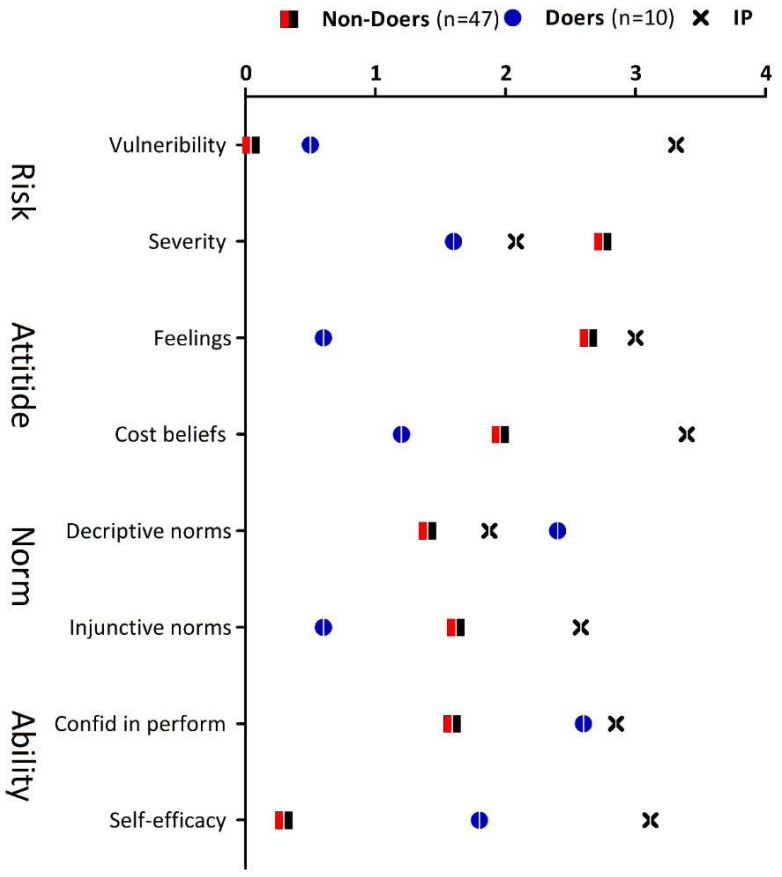

Figure 2. Results of the Risk, Attitude, Norm, Ability, and Self-regulation analysis, with a focus on riskand ability.

Concerning norms, the perception of how common the behaviour of collecting water from a safesource was observed in the community was scored low (descriptive norm; M = 1.578; SD = 1.413). The

difference between doers and non-doers was moderate, up to 1.0 scale point. There was a significant difference between groups of doers and non-doers (t = 2.082, p = 0.021). Furthermore, injunctive norms which represent people's experience of how strongly they felt, people in authority or their leaders promote the use of safe water sources was also rated low (M = 1.439; SD = 2.946). The difference between doers and non-doers was also large (91.02 scale points) but not significantly different between doers and non-doers. (t = −0.991, p = 0.162). The two subscales resulted in a moderate IP for the norm component.

Ability factors that measure people's perceptions of their own skills to pick up and maintain the behaviour of collecting water from a safe source were low (M = 1.771; SD = 1.721). The difference between groups was large at 1.01 scale points and it was statistically significant (t = 1.703, p = 0.04). Furthermore, the subscale that measures recovery from a drawback (self-efficacy) was rated very low (M = 0.561; SD = 3.245). An insignificant difference (t = 1.338, p = 0.09) of 1.51 scale points between the doers and non-doers was observed. The combined effect of confidence in performance and self-efficacy translated to a high IP.

Self-regulation factors were not assessed because we had a small sample of doers which did notpermit assessment of self-regulation among non-doers.

4. Discussion

The psychosocial data provide an evidence-based choice for appropriate Behavioural Change Techniques (BCTs) for promotion of use of safe water sources. We used an innovative approach that contributes to the knowledge of schistosomiasis control. This approach contributes strongly to preventative approaches, which fall within the theme of health promotion. While the mainstay of schistosomiasis control focuses on treatment of the disease, the health promotion approach focuses on preventing disease thus promoting health. We used the RANAS model to identify psychosocial factors that determine the use of safe water sources in Madeya village, located in uMkhanyakude district. These psychosocial factors inform an intervention framework for protecting community members from contracting schistosomiasis. Schistosomiasis can be prevented when these factors are targeted and changed, resulting in more people using safe water sources and avoiding unsafe water sources.

Our research findings show that perceived vulnerability was rated low and the difference between groups of doers and non-doers was not significant. This means that both groups did not perceive themselves as vulnerable to schistosomiasis and diarrhoea. Furthermore, severity was scored moderate but with a significant the difference in scores between groups of doers and non-doers indicating thatdoers did perceive schistosomiasis and diarrhoea to be serious diseases while non doers did not. A study conducted in Burundi reported that an increase in knowledge about diarrhoea diseases resultedin a lower prevalence of the disease [23]. Therefore, health education or hygiene education is critical ifone aims to increase perceived vulnerability and severity of a disease. Our findings also show that the majority of the community relied on surface water as the main source of water. Results from a study conducted in Ghana reported that inadequate access to potable water was associated with a high incidence of diarrhoea [24]. Furthermore, the study suggested that childhood diarrhoea decreased with availability of standpipes and private indoor pipes. In our study we found that, only a few households had access to piped or pumped water sources. Low perceived vulnerability and severity of the disease may be a contributing factor to the use of surface water or unsafe water sources.

Our results show that for the risk component, the intervention potential for the sub-component vulnerability was high and that of severity was moderate. The combined subscales produced a moderate IP for the risk component. The intervention needs to target the perceived vulnerability psychosocial factor because the results are informing us that respondents do not perceive themselves as vulnerable to schistosomiasis even though schistosomiasis is prevalent in the study area [18]. The risk component is therefore considered important for the design of intervention programmes. A previous study on knowledge attitude and practice (KAP) on schistosomiasis in the study area reported poor knowledge about schistosomiasis [25]. This could be the reason why there is low perceived risk of

schistosomiasis among members of the community even though the disease is prevalent. These results are similar to a study conducted in Chad that reported low perceived risk of cholera despite the high prevalence of the disease in the area because no Cholera cases were observed prior to the survey [10].

Given that infected snails have been found at some of the water source points used by the community in this schistosomiasis endemic area, there is need for an intensified health promotion campaign to change people's behaviour and perceptions regarding schistosomiasis. There are many strategies that can be used to bring about changes in behaviour. Dreibelbis et al. [26] reported environmental nudges to have successful results in promoting handwashing behaviour. Similarly, environmental nudges can also be applied in this community to prompt members of the community to use safe water sources.

For the attitude component, respondents scored moderate towards how they felt about using safe water sources and scored low on the cost–benefit scale. This means that the majority of the community members had negative attitudes towards the use of safe water sources. They felt that collecting waterfrom a safe source needed more effort and was time consuming. One of the reasons for this observation was the limited number of improved water sources in the study area [27] which resulted in people having to wait for a long time in queues or having to travel long distance to collect water from asafe sources. Limited resources in the environment (contextual factors) resulted in negative attitudestowards collecting water from safe sources as indicated by the low scores on the cost–benefit scale forboth doers and non-doers. Limited resources had a time cost to it as perceived by members of the community, meaning that individuals had to spend more time collecting water from improved sources than they would if they collected water from the rivers. Additionally, they had to be at public taps atspecific times, usually at odd hours such as very early in the morning, because that would be the onlytime that water would be available. Other studies have indicated that improving access to clean watercoupled with hygiene education can bring about behavioural change [28–30].

The attitude component produced a high IP. The high IP for attitude component requires that persuasive messages be included in the intervention to improve attitudes towards collecting water from a safe source. The message should highlight the health benefits of collecting water from safe sources as well as the health consequences of collecting water from unsafe water sources.

Both subscales on the normative factor (descriptive and injunctive norms) were scored low. Wefound a significant difference between doers and non-doers on the descriptive norm scale. The low subscale scores mean that majority of the community members were not collecting water from safe water sources. In other words, the behaviour was not commonly practiced. In order to change behaviour, one needs to engage respected individuals in the community to ensure that they adopt thebehaviour and that will have an influence on other members of the community who would want to model the behaviour. In a similar study conducted in Bolivia where the authors wanted to increase the adoption of a water technology, their results showed that the influence of opinion leaders had desirable outcomes during the middle of the diffusion process [31].

The normative component resulted in a moderate IP. Moreover, there was a significant difference between doers and non-doers on the descriptive norm scale with the non-doers scoring much lower than the doer group. This means the use of safe water sources was not commonly observed among non-doers compared to the doers. Therefore, the recommended behavioural change technique should prompt public commitment to collect water from a safe source as well as have the support of community leaders to promote the use of improved water sources to promote injunctive norms.

Confidence in performance and self-efficacy as subscales of the Ability component were both scored low. This means that members of the community did not feel confident in their ability to consistently use improved water sources. Moreover, this can also be attributed to the limited improved water sources in the community. Studies in West Africa that have looked at the influence of psychosocial factors in the prevention of Ebola and found that the ability component was an important factor in theprevention of Ebola [14,32].

Abilities factors (confidence in performance and self-efficacy) revealed a high IP. This means the intervention should target ability factors. We found that there was a significant difference between groups of doers and non-doers on the scale of confidence in performance. Non-doers rated themselves as less confident in having the skill to use and maintain the use of safe water sources compared to the doers. This outcome can also be attributed to limited improved water sources in the community thatcould have made people to believe that it was difficult to develop a habit of using safe water sources.The behavioural change technique recommended for this psychosocial factor is the provision of safe water sources such as boreholes and communal taps as well as prompt coping and recovery from a relapse. This includes telling people that lapses are normal when adopting a new behaviour.

Our findings show that the Madeya community relies on surface water (unprotected dug wells,rivers and dams) as the main source of water for domestic use. This implies that the risk of contracting schistosomiasis infection from exposure to cercariae infested waters was high [33,34]. Previous studies in the same area reported high prevalence of schistosomiasis among school-going children [11,12].

5. Conclusions

We determined psychosocial factors that influence people's behaviours with regards to the use of safe water sources. The factors that resulted in a high intervention potential are vulnerability, attitudinal and ability factors. Therefore, the Water, Sanitation and Hygiene (WASH) intervention needs to focus on these psychosocial factors in order to increase the use of safe water sources. Based on these findings, a community-based empowerment intervention strategy is recommended to prompt change in behavioural practice and public commitment. Furthermore, use of persuasive language tobooster self-efficacy is indicated. The intervention should be targeted to younger caregivers with lowincome as the older age group and high-income groups seemed to do better than the former groups.

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Abbreviations

RANAS	Risk, Attitudes, Norms, Ability, Self-Regulation
BCT	Behavioural Change Technique
WASH	Water, Sanitation and Hygiene

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CHAPTER 5

A CONCEPTUAL FRAMEWORK FOR AN INTEGRATED BEHAVIORAL CHANGE WASH INTERVENTION STRATEGY FOR SCHISTOSOMIASIS PREVENTION IN MADEYA VILLAGE

Previous Chapters explored contextual, psychosocial, and institutional factors as well as practices of WASH, and how these predispose individuals to schistosomiasis. Chapter 5 proposes a WASH conceptual framework for schistosomiasis prevention in Madeya village. The conceptual framework was developed from the bottom up using the data that was collected from the previous chapters and considered the context of the study area.

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A conceptual framework for an integrated behavioral change WASH Intervention strategy for schistosomiasis prevention in Madeya Village

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Abstract: Most public health interventions on the prevention of WASH diseases place much emphasis on biomedical aspects that influence the transmission of the diseases with little or no considerations of the social and behavioral aspects. This paper describes the development of a behavioral change WASH intervention conceptual framework to reduce schistosomiasis transmission in Madeya village located in uMkhanyakude district based on the behavioral change theories. Psychosocial and contextual factors were integrated with three behavioral change theories; the RANAS model; the IBM-WASH model and the Ecological Model to develop the intervention conceptual framework. The behavioral change conceptual framework considered four levels of the ecological model: the individual level, interpersonal level, community level, and societal level. At each level, appropriate psychosocial and contextual factors as well as the behavioral change strategy consisting of a behavioral change technique and an appropriate communication channel to prevent schistosomiasis are presented.

Keywords: WASH Intervention strategy; Schistosomiasis; behavioral change

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1. Introduction

Water, sanitation and hygiene (WASH) provide tremendous health benefits (World Health Organization, 2019). Most rural areas in sub-Saharan Africa have very low WASH coverage (Pullan, Freeman, Gething, & Brooker, 2014; World Health Organization & Unicef, 2006), thus explaining the observed high prevalence of preventable WASH related diseases. An estimated 748 million people do not have access to improved water sources globally and almost a quarter of the 748 million people (173 million) rely on untreated surface water (World Health Organization and Unicef, 2014). Much of this population is in sub-Saharan Africa. Natural surface water may be a risk factor for contracting Schistosomiasis (Kulinkina, Kosinski, Adjei, Osabutey, Gyamfi, Biritwum, Bosompem, & Naumova, 2019). Schistosomiasis is a tropical disease caused by worms of the genus *Schistosoma*. Transmission of schistosomiasis is perpetuated through an aquatic intermediate host snail. When eggs of the parasite (Schistosome) reach fresh water, either from urine or stool of an infected person, they hatch and find an appropriate intermediate host snail to penetrate and undergo asexual reproduction. After about 3 weeks an infective larva (cercarium) emerges from the snail and can penetrate skin of humans that come in contact with infectious water. In the human being the parasite develops into an adult worm that starts laying eggs after 6 weeks resulting in the infected person passing the parasite eggs to the environment through urine or stool depending on the species of schistosome (intestinal or urinary form). (Gryseels, Polman, Clerinx, & Kestens, 2006; Nelwan, 2019).

Approximately 4.5 billion people do not have access to safely managed sanitation services (World Health Organization, 2018). About one billion people defecate in open

bushes or in open water bodies (World Health Organization, 2019). Rollemberg, Silva, Rollemberg, Amorim, Lessa, Santos, Souza, Melo, Almeida and Silva (2015) reported high risk of *Schistosoma mansoni* (intestinal form) coinciding with inadequate sewage systems and drinking untreated water. The sustainable development goal (SDG) 6 and 3 aim to ensure availability and sustainable management of water and sanitation for all by 2030; and to ensure healthy lives and promote well-being for all at all ages, respectively (United Nations, 2018). To eradicate a wide range of diseases including schistosomiasis and diarrhoeal diseases, efforts to provide water and sanitation have to be enhanced (Mara, Lane, Scott, & Trouba, 2010). Prüss-Ustün, Bartram, Clasen, Colford, Cumming, Curtis, Bonjour, Dangour, De France, Fewtrell, Freeman, Gordon, Hunter, Johnston, Mathers, Mäusezahl, Medlicott, Neira, Stocks, Wolf and Cairncross (2014) reported that in 2012 approximately 502,000 diarrhoeal deaths were attributed to unsafe drinking water, 280,000 deaths resulted from inadequate sanitation, and attributed 297,000 deaths to poor hand.

WASH, including all water use, sanitation and hygiene can prevent and reduce the spread of diseases (Ginja, Gallagher, & Keenan, 2019) leading to a reduction in child mortality (Prüss-Ustün & World Health Organization, 2008). Furthermore, promotion of hygiene could be one of the most cost-effective means for reducing the global burden of diseases (Jamison, Breman, Measham, Alleyne, Claeson, Evans, Jha, Mills, & Musgrove, 2006). The behavior of people determines the success of efforts to prevent contamination of the environment with schistosome eggs and to interrupt schistosomiasis transmission. For example, restriction in water contact activities with natural bodies, discouraging people from urinating and defecating in and around natural water bodies can effectively prevent and reduce transmission of schistosomiasis. Primary school children whose households are near ponds or natural water sources are predisposed to higher prevalence of schistosomiasis infection compared to those living far from natural water bodies (Angelo, Buza, Kinung'hi, Kariuki, Mwanga, Munisi, & Wilson, 2018; Hajissa, Muhajir, Eshag, Alfadel, Nahied, Dahab, Ali, Mohammed, Gaafar, & Mohamed, 2018). However, very little has been reported on how predisposing behaviours can be reduced using WASH strategies.

While mass drug administration with praziquantel is the mainstay of schistosomiasis control, WASH interventions are critical for preventing and reducing transmission of schistosomiasis (Chimbari, Dhlomo, Mwadiwa, & Mubila, 2003; Evan Secor, 2014; Grimes, Croll, Harrison, Utzinger, Freeman, & Templeton, 2015; Lo, Addiss, Hotez, King, Stothard, Evans, Colley, Lin, Coulibaly, & Bustinduy, 2017). Paradoxically, there is limited research that focuses on the social cultural aspects that influence WASH behaviour change for local disease control and transmission (Dreibelbis, Winch, Leontsini, Hulland, Ram, Unicomb, & Luby, 2013; Garn, Sclar, Freeman, Penakalapati, Alexander, Brooks, Rehfuess, Boisson, Medlicott, & Clasen, 2017). Much of research on WASH is on technologies introduced in communities with little or no engagement with the communities (Cairncross, Hunt, Boisson, Bostoen, Curtis, Fung, & Schmidt, 2010; Waddington & Snilstveit, 2009). Studies from sub-Saharan Africa have shown that provision of hardware to WASH is not sufficient indicating the need to explore socio-cultural issues that play an important role to achieve effective utilization of the technologies (Garn et al., 2017; Hulland, Leontsini, Dreibelbis, Unicomb, Afroz, Dutta, Nizame, Luby, Ram, & Winch, 2013) and subsequent reduction of WASH related diseases.

The Psychosocial and contextual factors of WASH play a key role in accelerating WASH (Garn et al., 2017). It is imperative to understand the human centered or human component of WASH, usually referred to as the 'software'. Factors such as feelings, motivation to engage in a health seeking behaviour, past and planned behaviour, all influence an individual's decision to adopt a WASH related behaviour (Aunger, Schmidt, Ranpura, Coombes, Maina, Matiko, & Curtis, 2010; Curtis, Danquah, & Aunger, 2009; Scott, Curtis, Rabie, & Garbrah-Aidoo, 2007). Interventions that focus on WASH coverage are referred to as the "hardware" aspects and they include provision of hardware material such as

latrine construction, installing sewage systems, provision of piped water or boreholes. Provision of hardware facilities does not necessarily guarantee uptake. Some studies have reported that individuals may opt to defecate in the open even in areas where sanitation coverage is high (Coffey, Gupta, Hathi, Khurana, Spears, Srivastav, & Vyas, 2014; Gupta, Coffey, & Spears, 2016). Such behavior is influenced by technological, contextual and Psychosocial factors (Dreibelbis et al., 2013). Therefore, an understanding of how these factors interact is the foundation for attaining health benefits such as reduction of the risk of contracting WASH related diseases.

Previous studies in Ingwavuma, an area where schistosomiasis is prevalent, were largely influenced by biomedical models that mainly focused on screening and treatment for schistosomiasis (Kabuyaya, Chimbari, Manyangadze, & Mukaratirwa, 2017; Manyangadze, Chimbari, Gebreslasie, Ceccato, & Mukaratirwa, 2016). Although water and sanitation were reported as some of the risk factors for contracting schistosomiasis in Ingwavuma, the behavioral aspects were not thoroughly interrogated. This paper describes the development of a WASH behavioral change conceptual framework informed by previous primary studies conducted by the authors. The proposed intervention framework can be applied to reduce WASH related risk factors and prevent WASH related diseases particularly schistosomiasis. Since there is an argument that suggests that public health interventions that apply social and behavioral science theory are most effective, we incorporated social and behavioral science theories in developing our conceptual framework(Glanz & Bishop, 2010; Hagger & Weed, 2019). For the purpose of completeness, appropriate behaviour change theories for influencing change are described highlighting how this study embraces constructs of different theories to develop a context specific WASH behaviour change model.

2. Methodology

The methodology used to develop the behavioral change WASH intervention conceptual framework, to reduce schistosomiasis trans-mission in Ingwavuma Community is based on behavior change theories and papers previously published by the authors. The theories are described below in detail.

Unpacking Behavioral Change Theories

The most successful public health programs and initiatives are the ones that consider health behaviors in the context in which they occur (Glanz, 1997; Glanz & Bishop, 2010). Public health and health promotion interventions that are based on social and behavioral science theories are reported to be more effective than those that lack a theoretical base (Noar, Benac, & Harris, 2007). Furthermore, interventions that combine multiple strategies and concepts have been reported to be more effective (Ammerman, Lindquist, Lohr, & Hersey, 2002). Hence interventions to improve health are best designed with an understanding of relevant theories of behavior change and the ability to use them skillfully (Bernstein, 1971; Glanz, Rimer, & Viswanath, 2008).

There are multiple determinants and multiple levels of determinants of health and health behaviour. Knowledge, attitudes, and motivation are important individual determinants of health behaviour. Additionally, families, social relationships, socioeconomic status, culture, and geography are other important influences (Glanz & Bishop, 2010). To develop a well-informed public health program, a broad understanding of key factors and models for understanding behaviors and behavior change is crucial. This is important because it helps to identify the most influential factors for a particular person or population and enables the program developers to focus on the most important factors. Ecological approaches to public health programs are considered to be more effective because such interventions not only target individuals but also affect, interpersonal, community and

environmental factors influencing health behavior (Mcleroy, Bibeau, Steckler, & Glanz, 1988; Smedley & Syme, 2000).

Theories help to identify what information is needed to design an effective intervention strategy, and provide insight into how to design a program so that it is successful (Glanz et al., 2008). Theories and models help explain behavior, as well as suggest how to develop more effective ways to influence and change behavior(Glanz & Bishop, 2010). There are several theories that target behavior change. Some of the behavioral change theories and models for promoting or changing WASH related behaviors include the RANAS (Risk, Attitude, Norms, Ability and Self-regulation) model, which is an approach to systematic behavior change and is an established method for designing and evaluating behavior change strategies that target and change the behavioral factors of a specific behavior in a specific population (Contzen & Mosler, 2015). The IBM-WASH (Integrated behavioral model for water, sanitation and hygiene) model takes the form of a matrix and gives a multilevel (five rows) and dimensional (columns) model on how behaviors can be influenced (Dreibelbis et al., 2013). The COM-B (capability, opportunity motivation and behavior) model holds that for behavior to be changed, the capabilities, opportunities and motivations of the target group must be influenced (Mayne, 2018). Lastly the SaniFoam which is designed specifically for sanitation related behavior proposes that opportunity, ability, and motivation are key to behavior change (Devine, 2009).

A critique of Behavioral change theories and concepts used to develop the Madeya village intervention strategy for schistosomiasis prevention

Three model informed the development of an integrated behavioral change model for the prevention of schistosomiasis in Madeya village situated in Ingwavuma. Constructs from the RANAS model, the IBM-WASH model and the Ecological model were integrated to develop the strategy for schistosomiasis prevention in Madeya. Contextual and Psychosocial factors were drawn from previous studies conducted in the study area and reference was made to the IBM-WASH model to develop an intervention strategy consistent with the levels of the ecological model (Mulopo & Chimbari, 2021; Mulopo, Kalinda, & Chimbari, 2020a; Mulopo, Mbereko, & Chimbari, 2020b). Furthermore, the IBM-WASH model enabled us to identify the critical contextual factors that need to be targeted in behavioral change interventions. The contextual and Psychosocial factors identified were allocated to the appropriate level of the ecological model. The following section demonstrates how the combined constructs of the aforementioned theories informed the development of the strategy for Schistosomiasis prevention for poorly resourced settings.

3.1. *RANAS Model -The RANAS approach to systematic behavior change*

The RANAS model proposes a psychological model with five blocks of factors namely risk factors, attitudinal factors, normative factors, ability factors, and self-regulation factors. The model proposes that for behavior to be changed these five factors need to be positive with regards to behavior. Consequently, the role of the practitioner is to identify factors that keep the population attached to behavior that is unhealthy. Behavior is measured using a standard tool adapted to the local context. Furthermore, a doer/non-doer analysis is conducted whereby, the responses of individuals who perform the behavior (doer) is compared to the responses of those who do not perform the behavior (non-doer). Significant differences between doers and non-doers indicate how the behavioral factor in question steers the behaviour. The behavioral factor can then be targeted and changed using behavioral change techniques (Mosler, 2012; Mosler, 2016).

The psychosocial factors drawn from the previous studies were measured using the RANAS model (Mulopo et al., 2020a). However, the limitation of the model is that it only

measures phenomena at the individual level and does not consider contextual factors that influence the behaviour. Therefore, to identify contextual factors, the IBM-WASH model was used for this purpose.

3.2. *IBM-WASH Model*

The integrated behavioral model for water and sanitation (IBM-WASH) model is a synthesis of existing behavioral models. IBM-WASH model is in form of a matrix with three columns and five level rows consistent with matrices of the ecological framework. The IBM-WASH model argues that three intersecting dimensions influence WASH behavior; contextual, psychological and technological dimension (Dreibelbis et al., 2013). Although the IBM-WASH model has a psychological dimension, it does not provide a measuring tool for the psychosocial factors. For the purpose of this conceptual paper the technological aspect of the IBM-WASH model was not relevant because the focus was on behavior and not technology. Similarly contextual factors were drawn from a previous study conducted in the study area (Mulopo et al., 2020b). The contextual factors are well explained in the IBM-WASH model hence this model was best suited and more applicable in helping us understand contextual factors.

3.3. *ECOLOGICAL FRAMEWORK*

The ecological framework looks at phenomena within the context of the systems of relationship. Therefore from this perspective, no single factor can explain phenomena hence consideration of the interaction of the larger environment in which behavior is taking place has to be made (Ryan, 2001). The framework recognizes multiple levels of influence on behaviour. The ecological framework treats the interaction between factors at the different levels with equal importance to the influence of factors within a single level. The framework consists of four levels: the individual, interpersonal, community and societal level which are perceived to be nested structures each inside the other moving from the inner level to the outside (Rimer & Glanz, 2005). It was important to look at the community's exposure to freshwater bodies within different social contexts, hence we adopted the ecological framework levels to have a better understanding and explanation of this phenomena at different societal levels.

3.4. *Behavioural change strategy*

The adequate method of intervention delivery must be determined in order to achieve the desired behaviour change in the target population. Hence a communication Chanel needs to be identified. In addition to this, a behavioral change technique (BCT) is what is believed to change the critical behavioral factor. (Mosler & Contzen, 2016). A combination of a BCT and a communication channel is referred to as a behavioral change strategy. To select the BCT and communication Channel a catalogue for behavioral change technique was used (Mosler & Contzen, 2016). The catalogue lists BCTs thought to change each psychosocial factor, based on evidence from environmental and health psychology together with an appropriate communication channel which is a form of delivery of that BCT. The BCTs are combined with suitable communication channels, that become the mode of delivery of the communication channel. We therefore used the BCT catalogue to select the appropriate BCT and the communication channel for each psychosocial factor that had to change to improve the use of safe water sources and hence prevent people from getting into contact with unsafe water sources (Figure 1).

For this study we preferred the RANAS model, IBM-WASH model and the ecological model because they were more suitable and applicable to the context and the phenomena

of interest. The RANAS model was an excellent measure of psychosocial factors among individuals in the community, while the IBM-WASH model guided the process of identifying contextual factors and lastly the ecological model provided a holistic approach to the intervention. These theories and previous work by the authors are integrated below indicating how they were applied to build the conceptual framework. The previous work added value because the data was generated from the study community.

RESULTS

4. Development of integrated behavioral change WASH Intervention strategy

The behavioral change conceptual framework for the prevention of schistosomiasis proposed in this paper was developed from a synthesis of primary studies and theories described in the methodology section. Thus, this paper focuses on the application of the findings as an intervention for schistosomiasis prevention in Madeya village. Critical psychosocial and contextual factors were extracted and allocated to an appropriate level of the ecological nested levels. The proposed strategy explains the psychosocial factors that need to be targeted at each level of the ecological nested levels to prevent schistosomiasis transmission. Furthermore, contextual factors which need to be targeted at each level are identified. Lastly, an appropriate behavioral change strategy that can be used to bring about change in behavior at each level of the ecological nested levels is presented. Consequently, we propose an appropriate integrated behavioral change WASH intervention that takes into account psychosocial, contextual, behavioral change theories and behavioral change strategies to prevent schistosomiasis through change in behavior (Figure 1).

4.1. Micro-level (Individual)

This level refers to the individual's socio-demographic characteristics, such as age, gender, individual cognitive factors as well as attitudes towards the behavior (Figure 1). The behavior in our study was the use of safe water sources which is critical in the prevention of schistosomiasis. Socio-demographic factors contribute to a person's susceptibility to contracting the disease. The psychosocial factors, which influence the use of safe water sources were identified using the RANAS model. These were severity, feelings, descriptive norms and confidence in performance. Therefore, at the individual level the intervention needs to focus on these psychosocial factors. In order to achieve this, we identified behavioral change techniques (BCT) tailored to change these psychosocial factors. To tackle severity as a psychosocial factor, threatening information that influences the severity of contracting schistosomiasis should be included in the intervention. To tackle feelings, messages describing positive feelings towards the use of safe water sources were included. The ability factor, which can be promoted through the use of persuasive arguments to bolster self-efficacy was also included.

For the conceptual framework to help achieve behavior change, we selected an appropriate communication channel. The combination of a communication channel and BCT is referred to as a behavioral change strategy. A suitable communication channel at this level is home visits using community health workers. Community health workers are an extension of primary health care which researches out to people at household level. They are members of the community trusted by the community to enter their homes and assist them with their health challenges. Community health workers visit households to educate community members about schistosomiasis using the BCTs.

We preferred use of community health workers because the health system in this community already has them operating in the community as educators and basic health service providers. This way we avoided introducing a parallel system and tapped into already existing resources.

4.2. Meso-level (Interpersonal)

The interpersonal level represents intimate interactions between the individual and other people in the immediate environment. These include close friends and family as well as neighbors (Figure 1). Roles and responsibilities in the household, and commonly practiced norms within the immediate environment contributes to a specific behaviour (Matthies, Selge, & Klöckner, 2012). The behavior of interest here is the use of safe water sources, depending on the norms and responsibilities in the households, certain groups of people are more likely to have a higher risk of exposure to infection than others. Qualitative data from our previous studies showed that women and children, boys and girls were responsible for collecting water (Mulopo & Chimbari, 2021; Mulopo et al., 2020b). Children usually accompanied the adults and assisted in collecting and transporting the water. On the measure of psychosocial factors, there was a significant difference (t=2.082, p=0.021) on the measure of descriptive norms among doers and non-doers implied that safe water sources among non-doers were not commonly observed. It is therefore imperative to promote good behavior (use of safe water sources) that can be modeled in the household and immediate environment. Norms at this level can be improved by placing more emphasis on the importance of only using safe water sources and having this behavior modeled within the household and immediate environment such as neighbors and friends. Descriptive norms play an important role at the interpersonal level since behavior is usually modeled in a household.

Therefore, the communication channel appropriate for this level is community meetings. We chose community meetings because this strategy already exists in the study area where regular meetings are called by i*Zinduna* (traditional leader). Members of the community meet once a month in *"what they call a war room"* where they discuss issues affecting the community. Health education and prevention of schistosomiasis can be discussed at these meetings to improve public awareness of the disease as well as to prompt public commitment to only use safe water sources.

4.3. Exo-level (Community level)

The community level refers to the physical and social environment in which members of the community are nested. It also refers to the formal and informal institutions that shape individual experiences in the community. The psychosocial intervention at this level is to ensure that there is public commitment from members of the community to only use safe water sources (Figure 1). This process can be initiated through the use of community leaders, where community leaders play a significant role in ensuring that members of the community commit to only using safe water sources. Additionally, norms at this level can also be targeted for change by engaging with influential people in the community and ensuring that they adopt the desired behavior to be followed by others. Injunctive norms play an important role at community level since behavior can easily be modeled in a community. The formal institution that existed in this area was the clinic. The clinic was an important source of information where nurses provided health education to community members.

The physical environment was characterized by limited water supply infrastructure. There was only one borehole operating and two taps that only had running water occasionally. Majority of the community used surface water as their main source of water. The communication strategy appropriate at this level is mass communication using radio. We identified the popular *Maputaland* Community Radio station as an appropriate channel to provide community members with information on schistosomiasis.

4.4. Macro-level (Societal level)

The macro-level refers to the broad structures, which influence behavior in a society such as institutions or culture. This includes factors such as laws and policies, climate and geography (Figure 1). These contextual factors are usually constant, meaning that one

might not find differences between doers and non-doers even though they influence the success of behavior change. We found that access to water was a major constraint associated with the natural environment. There were variations in the access by community members to improved water supply. It is therefore important to understand and recognize these variations in order to have a complete understanding of the context in which behavior takes place.

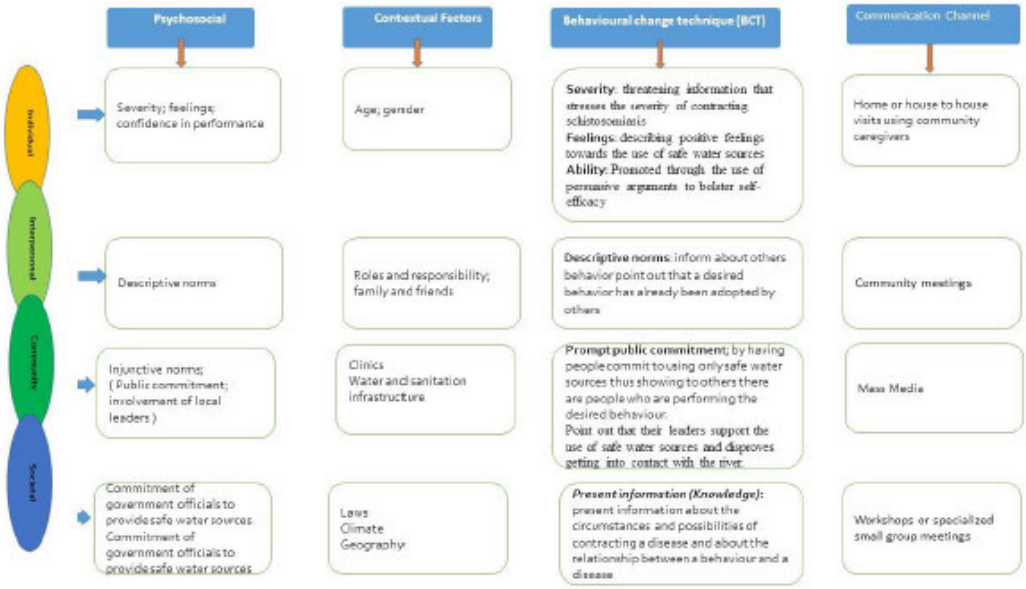

Figure 1. Water, sanitation and hygiene intervention conceptual framework for schistosomiasis prevention.

5. Discussion

This is the first study to develop a WASH behavior change intervention strategy by combining primary data with behavioral change theory for schistosomiasis prevention in uMkhanyakude. The behavioral change conceptual framework is specific to schistosomiasis in this context because schistosomiasis was the WASH related health problem of interest. However, the steps taken to develop this strategy and the conceptual framework can be adapted for application to other WASH related health problems.

We found that demographic factors and psychosocial factors are important and should be considered when designing an intervention for schistosomiasis prevention to complement current treatment efforts (Cioli, Pica-Mattoccia, Basso, & Guidi, 2014). We propose an intervention that targets the psychosocial factors namely: severity, feelings, and confidence in performance. Since we found that women and children are mostly involved in collecting water from unimproved water sources, implementation of the proposed intervention framework should target women and children (Mulopo et al., 2020a). Other studies have previously identified school age children as most vulnerable to schistosomiasis (Engels, Chitsulo, Montresor, & Savioli, 2002; Hajissa, Abd Elhafiz, Eshag, Alfadel, Nahied, Dahab, Ali, Mohammed, Gaafar, & Mohamed, 2018; Joof, Sanyang, Camara, Sey, Baldeh, Jah, Ceesay, Sambou, Sanyang, & Wade, 2021). Since the focus is on the person or the individual, the most suitable communication channel we identified was household visits using community health workers.

For interpersonal level, descriptive norms play a key role in ensuring that behavior is adopted and sustained over time. Previous research indicates that descriptive norms tend to motivate behavior in the immediate context in which other people's behavior occurs or can be observed (Smith, Louis, Terry, Greenaway, Clarke, & Cheng, 2012). Use of community meetings as a communication channel ensures that the community is well informed about the use of safe water sources. This encourages modeling in the social network to adopt behavior through descriptive norms. At this level, targeting inductive norms where prominent people in the community get involved and are encouraged to be exemplary in their behavior can be useful. Injunctive norms can cause behavioral change across a range of context (Cialdini, Demaine, Sagarin, Barrett, Rhoads, & Winter, 2006). This has an impact on the perception of the general community when they see that others in their social networks adhere to the use of safe water sources.

At the community level, although we found that there was limited infrastructure, there is need to promote public commitment to use the limited improved infrastructure available. This is imperative for reducing contamination of the environment thereby minimizing the number of schistosome eggs reaching natural water where there may be intermediate host snails for schistosomiasis. To prevent reinfection of schistosomiasis to groups that have received chemotherapy, these groups have to be provided with adequate water supplies (Esrey, Potash, Roberts, & Shiff, 1991; Jordan, Unrau, Bartholomew, Cook, & Grist, 1982). A study in Ethiopia found that the prevalence of diarrhoea was lower among under 2-year-olds from families with higher safe water usage rates per person compared to families with lower safe water usage rates (Tendick-Matesanz, 2013) thus demonstrating the benefits of water supply. Our study showed that the clinic played an important role in dissemination of health information through the nurses and community care givers (CCG's). However, the nurses reported that they did not teach about schistosomiasis and its transmission pathways but only focused on the importance of handwashing. Inclusion of schistosomiasis in the sessions conducted by nurses will improve the effectiveness of the proposed conceptual framework.

At society level, although change in polices and laws may be slow, promotion of use of safe water sources can be enhanced through changing policies and advocating for access to water for all in line with sustainable development goals.

Our conceptual framework can be applied in settings with similar societal structure, social economic status, and poor access to WASH. The context that informed this behavioural change conceptual framework is well described in studies preceding the framework by Mulopo and colleagues (Mulopo & Chimbari, 2021; Mulopo et al., 2020a; Mulopo et al., 2020b). However, we suggest the use of the RANAS questionnaire first to identify the psychosocial factors at play before proceeding with the subsequent steps of the framework.

The limitations of our behavioural change conceptual framework are that, if one starts with the measurement of psychosocial factors, it would be time consuming and costly. Moreover, if the strategy is adopted without a measure of Psychosocial factors, there could be other underlying psychosocial factors that may be missed and therefore the behavioural change intervention may not be very effective in changing haviour. Another limitation is that since the conceptual framework was informed by data from one study locality this might limit the application of the conceptual framework to a wider population.

6. Conclusion

We developed a conceptual framework for schistosomiasis using literature and behavioral change theories. We believe the strategy is effective because it considers unique characteristics of the population, both Psychosocial and contextual; and is aligned with existing behavioral change theories. The strategy identifies key intervention points as well

as the communication channels most suitable to achieve behavioral change. This conceptual framework is applicable to poorly resourced settings similar to our study area but should consider the contextual factors in places where it may be applied.

7. Declaration

Availability of Data and materials: The data set used for the current study is available upon request from the corresponding author.

Competing interest: We have no conflicts of interest to disclose

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Abbreviations

BCT: Behavioral Change Technique
COM-B: Capability, opportunity, motivation-behaviour
IBM-WASH: Integrated behavioral model for water, sanitation and hygiene
RANAS: Risk, Attitudes, Norms, Ability, Self-Regulation
WASH: Water, Sanitation and Hygiene

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CHAPTER 6

SYNTHESIS, CONCLUSIONS, AND IMPLICATIONS FOR FURTHER RESEARCH

6.1 Synthesis

This thesis comprises of several sub-projects connected together to answer the main objective of this study which was to explore the role that WASH interventions play in preventing schistosomiasis in resource limited settings. Background and literature reviewed in Mulopo et al., (Manuscript 1) in Chapter 1, indicated the need for determining and understanding WASH interventions necessary for preventing schistosomiasis transmission and maintaining low prevalence after chemotherapy. The key findings generated from this thesis are outlined below and put in the context of other studies.

6.1.1 schistosomiasis risk factors related to WASH practices

In Chapter 2, a participatory research design was applied to diagnose WASH conditions and to identify schistosomiasis risk factors. It was observed that community member's practices and behaviours contributed to the transmission of the infection. Furthermore, evidence of practices and behaviours such as risk factors for schistosomiasis transmission as reported by other researchers (1, 2-8) was presented.

6.1.2 Key behavioural determinants of schistosomiasis transmission

Chapter 2 also showed how schistosomiasis infections are influenced by the practices and behaviours of members of the community other than just environmental factors such as availability of toilets, piped water collection points and places of bath and laundry (9, 10-12). Environmental and behavioural factors interplay with each other and one influences the other. In the study participatory research methods highlighted the actual day to day experiences of members of the community living in poorly resourced water and sanitation setting. In this regard, the risk factors were documented through the eyes of members of the community. Similar methodologies were implemented in the subsequent sub-studies to identify the risk factors of schistosomiais patterning to Madeya village.

6.1.3 Stakeholder involvement in the prevention and control of schistosomiaisis

A detailed documentation and qualitative analysis of stakeholder engagement in WASH in the prevention and control of schistosomiaisis is presented in Chapter 3. The sub-study uses qualitative methods with a grounded theory approach to understand the stakeholder's perspectives. The data showed that the key players for the promotion of WASH were not clearly defined. Furthermore, effective implementation, promotion, and adoption of WASH for schistosomiasis prevention seemed to be the responsibility of various stakeholders with little coordination, thus indicating limited stakeholder collaboration.

6.1.4 Critical contextual and Psychosocial factors for behavior change to reduce risk of schistosomiasis

Chapter 4 indicated the key critical contextual and psychosocial factors in the prevention of Schistosomiasis for Madeya village. The data presented in Chapter 4 showed contextual factors, mainly the absence of adequate water resources which resulted in frequent contact with fresh water bodies. Furthermore, the RANAS model was used to measure the critical psychosocial factors that predispose people in Madeya to Schistosomiasis. The key psychosocial determinants were listed as vulnerability, attitudinal and ability factors. With the data gathered from the previous Chapters, an intervention framework was proposed in the subsequent chapter for the prevention of Schistosomiasis in Madeya.

6.1.5 A proposed behavioral change conceptual framework for schistosomiasis prevention in Madeya village

In chapter 5 the risk factors in Chapter 2, the level of stakeholder engagement in Chapter 3 as well as contextual and psychosocial factors in Chapter 4 were integrated with three behavioural change theories; RANAS model; IBM-WASH model and the Ecological model to develop the intervention conceptual framework. The conceptual framework was developed basedon the context of Madeya village as a preventative strategy of schistosomaisis.

6.2 Conclusions

The current study was set out to explore WASH in a rural community endemic to schistosomiasis. This evidence-based study indicates that WASH plays a significant role in preventing schistosomiasis. The current study builds on previous studies that highlighted the need for future studies to focus on local factors and social-economic context for WASH interventions to be effective in preventing schistosomiasis.

Contextual factors that made the community susceptible to schistosomiasis were explored using participatory methods that ensured the involvement of members of the community and also left them empowered in identifying risk factors for schistosomiasis in their community. Upon identifying contextual factors, behavioral factors (psychosocial factors) were also explored. It was important to identify which psychosocial factors were contributing to risky behavior, in this case the use of unsafe water sources. The interaction between the person (psychosocial) and the environment (contextual) is important to understand in order to adequately devise an intervention for schistosomiasis prevention.

The WASH practices that were identified to influence behaviour and contribute to the risk of schistosomiasis included people accessing the river for water collection for domestic use as well as for leisure due to limited access to improved water sources. Furthermore, proximity of the village to the rivers and a lack of recreational activities such as swimming pools in the community contributed to prolonged time spent in open water bodies. Irrigation of gardens was another practice that predisposed members of the community to schistosomiasis. Lastly, open defecation which was mainly practiced by men and children was a risk factor for schistosomiasis in the community. The psychosocial factors that influenced and predisposed members of the community to schistosomiasis included perceived vulnerability, attitudinal factors as well as perceived ability towards the use of safe water sources.

Lastly the role of stakeholders which represents societal factors was explored to identify gaps and opportunities that stakeholders can bring to ensure sustainable and effective schistosomiasis control programs. It was found that the key players in the promotion of WASH were not clearly defined. Furthermore, there was a limited collaboration among WASH stakeholders. The evidence collected from the study was summarized into a schistosomiasis control strategy for this rural community.

The implications for policy will include not only advocating for MDA as the mainstay for schistosomiasis control but also include social and behavioral strategies on the individual, community and societal level for a holistic approach to schistosomiasis prevention. Additionally, WASH interventions need to be appropriated implemented with understanding of the context for the intervention to be effective. When appropriate interventions are designed and implemented, they are more likely to be effective and will contribute to SDG 3 and 6.

6.3 Limitations

1. Challenging to observe WASH activities in a short-term cross-sectional study. A combination of long-term observational studies and cross-sectional studies would provide adequate information.
2. The current study focused mostly on water risky behaviors compared to sanitation.
3. Due to the sampling technique (purposive sampling) applied in this study caution should be taken in generalizing the findings to other contexts.

6.4 Recommendations

1. More studies are needed to explore the link between sanitation and schistosomiasis.

2. Guidelines need to be developed to ensure that WASH interventions are implemented considering different contexts. These guidelines need to include monitoring and evaluation of WASH interventions.
3. We recommend behavioral change interventions informed by social and behavioral change theory to inform WASH interventions for schistosomiasis prevention.
4. Strong collaborations are needed between stakeholders: the Municipality, the department of health as well as the community, for the provision of water sources and the use of these water sources to prevent diseases schistosomiasis
5. We recommend health education on the household and community level on schistosomiasis risks factors associated with water contact activities and open defecation.
6. In order to achieve SDG 6 and 3 behavioral practices need to be included in NTD control programs for complete eradication of NTDs and contribute to health and general wellbeing of the population.

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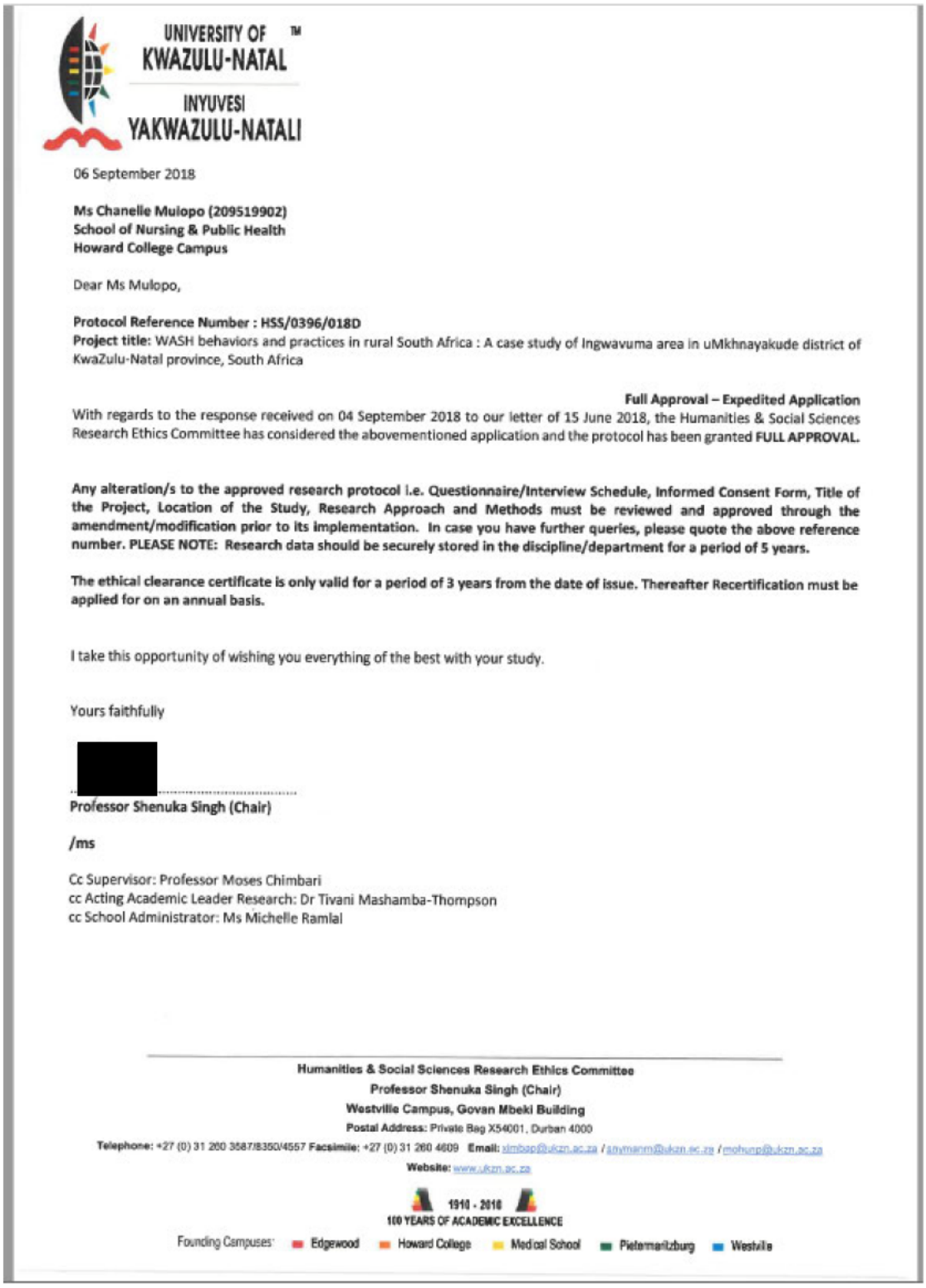
6.6 Appendices

Ethics clearance letter from Humanities and Social Sciences Research Ethics Committee



UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

06 September 2018

Ms Chanelle Mulopo (209519902)
School of Nursing & Public Health
Howard College Campus

Dear Ms Mulopo,

Protocol Reference Number : HSS/0396/018D
Project title: WASH behaviors and practices in rural South Africa : A case study of Ingwavuma area in uMkhnayakude district of KwaZulu-Natal province, South Africa

Full Approval – Expedited Application

With regards to the response received on 04 September 2018 to our letter of 15 June 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]
Professor Shenuka Singh (Chair)

/ms

Cc Supervisor: Professor Moses Chimbari
cc Acting Academic Leader Research: Dr Tivani Mashamba-Thompson
cc School Administrator: Ms Michelle Ramlal

Humanities & Social Sciences Research Ethics Committee
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Proof of submission: Manuscript 1: Infectious diseases of poverty

Infectious Diseases of Poverty

Water, sanitation, and hygiene (WASH) interventions for schistosomiasis control in Africa: A systematic review.

--Manuscript Draft--

Manuscript Number:	IDOP-D-21-00080
Full Title:	Water, sanitation, and hygiene (WASH) interventions for schistosomiasis control in Africa: A systematic review.
Article Type:	Scoping Review
Funding Information:	National Research Foundation — Ms Chanelle Mulopo British Academy (KF2\100075),) — Prof Moses J Chimbari National institute for health research — Prof Moses J Chimbari
Abstract:	Background : Schistosomiasis is one of the most prevalent parasitic infections and 93% of all cases are reported from Sub-Saharan Africa. Although WHO advocates for chemotherapy as the cornerstone of schistosomiasis control, it has limitations such as the inability to kill immature worms and failure to prevent reinfection. Therefore, there is a need for integrated approaches and strategies to effectively interrupt schistosomiasis transmission, especially in endemic foci. Objective : The objective of this review was to assess the impact of WASH interventions in the prevention of schistosomiasis. Methods : A systematic search of primary studies published in peer-reviewed journals on WASH interventions in the control of schistosomiasis was conducted. The following databases were searched: MEDLINE, ScienceDirect, ProQuest Psychology Journals, JSTOR Health & General Sciences Collection, CINAHL with Full Text, Health Source: Nursing/Academic Edition, MEDLINE with Full Text, PsychINFO, Worldcat, and WorldCat.org. A data extract table was used to extract relevant information from the included articles. Quality assessment for all included studies was done using the Mixed Method Appraisal Tool (MMAT). Thematic analysis was applied to extract data and information from the selected papers. Findings : Most interventions were integrative combined with preventive chemotherapy. Most studies indicated the value of WASH in the prevention of schistosomiasis especially in the context of maintaining low prevalence after chemotherapy. WASH was also highlighted as a key aspect in preventing the transmission of other diseases besides schistosomiasis. Behavioral interventions were effective in preventing open defecation and water contact activities hence interrupting schistosomiasis transmission. However, most WASH interventions rely on the provision of infrastructure or just assess the impact of existing WASH infrastructure on schistosomiasis, and very few incorporate behavioral change interventions. Conclusion: While our study indicated the value of behavioral change WASH interventions supported by provision of WASH infrastructure to ensure effective control of schistosomiasis, it was not conclusive on the efficacy of bottom-up approaches. We therefore recommend further studies that demonstrate the efficacy of bottom-up behavioural change approaches.
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Corresponding Author Secondary Information:	
Corresponding Author's Institution:	University of Kwazulu-Natal
Corresponding Author's Secondary Institution:	

Informed Consent Document

Dear Participant,

My name is Chanelle Mulopo. I am a Ph.D. student in the school of public health medicine at the University of KwaZulu-Natal, Howard College Campus. The title of my research is *Water sanitation and hygiene (WASH) behaviors and practices in rural South Africa: A case study of Ingwavuma area in uMkhanyakude district of KwaZulu-Natal province, South Africa.* The main research question for the proposed study is "**How are WASH behaviors and practices influenced by psychosocial, contextual, and institutional factors in Ingwavuma, uMkhanyakude district?"** To find answers to this main question several sub-questions have been posed: What is the population's access to and utilization of improved WASH facilities in Ingwavuma and handwashing behaviors; How do institutional factors influence WASH in Ingwavuma; How do psychosocial and contextual factors influence WASH; What is the appropriate WASH intervention framework for Ingwavuma community? If you accept to participate in the household survey you will be required to fill in a WASH questionnaire as well as a psychosocial questionnaire. Additionally, I am interested in conducting focus group discussions and in-depth interviews with you to share your experiences on the subject matter.

Please note that:

- The information that you provide will be used for scholarly research only.
- Your participation is entirely voluntary. You have a choice to participate, not to participate, or stop participating in the research. You will not be penalized for taking such an action. Participants have the right to withdrawal without any negative consequences.
- Your views in this interview will be presented anonymously. Neither your name nor identity will be disclosed in any form in the study.
- The household survey will last approximately (*30-40 minutes*)
- The focus group discussions and in-depth interviews will last approximately (*40-45 minutes).*
- All information recorded as well as other items associated with the research will be held in a password-protected file accessible only to myself and my supervisor. After 5 years, in line with the rules of the university, shredding and burning will dispose of it.

- If you agree to participate please sign the declaration attached to this statement (a separate sheet will be provided for signatures)

- The results of this research will provide data on geographic inequalities that still exist concerning access to improved water and sanitation that may be hidden in national statistics. The study will also generate knowledge on psychosocial factors that influence WASH in Ingwavuma. The results of the study will be used to develop an intervention framework for WASH interventions in Ingwavuma. The information generated from this study could also be used to inform policies on water, sanitation, and hygiene, and related behaviors in poor-resourced settings.

I can be contacted at the School of Public Health Medicine, University of KwaZulu-Natal, Howard College Campus, Durban. Email: cmulopo@gmail.com Cell: 073 5776016

My supervisor is Prof Moses J. Chimbari, who is located at the School of Public Human Sciences, Howard College Campus Durban of the University of KwaZulu-Natal. Contact details: email chimbari@ukzn.ac.za Phone number: 031 260 4833

For information on your rights as research, participants contact Ms. Phumelele Ximba, University of KwaZulu-Natal Research office: Tel: 031 260 3587.

Please complete the section below if you are willing to participate in the study.

Thank you for your contribution to this research.

Chanelle Mulopo

DECLARATION OF CONSENT TO PARTICIPATE IN THE STUDY

I _____ give my consent to participate in the study described above. I understand that my participation is entirely voluntary, that the information I provide will be confidential and anonymous in any publications or reports, and that I can withdraw from the study at any time. I hereby consent / do not consent to have this interview recorded. If I have any questions after today I can call the researcher Chanelle Mulopo or her supervisor Prof. Chimbari

_____ _____

Participant's signature **Date**

Socio-demographic questionnaire			
No	**Questions and filters**	**Coding categories**	**Code**
A1	Name		
A4	Name of Village		
A5	Ward		
A6	Gender	MALE 1 FEMALE 2	
A7	Age		
A8	How long have you lived in this area		
A9	Highest level of education		
A10	Occupation of participant	STUDENT 1 SELF EMPLOYED 2 EMPLOYED BY GOVERNMENT 3 EMPLOYED BY PRIVATE COMPANY 4 UNEMPLOYED 5 RETIRED 6 UNABLE TO WORK 7	
A11	Are you a recipient of a social grant	Yes…… ……1 No…… …....2	

		If Yes How much……..	
A13	Would you consider yourself as a decision-maker or an implementer		

Interview guide for Health workers		
Thank you for joining this discussion. We want to find out your opinions about water, sanitation, and hygiene issues. There are no wrong or right answers; we just want to know your opinion. Please speak freely; what you say will not be quoted individually. If you like to talk a lot, please make sure that others get a chance, and if you are quiet please try to participate. I want to play a game to start. Please tell us your name and something you like about living in this community I'll start. My name is X and I think XX,		
Main question	**Follow up**	**Probing question**
1. Who is responsible for providing water sanitation and hygiene in the community?	● *What role do you play as the clinic to promote water, sanitation, and hygiene?* ● *What are some of the activities that you engage in as the clinic to promote water, sanitation, and hygiene?*	● *Who are the other key stakeholders in WASH or organizations do you work with concerning water, sanitation, and hygiene?*
2. What are your experiences with water in the community? *2.1 Where do you get drinking water in the community? (if the answer is not from a safe source [Unprotected dug well; Unprotected spring; Bottled water; Tanker truck; Surface water (e.g. river, pond)] Why don't you use the safe option provided?*	● *What are some of the challenges that you face concerning water in the community?* ● *What do you think can be done about these challenges? What role can you play in overcoming challenges concerning water, sanitation, and hygiene*	● *Has there been a situation when there is no water? If yes what do you do under such circumstances?* ● *How long do you sometimes go without water?* ● *What recommendations would you make to improve the water provision in the community?*
3.What are your experiences with sanitation *3.1 Describe the toilet conditions in the community.*	● *What are the places of defecation for both adults and children? (if they say it's the toilet, ask them if they always use the toilet)*	● *What are some of the challenges that you face with regards to sanitation (places of defecation, the toilet itself; type of toilet, cleanliness of the toilet)*

3.2 Are young children able to use the toilet without support? (If not) where do they go? *3.3 Do children ever urinate/defecate outside the toilet? Where? Why?*	• *What are the experiences of children and the toilets that you have now? If the children are using diapers ask the question below.* • *How and where do you dispose of diapers and garbage? (burn, throw in a pit, bury)* • *Who provided you with the toilet that you have? If it's by external forces, where you consulted on the type of toilet provided?* • *How do you feel about the toilet that you have and why?* • *Do you think the toilet that you have is suitable for children under five? Why? What type of toilet do you think would be suitable for children below the age of five?*	• *How do these challenges affect children below the age of five?* • *Is there a type of toilet or sanitation system that you would recommend for the community and/or children below the age of five other than the flush toilet?* • *What recommendations would you make to improve the toilet situation in the community?*
4 What are your experiences with hygiene *4.1 Do you have a handwashing facility? If not why if yes why* *4.2 Please tell us what the children do about hand washing.*	• *Where do the children wash their hands? Probe:* • *Is the facility near enough?* • *Is there always enough water?* • *Is there always soap?* • *Is it sometimes too crowded?* • *When do the children usually wash their hands* • *Do the children always wash their hands after using the toilet? Why/ why not?* • *Do the children always wash their hands with soap?*	• *What are some of the challenges that you face concerning handwashing?* • *Are there any hygiene problems*
5. Are there any hygiene problems in the community?	• *Please tell me more about handwashing; is it a common practice in this community?* • *Where do people wash their hands* • *Is the facility near enough?* • *Is there always enough water?* • *Is there always soap?*	• *What are some of the challenges that you face concerning handwashing?*

	• *Is it sometimes too crowded?* • *Why do you think handwashing is practiced or not practiced?* • *When do people usually wash their hands* • *Do you always wash your hands with soap?* • *Why do you think it is necessary to have a handwashing facility?* • *Why do you think it is important for people to wash their hands?*	
6. How do children learn about hygiene (family, school, peers, health workers, CCG's).	• *What recommendations would you make to improve the handwashing in the community?* • *Why do you think it is important for children to wash their hands?*	
7. What are the most common health problems presented at the clinic? *7.1 What illnesses are common among children below the age of five?* *7.2 Is there a difference among illnesses for boys and girls?*	• *How frequent are these diseases?* • *In what seasons do they occur?* • *How do you think these diseases are transmitted?* • *How do you try to educate children to prevent these diseases?* • *Do you have any recommendations to improve the teaching of hygiene?*	• *Do you have any recommendations to improve the teaching of hygiene?* • *Are there other diseases that are a problem that is related to inadequate water, poor hygiene and sanitation*
8. Do you think there is a link between inadequate water-poor sanitation poor hygiene and diseases; what are the links? *8.1 Is there a link between inadequate water, poor sanitation, poor hygiene with diarrhoea, and schistosomiasis?*	• *Do you think schistosomiasis is a problem in the community and also among children below the age of five? Why?* • *Do you teach children about schistosomiasis (probe: what do you teach?)* • *Do you have many adults and children below the age of five presenting with symptoms of diarrhea and schistosomiasis in the community?* • *Where do children and parents suffering from schistosomiasis and diarrhea go for*	• *Do you have many people presenting with symptoms of diarrhea or schistosomiasis presenting at the clinics?* • *Are there other diseases that are a problem that is related to inadequate water, poor hygiene, and sanitation in the community?*

	treatment? Which is the preferred place for treatment for both the parent and the child?	● *Do you think WASH-related diseases such as diarrhea and schistosomiasis are recorded/captured appropriately at the clinic level?*
1. Who is responsible for educating people on WASH practices in the community?	● *What role does the primary health entity [sometimes known under local name] play in hygiene promotion?*	● *Do you have any recommendations to make hygiene promotion more effective (health worker; municipality)*
2. Are there any interventions concerning water sanitation and hygiene, implemented in your community? If so please describe them	● *What other recommendations do you have for improving the water, sanitation, and hygiene situation in your community?*	● *How could you get people interested in improving their sanitation and hygiene?*

Psychosocial measuring instrument

PART 1: RISK *(Health Knowledge; Vulnerability and severity)*

1.1 "I will present to you some potential causes of diarrhea. Could you please tell me for each whether it is a cause of diarrhea or not?"

Eating contaminated food 0 □ No 1 □ Yes 9 □ Do not know

Mosquito bite 1 □ No 0 □ Yes 9 □ Do not know

Walking in the sun for a long-distance 1 □ No 0 □ Yes 9 □ Do not know

Drinking contaminated water 0 □ No 1 □ Yes 9 □ Do not know

Vulnerability

1.2 How high or low do you feel is the level of risk your child under the age of five years contracts diarrhea?

-4 □ Very high -2 □ High 0 □ Either high or low 2 □ Low 4 □ Very low

Severity

1.3 Generally, how high do you feel is the risk that you get diarrhea?

0 □ Not severe 1 □ A little severe 2 □ Quite severe 3 □ Severe 4 □ Very severe

PART 2: ATTITUDES (*Feelings; beliefs about costs and benefits towards WASH)*

2.1 How much do you like or dislike using the toilet?

-4□ Very much dislike it -2□dislike it 0□either like or dislike it 2□like it 4□ Very much like it

2.2 How much do you like or dislike cleaning the toilet?

-4□ Very much dislike it -2□dislike it 0□either like or dislike it 2□like it 4□ Very much like it

2.3 How much do you like or dislike going to collect drinking water from an improved source (tap, pump)?

-4□ Very much dislike it -2□dislike it 0□either like or dislike it 2□like it 4□ Very much like it

2.4 How much do you like or dislike cleaning water transportation/storage containers?

-4□ Very much dislike it -2□dislike it 0□either like or dislike it 2□like it 4□ Very much like it

2.5 How much do you like or dislike washing your hands with soap/ash after using the toilet or before handling food.

-4□ Very much dislike it -2□dislike it 0□either like or dislike it 2□like it 4□ Very much like it

3. ***Beliefs about costs and benefits***

3.1 How time-consuming is it for you to build a toilet?

0□Not time-consuming 1□A little time-consuming 2□Quite time-consuming 3□Time-consuming 4□Very time-consuming

3.2 How time-consuming is it for you to clean the toilet?

0□Not time-consuming 1□A little time-consuming 2□Quite time-consuming 3□Time-consuming 4□Very time-consuming

3.3 How time-consuming is it for you to collect drinking water from an improved source (tap or pump)?

□ Not time-consuming □A little time-consuming □ Quite time-consuming □Time-consuming □ Very time-consuming

3.4 How time-consuming is it for you to clean water transportation/storage containers

□ Not time-consuming □A little time-consuming □ Quite time-consuming □Time-consuming □ Very time-consuming

3.5 How time-consuming is it for you to access a handwashing facility to wash your hands after using the toilet and before handling food?

□ Not time-consuming □A little time-consuming □ Quite time-consuming □Time-consuming □ Very time-consuming

4. ***Costs***

4.1How expensive is it for you to build a toilet?

□Not costly□A little costly□ Quite costly □Costly □ Very costly

4.2 How costly are detergents for cleaning the toilets?

□Not costly □ A little costly □ Quite costly □ Costly □ Very costly

4.3 How costly is collecting drinking water from an improved source (tap, pump)

□Not costly □ A little costly □ Quite costly □ Costly □ Very costly

4.4 How costly are cleaning detergents for transportation/storage containers?

□Not costly □ A little costly □ Quite costly □ Costly □ Very costly

4.5 How expensive is it for you to buy soap for handwashing?

□Not costly □ A little costly □ Quite costly □ Costly □ Very costly

5. ***Benefits***

5.1 How certain are you that using a toilet can prevent you from getting diarrhea?

□Not at all certain □ A little certain □Quite certain□Certainly □very certain

5.2How certain are you that cleaning a toilet can prevent you from getting diarrhea

□Not at all certain □ A little certain □Quite certain □Certainly □very certain

5.3How certain are you that collecting drinking water from an improved source (tap; pump) can prevent you from getting diarrhea?

□Not at all certain □ A little certain □Quite certain □Certainly □very certain

5.4How certain are you that cleaning transportation/storage water containers can prevent you from getting diarrhea?

□Not at all certain □ A little certain □Quite certain □Certainly □very certain

5.5 How certain are you that washing your hands with soap can prevent you and your family from getting diarrhea.

□Not at all certain □ A little certain □Quite certain □Certainly □very certain

PART 3: NORMS (*others' behaviors; others'(dis)approval; personal importance; social support; social discourse)*

6.1. How many of your greater family and friends use a toilet?

0□(Almost) nobody (0%) 1□ Less than half of them (25%) 2 □Half of them (50%) 3□More than half of them (75%) 4 □ (Almost) all of them (100%)

6.2 How many of your greater family and friends clean the toilet?

0□(Almost) nobody (0%) 1□ Less than half of them (25%) 2 □Half of them (50%) 3 □More than half of them (75%) 4 □ (Almost) all of them (100%)

6.3 Who is tasked in your greater family and friends with the collection of drinking water from an improved source (tap or pump)? 0□(Almost) nobody (0%) 1□ Less than half of them (25%) 2 □Half of them (50%) 3 □More than half of them (75%) 4 □ (Almost) all of them (100%)

6.4 How many of your greater family and friends are tasked with clean the transportation/storage water containers? 0□(Almost) nobody (0%) 1□ Less than half of them (25%) 2 □Half of them (50%) 3 □More than half of them (75%) 4 □ (Almost) all of them (100%)

6.5 How many people of your greater family and friends are tasked to wash their hands with soap/ash after using a toilet? 0□(Almost) nobody (0%) 1□ Less than half of them (25%) 2 □Half of them (50%) 3 □More than half of them (75%) 4 □ (Almost) all of them (100%)

Others' (dis)approval

7.1 People, who are important in the community e.g the Induna, how much do they promote that people should use a toilet?

4□They disapprove of it much -2 □They disapprove of it 0 □ They either approve or disapprove of it 2 □ They approve of it 4 □ They approve of it much

7.2People who are important in the community e.g the Induma, how much do they promote that people should clean toilets?

4□They disapprove of it much -2 □They disapprove of it 0 □ They either approve or disapprove of it 2 □ They approve of it 4 □ They approve of it much

7.3People who are important in the community e.g the Induma, how much do they promote that people should collect drinking water from a safe source e.g (tap, pump)

4□They disapprove of it much -2 □They disapprove of it 0 □ They either approve or disapprove of it 2 □ They approve of it 4 □ They approve of it much

7.4People who are important in the community e.g the Induma, how much do they promote that people should clean transportation/storage water containers

4□They disapprove of it much -2 □They disapprove of it 0 □ They either approve or disapprove of it 2 □ They approve of it 4 □ They approve of it much

7.5People who are important in the community e.g the Induma, how much do they promote that people should wash their hands after using the toilet and/or before handling food?

Personal importance

8.1 Do you feel a personal obligation to use a toilet?

0□Not obliged 1 □A little obliged 2 □ Quite obliged 3 □ Obliged 4 □ Very obliged

8.2 Do you feel a personal obligation to clean the toilet?

0□Not obliged 1 □A little obliged 2 □ Quite obliged 3 □ Obliged 4 □ Very obliged

8.3 Do you feel a personal obligation to collect drinking water from a safe source (tap, pump)?

0□Not obliged 1 □A little obliged 2 □ Quite obliged 3 □ Obliged 4 □ Very obliged

8.4 Do you feel a personal obligation to clean transportation/storage containers?

0□Not obliged 1 □A little obliged 2 □ Quite obliged 3 □ Obliged 4 □ Very obliged

8.5 Do you feel a personal obligation to wash your hands with soap/ash after using a toilet and/or before handling food?

0□Not obliged 1 □A little obliged 2 □ Quite obliged 3 □ Obliged 4 □ Very obliged

Social support

9.1 How strong does the head of your household support your family in using a toilet?

0□Not at all 1 □ A little 2 □ Quite 3 □ Much 4 □ Very much

9.2 How strong does the head of your household support your family in cleaning the toilet?

0□Not at all 1 □ A little 2 □ Quite 3 □ Much 4 □ Very much

9.3 How strong does the head of your household support your family in collecting water for drinking from a safe source (tap, pump)?

0□Not at all 1 □ A little 2 □ Quite 3 □ Much 4 □ Very much

9.4 How strong does the head of your household support your family in cleaning transportation/storage containers?

0□Not at all 1 □ A little 2 □ Quite 3 □ Much 4 □ Very much

9.5 How strong does the head of your household support your family in washing your hands with soap/ash after using the toilet or before handling food?

0□Not at all 1 □ A little 2 □ Quite 3 □ Much 4 □ Very much

Social discourse

10. 1 How often do you talk about using the toilet with other people?

0□(Almost) never (0%) 1□ Less than half of the times (25%) 2□ Half of the times (50%) 3 □More than half of the times (75%) 4 □ (Almost) always (100%)

10.2 How often do you talk about cleaning the toilet with other people?

0□ (Almost) never (0%) 1□ Less than half of the times (25%) 2□ Half of the times (50%) 3 □More than half of the times (75%) 4 □ (Almost) always (100%)

10.3 How often do you talk about collecting drinking water from a safe source (tap, pump)?

0□ (Almost) never (0%) 1□ Less than half of the times (25%) 2□ Half of the times (50%) 3 □More than half of the times (75%) 4 □ (Almost) always (100%)

10.4 How often do you talk about cleaning transportation/storage water containers?

0□ (Almost) never (0%) 1□ Less than half of the times (25%) 2□ Half of the times (50%) 3 □More than half of the times (75%) 4 □ (Almost) always (100%)

10.5 How often do you talk about washing your hands with soap after using a toilet and/or before handling food?

0□ (Almost) never (0%) 1□ Less than half of the times (25%) 2□ Half of the times (50%) 3 □More than half of the times (75%) 4 □ (Almost) always (100%)

Confidence in performance

12.1 How certain are you that you will always be able to use a toilet?

0□Not at all certain 1□ A little certain 2□Quite certain 3□Certainly 4□very certain

12.2 How certain are you that you will always be able to clean the toilet?

0□Not at all certain 1□ A little certain 2□Quite certain 3□Certainly 4□very certain

12.3 How certain are you that you will always be able to collect drinking water from a safe source (tap, pump)

0□Not at all certain 1□ A little certain 2□Quite certain 3□Certainly 4□very certain

12.4 How certain are you that you will always be able to clean transportation/storage water containers?

0□Not at all certain 1□ A little certain 2□Quite certain 3□Certainly 4□very certain

12.5 How certain are you that you will always wash your hands with soap after using the toilet and/or before handling food?

0□Not at all certain 1□ A little certain 2□Quite certain 3□Certainly 4□very certain

Confidence in continuation

13.1 How confident are you that you will be able to use a toilet even if you do not like doing so at the moment?

-4□Very unconfident -2 □Unconfident 0 □Either confident or unconfident 2□Confident 4 □Very confident

13.2 How confident are you that you will be able to clean a toilet even if you do not like doing so at the moment?

-4□Very unconfident -2 □Unconfident 0 □Either confident or unconfident 2□Confident 4 □Very confident

13.3 How confident are you that you will be able to fetch drinking water from a safe source even if you do not like doing so at the moment?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

13.4 How confident are you that you will be able to clean transportation/storage water containers even if you do not like doing so at the moment?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

13.5 How confident are you that you will be able to wash your hands with soap/ash after using the toilet even if you do not like doing so at the moment?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

Confidence in recovering

14.1 How confident are you that you will be able to continue to use a toilet even when you have forgotten to do this for a while?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

15.2 How confident are you that you will be able to continue cleaning the toilet even when you have forgotten to do this for a while?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

15.3 How confident are you that you will be able to continue fetching drinking water from a safe source even when you have forgotten to do this for a while?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

15.4 How confident are you that you will be able to continue cleaning transportation/storage water containers even when you have forgotten to do this for a while?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

15.5 How confident are you that you will be able to continue washing your hands with soap/ash after using the toilet even when you have forgotten to do this for a while?

-4□Very unconfident -2 □Unconfident 0□Either confident or unconfident 2□Confident 4 □Very confident

PART FIVE: SELF REGULATION: ***(Action planning; Action control; Barrier planning; commitment; habit; intention; behavior)***

16.1 Do you have any plans on how to make sure that you can always use a toilet?

□Yes □ No

If yes: Can you please specify how? ……

16.2 Do you have any plans on how to make sure that you can always clean a toilet?

□Yes □ No

If yes: Can you please specify how? ……

16.3 Do you have any plans on how to make sure that you can always collect drinking water from a safe source?

□Yes □ No

If yes: Can you please specify how? ……

16.4 Do you have any plans on how to make sure that you can always clean transportation/storage water containers?

□Yes □ No

If yes: Can you please specify how? ……

16.5 Do you have any plans on how to make sure that you can always wash your hands with soap/ash after using a toilet and/or before handling food?

□Yes □ No

If yes: Can you please specify how? ……

Action control

17.1 How strongly did you try to remember using a toilet at all times during the last week?

0□Not at all 1□A little 2□Quite 3□Much 4□Very much

18.1 How strongly did you try to remember cleaning a toilet at all times during the last week?

0□Not at all 1□A little 2□Quite 3□Much 4□Very much

19.1 How strongly did you try to remember fetching drinking water from a safe source (tap, pump) during the last week?

0□Not at all 1□A little 2□Quite 3□Much 4□Very much

20.1 How strongly did you try to remember cleaning the transportation/storage containers during the last week?

0□Not at all 1□A little 2□Quite 3□Much 4□Very much

21.1 How strongly did you try to remember washing your hands with soap/ash after using the toilet and/or before handling food during the last week?

0□Not at all 1□A little 2□Quite 3□Much 4□Very much

Barrier to planning

22.1 Do you have a plan on how you can always use a toilet?

□Yes □ No

If yes: Can you please specify how? ……

22.2 Do you have a plan on how you can always clean a toilet?

□Yes □ No

If yes: Can you please specify how? ……

22.3 Do you have a plan on how you can always fetch drinking water from a safe source?

□Yes □ No

If yes: Can you please specify how? ……

22.4 Do you have a plan on how you can always clean transportation/storage containers?

□Yes □ No

If yes: Can you please specify how? ……

22.5 Do you have a plan on how you can always wash your hands with soap/ash after using a toilet and/or before handling food?

□Yes □ No

If yes: Can you please specify how? ……

Commitment

23.1 How much do you feel committed to using a toilet?

0 □Not committed 1□A little committed 2 □ Quite committed 3 □ Committed 4□ Very committed

23.2 How much do you feel committed to cleaning the toilet?

0 □Not committed 1□A little committed 2 □ Quite committed 3 □ Committed 4□ Very committed

23.3 How much do you feel committed to collecting drinking water from an improved source?

0 □Not committed 1□A little committed 2 □ Quite committed 3 □ Committed 4□ Very committed

23.4 How much do you feel committed to cleaning the transportation/storage water containers?

0 □Not committed 1□A little committed 2 □ Quite committed 3 □ Committed 4□ Very committed

23.5 How much do you feel committed to washing your hands with soap/ash after using a toilet and/or before handling food?

0 □Not committed 1□A little committed 2 □ Quite committed 3 □ Committed 4□ Very committed

Intention

24. 1 How strongly do you intend to always use a toilet?

0 □Not at all 1 □ A little 2 □ Quite 3 □Much 4 □Very much

24.2 How strongly do you intend to always clean the toilet?

0 □Not at all 1 □ A little 2 □ Quite 3 □Much 4 □Very much

24.3 How strongly do you intend to always collect drinking water from a safe source (tap, pump)

0 □Not at all 1 □ A little 2 □ Quite 3 □Much 4 □Very much

24. 4 How strongly do you intend to always clean transportation/storage water containers?

0 □Not at all 1 □ A little 2 □ Quite 3 □Much 4 □Very much

24.5 How strongly do you intend to always wash your hands with soap/ash after using the toilet and/or before handling food?

0 □Not at all 1 □ A little 2 □ Quite 3 □Much 4 □Very much

Habit

25.1 How much do you use the toilet automatically without having to think about it a lot?

0 □Not habitually 1□ A little habitually 2 □ Quite habitually 3 □ Habitually 4 □ Very habitually

25.2 How much do you have to clean the toilet automatically without having to think about it a lot?

0 □Not habitually 1□ A little habitually 2 □ Quite habitually 3 □ Habitually 4 □ Very habitually

25.3 How much do you have to collect drinking water from a safe source (tap, pump) without having to think about it a lot?

0 □Not habitually 1□ A little habitually 2 □ Quite habitually 3 □ Habitually 4 □ Very habitually

25.4 How much do you have to clean transportation/storage water containers without having to think about it a lot?

0 □Not habitually 1□ A little habitually 2 □ Quite habitually 3 □ Habitually 4 □ Very habitually

25.5 How much do you have to wash your hands with soap/ash after using a toilet and/or before handling food without having to think about it a lot?

0 □Not habitually 1□ A little habitually 2 □ Quite habitually 3 □ Habitually 4 □ Very habitually