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**Examining the Cross-Sectional Relationship Between Women's Empowerment, Water Treatment,
and Childhood Health Outcomes in Zambia**

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and Childhood Health Outcomes in Zambia**

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B.S.
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Abstract

Examining the Cross-Sectional Relationship Between Women's Empowerment, Water Treatment, and Childhood Health Outcomes in Zambia

By Christiana M. Hug

Poor water sanitation, and hygiene (WASH) is a major contributor of diarrheal disease, which has resulted in the death of 12% children under the age of five in Zambia in 2019. Women's empowerment may be linked to childhood health outcomes. The purpose of this study is to understand the relationship between women's empowerment, safe water treatment methods and children's diarrhea.

We used Zambia 2018-2019 Demographic and health survey (DHS) datasets to examine the relationship between women's empowerment and use of safe water treatment methods and diarrhea. The Survey-based Women's EmPOWERment index (SWPER) was used to measure empowerment using three separate domains; attitudes towards violence, participation indecision making, and social independence. Values of 0-2 were assigned based on responses to a given variable, and final scores for each domain ranged between -1.5 and 1.5. The direct relationships between empowerment, safe water treatment, and children's diarrhea were then calculated using logistic regression.

The final sample consisted of 3151 women. 72% of respondents were from urban areas, 28% were from rural areas, 31% used safe water treatment, and 12% of children reported having diarrhea within 2 weeks of interview. The mean overall score was highest for participation in decision making domain at 0.34 and lowest for attitude towards violence at -0.997. Social independence was most positively associated with increased use of safe water treatment (AOR=1.5), and with children's diarrhea (AOR=1.3) Attitude towards violence and participation in decision making were not found to be strongly associated with either outcome.

The results of this study are in agreement with existing literature and suggest that social independence is associated with use of safe water treatment and diarrhea. More research using the SWPER index to measure empowerment and other WASH related variables is needed to fully understand the relationship between women's empowerment and WASH in Zambia.

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1. Introduction

1.1 Background

Diarrheal diseases in 2019 were the cause of 9.92% of deaths in children under five globally and are the leading cause of malnutrition in children [1, 2]. Water, sanitation, and hygiene (WASH) and repeated diarrheal infections have been linked to stunting and effects on early childhood development including impairment of cardiovascular, motor, and cognitive deficiencies. These impairments are a result of repeated enteric infections causing environmental enteric dysfunction, which is defined as a decreased ability of the intestines to absorb nutrients [3-7]. The role of women as caretakers and in household chores has long meant that women's health and behavior is pivotal to the health of their children [8].

In Zambia, poor WASH is a major contributor to the transmission of diarrheal diseases. In 2019, diarrheal diseases accounted for 11.9% of deaths in children under five [1]. This may be in part due to the fact that 64% of the population uses basic drinking water services, only 33% use basic sanitation services, 10% practice open defecation, and only 24% have access to basic hygiene services. Furthermore, there is significant gender inequality in Zambia [1]. Less than 31% of women have completed primary school and even fewer (8%) have completed secondary school [9]. Discrimination against women has affected women's employment, health, ownership of assets, and general control over their lives [10]. Given the role of women in children's health and development, it is important to understand the relationship that women have with safe wash behaviors and how this impacts children's health [11].

1.2 WASH and Empowerment

Gender and development research has long identified the importance of the role of women in communities but the impact that women's empowerment may have on WASH-related behaviors and outcomes is not yet well understood [8]. One particular scoping review sought to evaluate the existing literature on WASH and women's empowerment and only identified 13 relevant studies. Based on these studies, the researchers concluded that empowerment is dynamic in that it influences how women interact with resources and WASH practices [12]. This is evident through the array of studies that have measured empowerment as either an exposure for utilization of safe WASH or as an outcome of safe WASH programs [13, 14]. Concept mapping of the relationships between WASH and empowerment has called for more research in both areas of how empowerment leads to use of WASH, and how access to WASH improves empowerment. [15].

1.3 Empowerment and Children's Health

Additionally, there is some evidence suggesting that women's empowerment may have an impact on and children's health. Several studies have focused specifically on the links between women's empowerment and childhood health outcomes, but only a few have made specific links between women's empowerment and WASH [14, 16-21]. For example, in Nepal, improved WASH was found as a mediator between the women's empowerment and childhood stunting [14]. Similarly, in a study on determinants of childhood diarrhea in Bolivia, a reduction in childhood diarrhea was associated with a higher ability of women to make decisions [21]. However, literature regarding empowerment and WASH is minimal and more systematic approaches are needed to measure their relationship [15].

1.4 Measuring Empowerment

Since measuring women's empowerment has only more recently become a public health practice, there is minimal consistency in the methodology used to measure empowerment. Some papers define empowerment as an overarching term to describe a collection of maternal characteristics including education; occupation; wealth; and assets. Others focus on how women's education impacts their life, and yet other studies measure a combination of women's communication with her spouse, decision making, and family planning [17, 18, 20]. Secondary analysis studies using Demographic and Health Survey (DHS) data have similarly used a variety of methods to measure and define empowerment [22-26]. Some researchers have sought to develop more systematic methods for measuring empowerment in specific sectors. The Women's Empowerment in Agriculture Index (WEAI) seeks to measure women's empowerment, agency, and inclusion in agriculture while other researchers have recently released the Empowerment in WASH Index (EWI) through concept mapping of important empowerment dimensions and their relationship to WASH [15, 27, 28].

Other researchers have focused more specifically on leveraging population level data to understand women's empowerment. In recent years, a group of researchers has developed and validated the Survey-based Women's EmPowERment index (SWPER) for measuring women's empowerment in Africa using DHS data. The index incorporates 15 different items to make up three domains of empowerment; women's attitude towards violence, decision making, and social independence (education, age at first childbirth, employment, etc.) [29]. The empowerment scores were compared to the Gender Development Index in order to validate the index and a high correlation between the studies was observed.

No existing published studies have used this index to measure empowerment and WASH but some studies have measured empowerment and childhood outcomes. One study used the SWPER index to measure the relationship between mothers' empowerment and early childhood development across 26 countries in Africa, and found a positive relationship between empowerment domains, particularly mothers' social independence domain, and child literacy-numeracy, but little relationship between mothers empowerment and children's physical and emotional development [23]. Another study in South-Central Asia used the index and found that social independence and decision making may be important when addressing childhood nutrition [30].

1.5 Study Purpose

This study will use the SWPER Index to 1) assess the relationships between women's empowerment scores in the three domains (attitude towards violence, decision making, and social independence) and use of safe water treatment; 2) assess the relationship between women's empowerment and childhood diarrhea; and 3) based on the results of the first two aims, we will test for possible mediation of water treatment along the pathway between empowerment and childhood diarrhea. We hypothesize that as empowerment scores increase in value, indicating greater empowerment, use of safe water treatment will increase, and children's diarrhea will decrease.

2. Methods

2.1 Study Design, Dataset, and Participants

This study is a secondary analysis of data from a cross-sectional survey that was carried out in Zambia. Specifically, this study uses publicly available data from the 2018-2019 Zambia

Demographic and Health Survey (ZDHS). The ZDHS researchers employed a stratified two-stage sample design. In the first stage, 545 clusters were selected across the whole country. Each cluster was made up of enumeration areas (EA) with each EA consisting of approximately 110 households. The second stage used systematic sampling of 25 households per cluster for a total sample of 13,625 households. All women aged 15-49 and men 15-59 who were residents of the household or stayed in the home the night before were eligible to participate [31].

The ZDHS data files used in this study were the household, individual, and children's files. The household data file includes information pertaining to basic demographic and household characteristics. The individual data file contains information collected as a part of the women's questionnaire pertaining to women's education, female health, women's attitudes and perceptions towards health issues, and women's empowerment. The children's file contains information pertaining to childhood health outcomes and treatments [31]. Women were included in this analysis if they were over the age of 15, participated in the Zambian DHS women's questionnaire, and had non-missing values for all variables were included in this study.

2.2 Setting

According to the 2018-2019 ZDHS final report, 78% of households in Zambia have access to an improved water sources with 92% of urban households having access but only 58% of rural households having access to an improved water source. Furthermore, only 54% of urban households and 22% of rural households use an appropriate method to treat their water (boil, bleach, filter, solar disinfection). 60% of females over the age of six across Zambia have no education or only some primary education. Mothers reported that 15% of children under the age of 5 had a diarrhea within 2 weeks prior to the survey. The prevalence of diarrhea among children

using an unimproved water source is 17% and among children using an improved water source is 14%. Higher wealth quintile was found to be associated with an increased likelihood for using an improved water source or achieving a higher level of education, and a decreased likelihood for childhood diarrhea[31].

Overall, 57% of married women reported making decisions alone or with their partner. Women who were employed for cash were found to be more likely to participate in decision making (61%) than women who were not employed (56%). Similarly, women who had achieved a higher education status were more likely to participate in decision making. The ZDHS report also found that 1/3 of all women who participated in the survey had experienced violence at least once in their life and 18% had experienced violence within the past 12 months. Furthermore, ever experiencing domestic violence was more common in rural areas (37%) than urban areas (34%) and among women who work for cash (40%) than women who are unemployed (30%). Overall, 46% of women were found to believe that beating is justified for at least one reason (arguing, neglecting children, refusing sex etc.)[31].

2.3 Variables

The primary outcome of interest in this study is use of safe water treatment. We defined a respondent as using 'safe water treatment' if they reported using bleach/chlorine, boil, filter, or solar disinfection (SODIS) methods to treat their water. A respondent was labeled as not using safe water treatment methods if they reported using strain, stand, other, or nothing done.

The secondary outcome of interest was childhood diarrhea within the two weeks prior to interview. This included children under the age of five whose mother completed the women's survey.

The exposure variable of interest are women's empowerment scores. This variable was calculated using the SWPER Index guidelines. The SWPER Index is a tool created for using DHS data to measure women's empowerment and verified for the majority of countries in Africa [32]. The index is made up of 15 variables related to three separate domains: attitudes towards domestic violence, women's decision making, and women's social independence and can be viewed in table S5 in the appendix. Standard variable coefficients calculated in the SWPER study were used to calculate the final decision making, independence, and attitude towards violence scores. Variable coefficients can be found in table S6 in the appendix and all instructions from the SWPER study supplementary index were followed [32]. Scores range between -1.5 and 1.5 [32]. Scores of zero indicate that the empowerment level is average in comparison to the data from low- and middle-income countries used to create the standardized index. A negative score indicates that the empowerment level is lower or worse than the average, and a positive score indicates that the empowerment level is higher or better than average.

Since 2.4% of women did not have a child at time of the interview, missing values for the age at first birth variable were imputed using a single hot-deck imputation and clustered in groups of age at first cohabitation as suggested in the SWPER index guidelines [32]. Although women without children were excluded from the sample for the analysis, the imputation step was completed to account for any women that may care for a child but may not have given birth to that child. Because several of the SWPER questions were asked only of women in union, we restricted the sample to this group. Respondents with missing data for all other variables were excluded from the analysis [23, 32].

To address bias in the development of the model, existing literature was reviewed to inform and justify inclusion of covariates. The covariates of wealth, place of residence, type of water

source, and education will therefore be tested for confounding and controlled for in the final model. In this study, wealth was measured by using an asset index of which residents reported if they owned or did not own nine different items including radios, cars, and televisions. Scores for this variable ranged between zero and nine and were derived based on how many each respondent's household owned. Place of residence was measured by whether the respondent reported living in a rural or urban area. Type of water source was measured by if the respondent used an improved or unimproved water source. Improved and unimproved water sources were defined based on WHO standards [33]. Lastly education was measured by whether respondents had completed either less than secondary education, or at least secondary education.

2.4 Analysis

Weighted frequencies will be reported to convey descriptive characteristics of the sample with complete covariate data contributing to the analysis. Descriptive statistics will be reported for both outcome variables (water treatment and diarrhea) as well as the three empowerment domains and covariates including assets, type of water source and maternal level of education. Survey weights will be used in the analysis to generate estimates from survey samples that are representative of the target population by accounting for non-response and differential sampling like under or over sampling [34].

The relationship between women's empowerment and safe water treatment will be assessed using logistic regression. Both the unadjusted and adjusted frequencies will be reported to demonstrate the crude and adjusted associations between each variable and safe water treatment. The analysis will also be stratified by women living in rural and urban areas to determine any differences between these regions. Next, we will conduct a similar analysis on the direct

association between women's empowerment domains and childhood diarrhea and again will report unadjusted and adjusted associations for rural and urban residents, and the full sample.

Lastly, use of safe water treatment will be tested as a mediator between women's empowerment domains and childhood diarrhea, however, if no consistent relationship is found between empowerment domains and cases of diarrhea, then safe water treatment then we will not tested as a mediator. The proposed relationship can be viewed in the simplified model in Figure 1. Both descriptive and regression analysis will be conducted using SAS 9.4 software.

3. Results

3.1 Descriptive Analysis

The observed sample with complete data consisted of 3151 women in union, between the ages of 15 and 40, who had a child under the age of five. 9.3% of women sampled, and 12% of women who completed the women's questionnaire were included in this analysis. The population of women living in urban areas (n=2282; 72.4%) was much larger than the population of women living in rural areas (n=869; 27.6%). Women in rural areas were more likely to report using safe water treatment (n=439; 52.1%) compared to 20.8% (n=475) of women living in urban areas and the full sample (n=914 31.4%). Furthermore, 11.6% (n=352) of children in the overall sample were reported to experience diarrhea in the 24 hours or 2 weeks prior to interview and was similar in both urban (n=243; 11.1%) and rural (n=109; 12.5%) areas (Table 1).

In the full sample, the majority of women generally reported having less than three assets (n=1818; 54.1%). When stratified by rural vs urban, 67.7% (n=1545) of women living in urban areas had less than three assets, while only 27.6% (n=274) of women in rural areas had less than three assets (Table 1). Women in rural areas were also more likely to have completed at least

secondary education (n=526; 62.6%) compared to women in urban areas (n=513; 21.8%) and the full sample (n=1039; 35.6%).

For empowerment scores, the weighted mean scores for attitude towards violence in the overall sample was -0.997, which suggests that the women in Zambia overall scored lower than average compared to the standard for 28 countries in Africa. When stratified by rural and urban, attitude towards violence was lower among women living in rural areas (-1.326) compared to women in urban areas (-0.828) suggesting women in rural areas justify violence more than women in urban areas. For the participation in decision making domain, the overall score was 0.304, which is slightly above average compared to other countries. Women in rural areas scored slightly higher (0.345) than women in urban areas (0.282) suggesting greater participation in decision making in rural areas. Social independence in the overall sample was 0.073 which suggests social independence was generally very close to average compared to other countries. When stratified by rural in urban, women in rural areas scored higher (0.43) than women in urban areas (-0.111) suggesting greater social independence in rural areas (Table 1).

3.2 Relationship between Empowerment Domains and Safe Water Treatment

Attitude towards violence score was found to be negatively associated with safe water treatment in rural areas [AOR=0.7; 95% CI: 0.6, 0.9] and the full sample [AOR=0.9; 95% CI: 0.8, 1.0], but was not associated with safe water treatment in urban areas [AOR=1.0; 95% CI: 0.9, 1.2] (Table 2). The negative association between attitude towards violence and use of safe water treatment suggests that as attitude towards violence score increases (participants justify violence less), use of safe water treatment decreases. Participation in decision making was found to have no significant association with odds of safe water treatment in the overall sample [AOR=1.0 95%

CI: 0.9, 1.2]. In rural areas the odds were similarly found to be insignificant [AOR=1.0; 95% CI: 0.9, 1.3] as well as in urban areas [AOR=1.0; 95% CI: 0.9, 1.1]. Social independence appeared to have the greatest association with use of safe water treatment [AOR= 1.5; 95% CI: 1.3, 1.8]. Social independence was found to be significant and positively associated with safe water treatment in both urban [AOR=1.5; 95% CI: 1.2, 1.8] and rural areas [AOR=1.3; 95% CI: 1.0, 1.6], but the association was greater among women in urban areas. The positive association suggests that as social independence scores increase, the odds of using safe water treatment also increase.

The association between safe water treatment and other covariates were also measured in this analysis. For example, use of safe water treatment appeared to increase with an increase in ownership of assets. The adjusted odds of safe water treatment among women with three to four assets was 2.0 [95% CI: 1.6, 2.6] and among women with five or more assets was 3.4 [95% CI: 2.4, 4.8] (Table 2). Among women living in rural areas with three to four assets, the adjusted odds of safe water treatment were 1.5 [95% CI: 0.8, 2.6] and among women with five or more assets, the adjusted odds of safe water treatment were 2.2 [95% CI: 1.3, 3.9]. The odds of safe water treatment in urban areas was slightly higher than women living in rural areas but similarly increased as the number of assets owned increased [3-4 Assets: AOR = 1.6 ;95% CI: 1.3, 2.0]; [5 or more assets: AOR 2.4; 95% CI: 1.6, 3.7]. Furthermore, women who had obtained at least secondary education at the time of interview were more likely to use safe water treatment [AOR= 1.6; 95% CI: 1.3, 1.9]. Among women living in rural areas, the relationship between education and safe water treatment was found to be insignificant [AOR= 1.0; 95% CI: 0.7, 1.4]. In urban areas, safe water treatment was found to significantly increase as level of education increased [OR=1.9; 95% CI=1.4, 2.5] and [AOR=1.6; 95% CI: 1.2, 2.1]. Lastly, the odds of safe water treatment were found to be negatively associated with use of an unimproved water source across the sample [AOR= 0.5;

95% CI= 0.5, 0.8]. In rural areas, odds of safe water treatment were found to be negative but insignificant [AOR= 0.7; 95% CI: 0.4, 1.5]. In urban areas, the odds of safe water treatment were significant in the unadjusted model [OR= 0.7; 95% CI: 0.6, 1.0], and insignificant in the adjusted model [AOR= 0.8; 95% CI: 0.6, 1.1].

3.3 Relationship between Empowerment Domains and Child Diarrhea

For childhood diarrhea within two weeks of the interview, most of the results were found to be insignificant in the full sample as well as when stratified by women living in rural and urban areas (Table 3). The odds of childhood diarrhea were found to increase as attitude towards violence score increased but was overall insignificant [AOR=1.1; 95% CI: 1.0, 1.3]. When stratified by rural and urban, the association between odds of children's diarrhea and attitudes towards violence was positive and significant [AOR=1.2; 95% CI: 1.1, 1.4] suggesting that cases of children's diarrhea increase as women's attitude towards violence improves (is less justified). There was little to no association between children's diarrhea and attitude towards violence in rural areas [AOR=1.0; 95% CI: 0.7, 1.3]. Participation in decision making was found to have no significant association with odds of children's diarrhea in the full sample [AOR=1.0; 95% CI: 0.9, 1.2], rural areas [AOR=0.9; 95% CI: 0.7, 1.2], nor urban areas [AOR=1.1; 95% CI: 1.0, 1.3]. Social independence appeared to have the greatest association with cases of childhood diarrhea [AOR=1.306; 95% CI: 1.03, 1.6]. Little to no association was found in urban areas [AOR=1.0; 95% CI: 0.8, 1.3], but in rural areas, the odds of childhood diarrhea increased as social independence score increased [AOR=1.6; 95% CI: 1.2, 2.3].

For other variables in the model, adjusted odds of diarrhea in the full sample decreased from 1.0 [95% CI: 0.7, 1.4] among women with 3-4 assets to 0.9 [95% CI: 0.45, 1.6] among women

with 5 or more assets, but were overall insignificant. When stratified by urban and rural, the odds of diarrhea similarly decreased as the number of assets increased, but were overall insignificant (Table 3). Furthermore, the adjusted odds of children experiencing diarrhea among mothers who had completed at least secondary education were 1.3 [95% CI: 0.9, 1.8], but were also insignificant. In urban areas, there seems to be little to no association of education with childhood diarrhea in the adjusted model [AOR= 0.8; 95% CI: 0.5, 1.2], but in rural areas, the odds of diarrhea appear to significantly increase as education increases [AOR=2.6; 95% CI: 1.5, 4.5]. Lastly, the adjusted odds of childhood diarrhea among women using an unimproved water source were 1.1 [95% CI: 0.8, 1.5]. In urban areas, the adjusted odds were found to be positive but insignificant [AOR=1.1; 95% CI: 0.8, 1.4]. In rural areas, the odds of childhood diarrhea increased slightly with use of an unimproved water source [AOR= 1.1; 95% CI: 0.5, 2.4] but was found to be insignificant.

3.4 Mediation Analysis

Since the association between empowerment scores and childhood diarrhea were somewhat inconclusive, this study did not qualify for mediation analysis because no clear direct association can be drawn between women's empowerment and diarrhea.

4. Discussion

4.1 Empowerment and Safe Water Treatment

In rural and urban communities, the weighted score for empowerment was lowest for the attitude towards violence domain suggesting that women in rural Zambia scored very low on the attitude towards violence scale and tend to justify violence. In rural areas, negative attitudes towards violence was also associated with a lower likelihood of using safe water treatment but no association was found in urban areas. Therefore, improving attitudes towards violence in rural

areas may have the potential to impact the use of safe water treatment, but more research should be conducted to understand this relationship. Although there is limited evidence connecting women's attitude towards violence to WASH, evidence suggests that attitudes towards violence is associated with improved health decisions including increased likelihood of attending antenatal care and vaccination of children [35-38].

Social independence score was found to be higher among women living in rural areas, but had a greater association with use of safe water treatment in urban areas. This may be due to relative availability of resources in urban areas compared to rural that make it easier for women in urban areas to treat their water, however more research on this contextual evidence is needed to fully explain why social independence has a greater influence in urban areas. In this analysis, the social independence domain consisted of variables related to educational attainment, employment state, family planning, and literacy. Some studies have found women with higher capacity for knowledge of risks are more likely to engage in safe behaviors [39]. Furthermore, some studies have found that education is significantly linked with higher rates of children being vaccinated and care seeking for acute respiratory infections [40].

Participation in decision making was not associated with safe water treatment in this analysis. Women in rural areas overall scored higher in the decision making domain, but the odds ratios for decision making and safe water treatment were found to be insignificant. This is surprising since women are generally in charge of household duties, which may include collection and treatment of water and therefore likely the decisions surrounding water treatment. Furthermore, this differs from the relationship of other aspects of WASH and women's participation in decision making. For example, in Brazil, evidence suggests that women with greater decision making power are more likely to choose safer water sources for drinking water

and in Bangladesh, women with greater decision making power are more likely to own WASH resources like toilets and yet other studies have found decision making power to be associated with improved WASH program outcomes [41-43]

4.2 Empowerment and Childhood Diarrhea

Overall, mothers' empowerment scores for each of the three domains were found to have little to no impact on childhood diarrhea within two weeks prior to survey interview or have an opposite association from what was expected and differs from existing literature. Our a priori hypothesis was that childhood diarrhea would decrease as empowerment domain scores increase, but attitude towards violence was positively associated with diarrhea in urban areas, and social independence was positively associated with diarrhea in rural areas. This contradicts existing literature suggesting positive associations between women's empowerment indicators and children's health [44, 45]. Furthermore, studies in Bolivia and Indonesia show maternal empowerment indicators to be protective of children's diarrhea [21, 46]. The negative association found in this analysis may therefore indicate that there are other variables, confounders, or effect modifiers that may explain the relationship between mothers' social independence and childhood diarrhea in rural areas. The complex nature of enteric diseases and the existence of multiple pathways for exposure to enteric pathogens may explain why the results did not support our hypothesis [47-49]. For example, children may become infected with an enteric pathogen from other sources that may be beyond the scope or difficult for a mother to fully prevent including playing with contaminated soil, water, or animals.

Children's diarrhea has also been found to be associated with a number of other important factors including vaccination status, distance to health care facility, and mothers handwashing

practices which were not controlled for in this analysis [50]. Furthermore, diarrhea is not necessarily the best measure or indicator of pathogen infection because not all gastrointestinal infections result in diarrhea, and some children may be asymptomatic [51]. Therefore, further research in this area should include using biological samples to measure child's gastrointestinal health, rather than cases of diarrhea or consider using children's length for age z-score since this can be an indicator of repeated enteric infections or environmental enteric dysfunction [14].

4.3 Population Characteristics

In both rural and urban communities and the full sample, the odds of safe water treatment were negatively associated with women using an unimproved water source. This may be because women living in areas where they must use an unimproved water source may also generally have lower access to resources including tools necessary for treating water. Women using an unimproved water source may also spend more time collecting water or completing other household duties that limits the amount of time they have to treat their water [52]. It is possible that some women using improved water sources may still treat their water if the methods used for storage are not considered safe, which may have affected these findings as well, and is the reasoning for why women using an improved water source were not excluded from the sample originally.

The differences in water access and water treatment between rural and urban communities may be accounted for by the differences in lifestyle and infrastructure. For example, the Kanyama slum outside of Lusaka is characterized by extreme poverty, which may account for the high percentage of people using an unimproved water source (45.39%) compared to only 8.56% of people in rural areas [53]. The evidence from this analysis is consistent with other research that

found that 40% of the Kanyama slum relies on shallow wells, an unimproved water source, for their drinking water [54]. Since this analysis included all urban residents, further research on empowerment specifically in urban Zambian slums may provide more detailed information on this population.

4.4 Strengths and Limitations

The use of a DHS data and the completeness of data on these variables used in this study is an important strength of this study. The use of the SWPER Empowerment Index which has specifically been validated for use in most African countries including Zambia verifies the relevance of variables used to measure empowerment. Some limitations are that this DHS Survey is missing some contextual information that might have informed additional confounders and covariates that may influence use of water treatment. For example, availability of resources used to treat water, cultural context, and type of water storage method may all impact use of water treatment. Another limitation of this study is that we were not able to restrict the sample to people using an unimproved water source since the sample size would be too small. Exclusion of this criteria may have affected the overall relationship between score and treatment of water since people using an improved water source may be less likely to treat their water regardless of empowerment score. Ultimately, other research informed us that use of an improved water source does not necessarily indicate safety of the water if the storage or transportation of the water allows for contamination, suggesting that at least some women may treat their water if they are using an improved water source. Furthermore, the sample was restricted to only women in union because several of the SWPER questions were asked only of married women. Respondents with missing data for all other variables were also excluded from the analysis which further restricted the

sample. Lastly, DHS data is cross-sectional, and therefore it is difficult to draw any causal inferences from these results.

4.5 Next Steps

There is existing literature in India that suggests women must manage gendered challenges when using sanitation [55]. However, the DHS survey only asks about sanitation access, and not sanitation use and preferences. While sanitation access is often used as a proxy for measuring use, it is not an ideal measure. Therefore, it may be interesting to conduct further research on the relationship between women's empowerment using the SWEPR index and use of sanitation through further studies. Some studies have also begun to study interventions geared towards improving maternal agency and determine their impacts on children's health and the results of this study could be used similarly [50].

5. Conclusion

Overall, the results of this study suggest that empowerment scores for social independence may be associated with use of water treatment, especially in urban communities. In rural areas, attitude towards violence may be associated with safe water treatment and may be associated with diarrhea cases in urban areas. Participation in decision making was found to have little association with use of water treatment or cases of diarrhea in any setting. Since little to no associations were found between empowerment domains and children's diarrhea this study did not qualify for a mediation analysis. Some of these results may be explained by differences between urban and rural communities, specific challenges faced by individuals living in the Kanyama slum, and the limited value of using childhood diarrhea to measure childhood gastrointestinal infection. More research on the cultural context in Zambia or within specific regions may help to further explain these

results. As a secondary analysis using widely available DHS data, this study serves as an example to how others may utilize this empowerment index to measure health outcomes and may be beneficial for understanding broad population dynamics.

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Tables and Figures

Figure 1: Proposed relationship between women's empowerment domains, use of safe water treatment, children's diarrhea, and covariates.

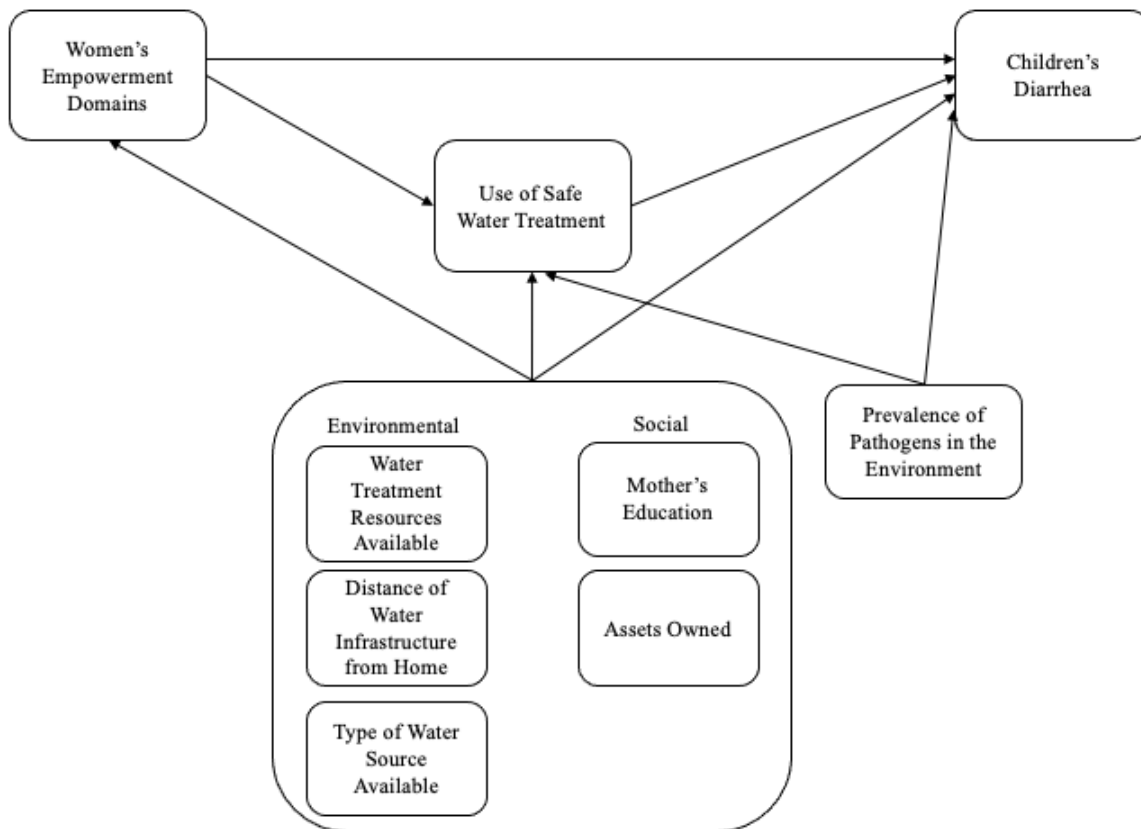


Table 1: Characteristics of women in union who participated in the 2018-2019 Zambia Demographic and Health Survey and included in this analysis from (n= 3151)

Characteristic	Rural		Urban		Total	
	Weighted n	Weighted %/Mean and 95% CI	Weighted n	Weighted %/Mean and 95% CI	Weighted n	Weighted %/Mean and 95% CI
Total (n)	869	-	2282	-	3151	-
Clusters (n)	192		346	-	538	-
Assets owned¹ (%)						
0-2 assets	274	27.41 (22.0, 32.8)	1545	67.74 (65.0, 70.5)	1819	54.1 (51.4, 56.8)
3-4 assets	284	35.20 (30.6, 39.8)	625	27.61 (25.1, 30.1)	909	30.1 (27.9, 32.4)
5 or more	311	37.39 (31.5, 43.3)	112	4.65 (3.4, 5.9)	423	15.72 (13.3, 18.1)
Education Level Completed (%)						
Less than secondary education	343	37.36 (32.0, 42.8)	1769	78.24 (75.8, 80.7)	2112	64.4 (61.6, 67.2)
At least secondary education	526	62.64 (57.2, 68.0)	513	21.76 (19.3, 24.2)	1039	35.59 (32.8, 38.4)
Type of water source (%)						
Improved ³	770	91.44 (88.6, 94.3)	1210	54.6 (50.4, 58.8)	1980	67.07 (63.7, 70.5)
Unimproved ⁴	99	8.56 (5.7, 11.4)	1072	45.39 (41.2, 49.6)	1171	32.93 (29.5, 36.3)
Water Treatment² (%)						
Use of any type of water treatment ⁵	444	53.04 (46.2, 59.9)	485	21.19 (18.9, 23.5)	929	31.97 (29.4, 34.6)
Uses safe water treatment ⁶	439	52.14 (45.4, 58.9)	475	20.76 (18.5, 23.1)	914	31.37 (28.8, 34.0)
Children's Diarrhea⁷ (%)						
Child experienced diarrhea	109	12.47 (9.5, 15.4)	243	11.14 (9.5, 12.7)	352	11.59 (10.1, 13.0)
Child did not experience diarrhea	760	87.53 (84.6, 90.5)	2039	88.86 (87.3, 90.5)	2799	88.41 (87.0, 89.9)
Empowerment Scores (mean)						
Attitude towards violence	869	-1.326 (-1.41, -1.24)	2282	-0.828 (-0.90, -0.76)	3151	-0.997 (-1.05, -0.94)
Participation in Decision Making	869	0.345 (0.23, 0.46)	2282	0.282 (0.22, 0.35)	3151	0.304 (0.25, 0.36)
Social Independence	869	0.43 (0.34, 0.52)	2282	-0.111 (-0.15, -0.07)	3151	0.073 (0.03, 0.12)

(1) Assets measured include electricity, radio, television, refrigerator, bicycle, motorcycle, car, and bed-net; (2) Respondents may select more than one type of water treatment method; (3) An improved drinking water source defined piped household water connection, public standpipe, borehole, protected dug well, protected spring, or rainwater collection; (4) An unimproved drinking water source defined as unprotected dug well, unprotected spring, surface water, vendor-provided water, bottled water, or tanker truck. (5) Represents if respondents reported use of any type of water treatment method; (6) Safe water treatment= boil, bleach, solar, or filter. (7) Includes if children experienced diarrhea 24 hours or 2 weeks prior to interview. CI, Confidence Interval

Table 2: Examining the relationship between variables and safe treatment of water among women in union who participated in the 2019-2019 Zambia DHS Survey Women's Questionnaire.

Characteristic	Rural			Urban			Total		
	n	Unadjusted OR and 95% CI	Fully Adjusted OR and 95% CI	n	Unadjusted OR and 95% CI	Fully Adjusted OR and 95% CI	n	Unadjusted OR and 95% CI	Fully Adjusted OR and 95% CI
Total (n)	869	-	-	2282	-	-	3151	-	-
Assets owned¹ (%)									
0-2 assets		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)
3-4 assets		1.518 (0.86, 2.69)	1.476 (0.82, 2.64)		2.109 (1.57, 2.81)	1.965 (1.49, 2.60)		2.356 (1.84, 3.02)	2.008 (1.57, 2.57)
5 or more assets		2.314 (1.39, 3.86)	2.230 (1.28, 3.88)		2.781 (1.65, 4.70)	2.212 (1.30, 3.78)		4.99 (3.62, 6.87)	3.358 (2.36, 4.77)
Education level Completed									
Less than secondary		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)
At least secondary		1.271 (0.89, 1.82)	0.988 (0.69, 1.42)		1.901 (1.43, 2.52)	1.60 (1.22, 2.11)		2.508 (2.05, 3.07)	1.566 (1.27, 1.94)
Type of water source (%)									
Improved ³		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)
Unimproved ⁴		0.587 (0.30, 1.15)	0.716 (0.35, 1.48)		0.747 (0.57, 0.98)	0.833 (0.63, 1.11)		0.430 (0.34, 0.55)	0.522 (0.48, 0.81)
Empowerment Scores									
Attitude towards violence		0.670 (0.56, 0.80)	0.720 (0.60, 0.87)		0.979 (0.86, 1.09)	1.024 (0.91, 1.15)		0.760 (0.69, 0.83)	0.90 (0.82, 0.99)
Participation in Decision Making		1.027 (0.84, 1.25)	1.043 (0.85, 1.27)		0.979 (0.85, 1.13)	0.982 (0.85, 1.13)		1.021 (0.93, 1.13)	1.038 (0.93, 1.16)
Social Independence		1.381 (1.09, 1.75)	1.264 (1.01, 1.58)		1.560 (1.27, 1.91)	1.460 (1.19, 1.79)		1.911 (1.64, 2.23)	1.520 (1.30, 1.77)

(1) Assets measured include electricity, radio, television, refrigerator, bicycle, motorcycle, car, and bed-net; (2) An improved drinking water source defined piped household water connection, public standpipe, borehole, protected dug well, protected spring, or rainwater collection; (3) An unimproved drinking water source defined as unprotected dug well, unprotected spring, surface water, vendor-provided water, bottled water, or tanker truck. CI, Confidence Interval

Table 3: Examining the relationship between variables and children's diarrhea among women in union who participated in the 2019-2019 Zambia DHS Survey Women's Questionnaire.

Characteristic	Rural			Urban			Total		
	N	Unadjusted OR and 95% CI	Fully Adjusted OR and 95% CI	N	Unadjusted OR and 95% CI	Fully Adjusted OR and 95% CI	N	Unadjusted OR and 95% CI	Fully Adjusted OR and 95% CI
Total (n)		869	-	-	2282	-	-	3151	-
Assets owned¹ (%)									
0-2 assets		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)
3-4 assets		1.107 (0.57, 2.14)	0.872 (0.44, 1.74)		1.006 (0.68, 1.49)	1.048 (0.70, 1.57)		1.067 (0.77, 1.48)	1.022 (0.73, 1.44)
5 or more assets		0.968 (0.37, 2.56)	0.67 (0.25, 1.80)		0.567 (0.25, 1.29)	0.651 (0.28, 1.53)		0.939 (0.51, 1.73)	0.852 (0.45, 1.60)
Education level Completed									
Less than secondary		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)
At least secondary		2.284 (1.26, 4.13)	2.588 (1.48, 4.52)		0.737 (0.50, 1.09)	0.768 (0.50, 1.18)		1.203 (0.89, 1.65)	1.28 (0.94, 1.75)
Type of water source (%)									
Improved ²		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)		1.0 (ref)	1.0 (ref)
Unimproved ³		1.063 (0.49, 2.30)	1.092 (0.50, 2.39)		1.183 (0.86, 1.62)	1.137 (0.83, 1.57)		1.083 (0.82, 1.43)	1.117 (0.84, 1.49)
Empowerment Scores									
Attitude towards violence		0.952 (0.73, 1.25)	1.006 (0.77, 1.31)		1.223 (1.07, 1.403)	1.201 (1.05, 1.38)		1.124 (0.99, 1.27)	1.140 (1.01, 1.29)
Participation in Decision Making		0.888 (0.705, 1.12)	0.937 (0.72, 1.22)		1.096 (0.95, 1.26)	1.089 (0.95, 1.26)		1.011 (0.90, 1.14)	1.020 (0.90, 1.16)
Social Independence		1.546 (1.12, 2.13)	1.623 (1.17, 2.25)		0.978 (0.74, 1.29)	1.002 (0.75, 1.34)		1.244 (1.0, 1.54)	1.306 (1.03, 1.65)

(1) Assets measured include electricity, radio, television, refrigerator, bicycle, motorcycle, car, and bed-net; (2) An improved drinking water source defined piped household water connection, public standpipe, borehole, protected dug well, protected spring, or rainwater collection; (3) An unimproved drinking water source defined as unprotected dug well, unprotected spring, surface water, vendor-provided water, bottled water, or tanker truck. CI, Confidence Interval

Appendix

Table S5. Variables used in the development of the survey-based women's empowerment index.

Variable	Code or unit
Beating justified if:	
1. wife goes out without telling husband	
2. wife neglects the children	
3. wife argues with husband	Yes = -1; DK=0; No=1
4. wife refuses to have sex with husband	
5. wife burns the food	
6. Frequency of reading newspaper or magazine	Not at all=0; <once a week=1; ≥once a week=2
7. Respondent worked in last 12 months	No = 0; In the past year = 1; Have a job, but on leave last 7 days = 2; Currently working = 2
8. Woman education in completed years of schooling	Years
9. Education difference: woman's minus husband's years of schooling	Years
10. Age difference: woman's minus husband's age	Years
11. Age at first cohabitation	Years
12. Age of woman at first birth*	Years
Who usually decides on:	
13. Respondent's health care	Husband/other alone= -1; joint=0;
14. Large household purchases	respondent alone=1
15. Visits to family or relatives	

* This variable was imputed for women who had not had a child, please see section 1.1 for details.

Table S6. Variable weights used in the equations for estimating individual scores for each domain of the SWPER Index.

Variable (v)	λ_{v1} Attitude to violence	λ_{v2} Social independence	λ_{v3} Decision- making
1. Beating not justified if wife goes out without telling husband	0.489	-0.006	-0.001
2. Beating not justified if wife neglects the children	0.493	-0.020	-0.040
3. Beating not justified if wife argues with husband	0.501	0.000	0.007
4. Beating not justified if wife refuses to have sex with husband	0.493	0.000	0.026
5. Beating not justified if wife burns the food	0.546	-0.003	-0.014
6. Frequency of reading newspaper or magazine	0.056	0.549	0.150
7. Woman education	0.015	0.090	0.026
8. Age of respondent at first birth	-0.008	0.141	-0.019
9. Age at first cohabitation	-0.004	0.131	-0.006
10. Age difference: woman's minus husband's age	0.002	0.026	0.012
11. Education difference: woman's minus husband's years of schooling	-0.004	0.050	-0.009
12. Who usually decides on respondent's health care	0.008	0.004	0.770
13. Who usually decides on large household purchases	-0.034	-0.013	0.831
14. Who usually decides on visits to family or relatives	0.008	-0.052	0.768
15. Respondent worked in last 12 months	-0.001	-0.060	0.180