Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world-wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____   _____

Gregory Thomas Blazek   Date

Quantifying the relationships between WASH conditions and mental well-being in Amhara, Ethiopia

By

Gregory Thomas Blazek

Master of Public Health

Epidemiology

_____

Matthew Freeman, Gangarosa Department of Environmental Health

Committee Chair

_____

Jed Snyder, Gangarosa Department of Environmental Health

Committee Member

_____

Maryann Delea, Gangarosa Department of Environmental Health

Committee Member

Quantifying the relationships between WASH conditions and mental well-being in Amhara,
Ethiopia

By

Gregory Thomas Blazek

B.S.,

University of Washington,

2015

Faculty Thesis Advisor: Matthew Freeman, PhD

An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology

2020

Abstract

Quantifying the relationships between WASH conditions and mental well-being in Amhara, Ethiopia

By Gregory Blazek

Water, sanitation, and hygiene (WASH) conditions are large contributors to illnesses and mortality across the world. Although the WHO's definition of health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity," most current research focuses on the impact of WASH conditions on infectious disease. Few quantitative studies focus on WASH and mental well-being. Using data collected as a part of the *Andilaye* Trial, this study aims to quantify the relationships between household WASH conditions, insecurity, and mental well-being. Our sample includes respondents from 1,589 households from the Bahir Dar Zuria, Fogera, and Farta districts of Amhara, Ethiopia. We gathered seven household indicators from the WHO/UNICEF Joint Monitoring Programme's targets for sustainable WASH development goals, as well as water and sanitation insecurity metrics from previously validated studies. Mental well-being was assessed using the Hopkins Symptom Checklist for anxiety, depression, and emotional distress symptoms, and the WHO-5 Well-Being Index. Our linear regression models demonstrate that poorer WASH conditions are associated with poorer mental well-being for almost all household indicators. Similarly, poorer WASH insecurity scores are universally associated with poorer mental well-being. We also find that the relationship between WASH conditions and mental well-being is mediated by WASH insecurity in unpredictable ways. Our results clearly show the adverse effects that poor WASH conditions have on mental well-being and the complex interactions between WASH factors and mental well-being. Future WASH research should focus on mental well-being outcomes as well as more nuanced definitions of WASH conditions and insecurity to holistically address health equity.

Quantifying the relationships between WASH conditions and mental well-being in Amhara, Ethiopia

By

Gregory Thomas Blazek

B.S., University of Washington,

2015

Faculty Thesis Advisor: Matthew Freeman, PhD

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology

2020

Introduction

Illnesses related to water, sanitation, and hygiene (WASH) conditions are large contributors to

mortality across the world. In 2010, over seven million individuals died from a diarrheal disease

[1]. In Sub-Saharan Africa in 2012, it was estimated that 230,000 diarrheal deaths were linked to

inadequate water quality, 126,000 were linked to inadequate sanitation, and 123,000 were

linked to inadequate hand hygiene [2]. There is a robust literature linking poor access to WASH

with infectious disease outcomes, including diarrheal diseases, [3] maternal mortality [4],

helminth infection [5], and trachoma [6]. Nearly 600 million people lacked access to improved

drinking water sources, meaning they used unprotected sources or surface water [7]. 1.4 billion

individuals did not have access to a flush/pour flush sanitation facility or a latrine with slabs, and

1.7 billion did not have access to handwashing facilities with soap and water [7]. While these

numbers are staggering, it is hypothesized that high-risk water and sanitation practices are

underreported and may be much larger than current global estimates [8]. Many programs have

been created to address WASH access and behavioral interventions. However, these programs

often experience slippage, which is a return to previous behavior or an inability to continue safe

WASH practices [9].

The World Health Organization (WHO) defines health as "a state of complete physical, mental

and social well-being and not merely the absence of disease or infirmity" [10]. In addition, the

WHO's definition of mental health is "a state of well-being in which the individual realizes his or

her own abilities, can cope with the normal stresses of life, can work productively and fruitfully,

and is able to make a contribution to his or her community" [11]. Along with physical and social

health, mental well-being influences an individual's quality of life, and is an integral part of overall well-being.

The impact of WASH on mental well-being is underexplored, though the existing evidence suggests that poorer WASH conditions are associated with poorer mental well-being [12]. WASH's influence on mental well-being is likely complex with many intersecting psychosocial factors. For example, stressors arising from WASH conditions frequently include embarrassment, anxiety over lack of access, fear of being assaulted, disputes with neighbors over access, and perceived inequities [13]. A study in sub-Saharan African communities found that individuals who feel unsafe or have been assaulted using a sanitation facility had higher concentrations of hair cortisol, which is a biomarker for chronic stress [14]. WASH conditions and experiences may be modified by water and sanitation insecurity [12, 15]. Clearly, WASH access and quality, along with myriad related factors, greatly influence mental well-being.

Women in low-income countries face a significant burden of WASH-related stressors. Women may experience more WASH-related psychological distress due to having more household water responsibilities [16]. In a rural community in Odisha, India, a one point increase in a score ranking physical exertion or strain experienced to use the latrine led to a 31% decrease in their well-being score [17]. In another rural Indian community, 64% of female respondents reported some amount of stress due to a perceived lack of safety [18]. This stress may contribute to women's globally greater burden of psychiatric disorders than men [19].

Ethiopians face many of the same barriers to safe WASH conditions as those in other low and middle-income countries. Though progress has been made in water and sanitation access, it is

estimated that 43% of Ethiopians do not have access to basic, or protected, water sources [20].

Only 6.3% of households have access to improved sanitation facilities [21]. Slippages in WASH

behaviors after interventions have also been noted [22]. This is in spite of a high level of

awareness and positive attitude towards improved latrines [23].

There is also a noteworthy burden on mental health in Ethiopia, where 15% of Ethiopians suffer

from a mental health or substance use disorder [24]. Poor mental well-being is often an

unaddressed issue; even with this significant prevalence, Ethiopians often do not seek assistance

through clinical medicine, demonstrating a need for desirable and situationally-tailored

treatment options with respect to local communities [25]. Mental illness is underdiagnosed and

undertreated in many Ethiopian communities [25].

Like other low- and middle-income countries, there is evidence that poor WASH conditions in

Ethiopia adversely affect mental well-being. In the South Wello region, one point lower on a

validated water insecurity scale, which measured household access to safe water for drinking,

sanitation, and hygiene purposes, increased psychological distress scores by 25% [26]. Another

study found that, for every 1 point increase on the water insecurity scale, psychosocial distress

scores rose by a fifth of a point [27].

The few studies that exist on the association between WASH condition and mental well-being

are frequently observational and qualitative and do not assess the impact of interventions [12].

As part of the *Andilaye* Trial, we quantified the relationship between household WASH

conditions and mental well-being, quantify the relationship between water and sanitation

insecurity and mental well-being, and assess the relationship between household WASH

conditions and mental well-being for mediation by water and sanitation insecurity.

Methods

Setting and Population

We quantified the associations between WASH conditions, insecurity, and mental well-being as part of the Andilye study in Amhara Ethiopia [28]. The aim of the *Andilaye* Trial - Amharic for "togetherness/integration" - was to use behavioral theory and evidence from formative research to inform the design of a novel, holistic, community-based WASH intervention (i.e., "*Andilaye*") and evaluate its impact on sustained behavior change and mental well-being. Information on the *Andilaye* Trial, including its rationale, design and implementation, can be found elsewhere [28, 29]. In summary, the trial was a two-year impact evaluation and was designed as an ex-ante two-arm parallel cluster randomized trial. The trial was conducted in three districts (*woredas*) – Bahir Dar Zuria, Fogera, and Farta – of the Amhara National Regional State in Ethiopia. Rural and peri-urban sub-districts (*kebeles*) within these three purposely selected *woredas* were eligible for inclusion in the *Andilaye* Trial. The target study population included households residing in 50 randomly selected study clusters (i.e., *kebeles*). Eligible households who had at least one child aged 1-9 years and provided consent to participate in the study were randomly selected and enrolled into trial.

Aims

Our study addressed the following aims: (1) quantify the influence that household WASH characteristics have on mental well-being scores, (2) quantify the influence that water insecurity and sanitation insecurity have on mental well-being scores separately, and (3) quantify any potential mediation that water insecurity and sanitation security separately have on the relationship between household WASH conditions and mental well-being scores. We employed a structural equation model (SEM) relating to these aims (Figure 1).

Figure 1: Structural equation model diagram linking household WASH conditions to WASH insecurity and mental well-being
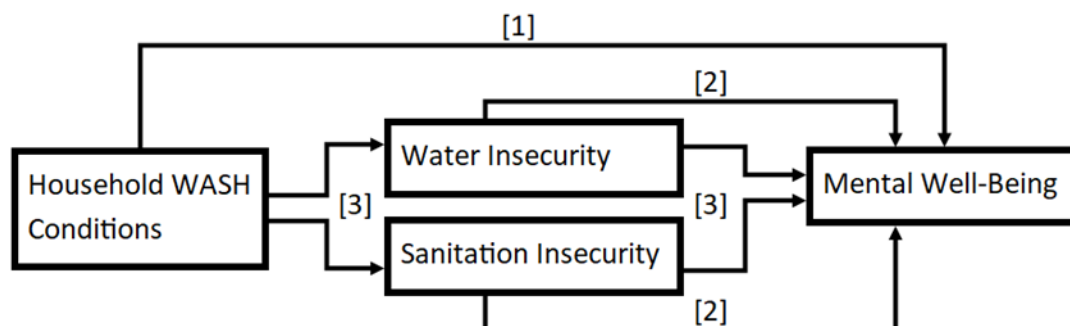
Data Collection

We used baseline data collected from the 1,589 enrolled households of the parent study [28]. During baseline data collection (March to April 2017), survey instruments were administered to collect data on key outcome indicators (i.e., sustainability of WASH-related behaviors and mental well-being) through reports from respondents and other household members. Survey indicators were developed using validated instruments from prior WASH research and standardized scale scores for mental well-being and WASH insecurity. The tools were translated into Amharic, and back-translated by two independent Amharic speakers. Cognitive interviews were also used in order to gauge respondent comprehension and further validate the tools. Enumerators and their supervisors were thoroughly trained on survey implementation at a bilingual group training. Enumerators targeted primary survey respondents based on the following order of priority: (1) the primary female caregiver of the index child (i.e., youngest child in the study household aged 1–9 years at baseline), (2) any female household member who

serves as a caregiver, (3) any male household member who serves as a caregiver, and (4) any household member over 18 year of age.

Data were collected electronically on password-protected mobile phones and stored securely using the freely available Open Data Kit (http://opendatakit.org/). Logic, range, and consistency checks were incorporated to minimize data entry error.

Measures

The main exposures of interest (WASH conditions, WASH insecurity), mediating variables (WASH insecurity), and outcomes of interest (mental well-being) can be seen in detail in Table 1.

Table 1: Description of main analysis variables

Variable	Subcategory	Means of verification	Sources
WASH conditions	Main drinking water source	Respondent reported	JMP SDG target [30]
	Location of drinking water source	Respondent reported	JMP SDG target [30]
	Availability of drinking water	Respondent reported	JMP SDG target [30]
	Sanitation facility	Enumerator observation	JMP SDG target [30]
	Shared sanitation facility	Respondent reported	JMP SDG target [30]
	Location of sanitation facility	Enumerator observation	JMP SDG target [30]
	Handwashing facility/water/soap observation	Enumerator observation	JMP SDG target [30]
WASH insecurity	Water insecurity scale	Respondent reported	5-question scale on water quality and access [34]
	Sanitation insecurity scale	Respondent reported	50-question scale on sanitation quality and access [15]
Mental well-being	Anxiety scale	Respondent reported	Hopkins Symptom Checklist [32]
	Depression scale	Respondent reported	Hopkins Symptom Checklist [32]
	Emotional distress scale	Respondent reported	Hopkins Symptom Checklist [32]
	Well-being	Respondent reported	WHO-5 Well-Being Index [33]

Household WASH Conditions

Indicators for household-level WASH conditions use both participant-reported and enumerator-observed responses. These indicators follow the Sustainable Development Goal (SDG) targets related to WASH per the World Health Organization and United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP), which produces internationally comparable estimates of WASH conditions and progress [30]. The JMP core wash indicators covered in these analyses include participant reports of the household's main drinking water source, the location of the main drinking water source, the availability of drinking water throughout the year, and if the primary latrine was shared by others outside of the household. Observational data was gathered on the presence of a handwashing station with soap and water, the location of the household's latrine, and the type of latrine the household had access to (improved/unimproved). According to the JMP, unimproved sanitation includes pit latrines without a slab or platform, hanging latrines, bucket latrines, or open defecation [31].

Mental Well-Being

Indicators for mental well-being included scales for symptoms of anxiety, depression, emotional distress, and well-being. The scales for anxiety, depression, and emotional distress were generated using the Hopkins Symptom Checklist [32]. A higher score for the anxiety, depression, and emotional distress scales are associated with a greater presence of these deleterious symptoms. Well-being scores were generated using the WHO-5 Well-Being Index (WHO-5), where a greater score indicates increased life satisfaction [33].

WASH Insecurity

Metrics for water insecurity used a 5-question scale assessing barriers to safe water for drinking or household use, where higher scores indicate higher water insecurity. This scale was based on previous research [34]. Sanitation insecurity was measured by summing the results of a 50-question survey on barriers to reaching and using sanitation facilities, with higher scores indicating higher insecurity. This measure consists of many factors contributing to sanitation and hygiene access, as the Millennium Development Goals, a worldwide objective of health conditions, tend to focus on latrine construction alone [15].

Covariates

Respondent gender and age were collected during baseline to control for covariates in our models used for analysis. A wealth quintile index was created to proxy for socio-economic status using a questionnaire with 20 items relating to wealth and asset ownership; principle component analysis was used to identify item weight, and quintiles were identified based on weighted scores for each household.

Food insecurity was controlled for using one survey question. This score ranked if household members had no, some, or frequent food insecurity in the past 3 months; higher scores indicated higher food insecurity.

Data Analysis

All analyses were conducted using Stata 14 (StataCorp, College Station, TX). Bivariate linear regression was conducted based on a structural equation model (SEM) (Figure 1). Mediation was assessed by introducing an interaction term between water or sanitation insecurity and each household WASH condition, and controlling for the insecurity in the interaction term. Our models used the method of least squares to calculate overall F-test statistics.

Ethics

Ethical approval for the *Andilaye Impact Evaluation* was provided by Emory University (IRB00076141), the London School of Hygiene & Tropical Medicine (9595), and locally by the Amhara Regional Health Bureau (HRTT0135909). We provided study participants with full details regarding the study as well as their rights as a participant in the study prior to inquiring about consent to participate. This process took place in Amharic. The *Andilaye* team took appropriate steps to ensure confidentiality for all study participants [29].

Results

Sample size and demographic characteristics

Of surveys initiated during baseline, 1589 (94%) met all inclusion criteria and were enrolled into

the study. Targeted households were excluded if they did not have a household member

between 1-9 years of age (n=81), had no eligible respondent available (n=17), did not fully

complete the survey (n=3), or did not consent to take the survey (n=1). Respondents were

largely female, at 90.7.69% (Table 2). All of the respondents were ethnically Amhara. The

average age of respondents was 34 (SD 0.25), and their households had an average of 5

members (SD 0.04). 78% had no formal schooling.

In terms of household WASH indicators, 63.6% of respondent households had access to an

improved water source, and 3.97% had a water source located in their home or compound.

75.1% had access to an improved sanitation facility, and 95.8% had a sanitation facility on their

compound. While 78.3% of respondents had a handwashing facility, only 8.88% had a cleansing

agent and water at the facility.

WASH insecurity was generally low; most households had high access to basic water sources and

basic sanitation faciltities, meaning from protected sources or latrines with at least a slab base.

The mean score for water insecurity was 0.83 (SD 0.04), and sanitation insecurity was 17.4 (SD

0.55). Baseline anxiety scales had a mean of 15.8 (SD 0.15), and depression's mean was 19.0 (SD

0.17). The emotional distress score mean was 34.5 (SD 0.30). The WHO-5 well-being score's

mean was 16.0 (SD 0.18).

Table 2: Baseline characteristics of study participants

Indicator		
Demographic information	N	%
Female	1441	90.7
Highest educational attainment (primary caregiver)		
No formal schooling	1239	78.0
Some or completed first cycle primary (grades 1-4)	256	16.1
Completed secondary (grade 8)	42	2.64
High school (grades 9-10) or above (preparatory, college/university)	52	3.27
District		
Bahir Dar Zuria	524	33.0
Farta	696	43.8
Fogera	369	23.2
Demographic information	N	Mean (SD)
Age of respondent	1582	33.7 (0.25)
Household members	1589	5.29 (0.04)
Household WASH indicator	N	%
Water		
Improved main drinking water source	1010	63.6
Drinking water located on household compound	63	3.97
Number of months main drinking water source is available	1589	11.8 (0.02)
Sanitation		
Improved sanitation facility	1167	75.1
Sanitation facility is not shared with other households	841	52.9
Sanitation facility is on respondents own compound	1513	95.6
Hygiene		
Handwashing facility present	1244	78.3
Handwashing facility has soap and water present	139	8.75
WASH insecurity scales	N	Mean (SD)
Water insecurity	1589	0.83 (0.04)
Sanitation insecurity	779	17.4 (0.55)
Food insecurity	1589	0.03 (0.01)
Mental well-being scales	N	Mean (SD)
Anxiety score	1584	15.6 (0.15)
Depression score	1588	19.0 (0.17)
Emotional distress score	1583	34.5 (0.30)

WHO-5 well-being score	1586	16.0 (0.18)

Household WASH conditions and mental well-being (Aim 1)

Poorer WASH conditions were correlated with higher anxiety, depression, and emotional

distress to varying degrees in all but the model correlating the location of the household's

sanitation facility with depressions symptoms (Table 3). For example, sharing sanitation facilities

with another household was associated with a 45.5% increase in reported depression symptom

scores. The location of the drinking water source had the highest influence on anxiety,

depression, and emotional distress; respondents from households with a water source on-

compound had reduced anxiety, depression, and emotional distress scores by 2.04, 2.04, and

4.06 points, respectively. The presence of a handwashing station, the presence of soap and

water at handwashing stations, and the location of sanitation facilities also had a high

magnitude score reduction across these three scales.

Improved WASH conditions were mostly positively associated with higher mental well-being

(WHO-5), with the exception of an improved sanitation facility. Similar to the other scales, on-

compound access to a drinking water source resulted in a 2.92-point increase of the WHO-5.

Scores were also increased by a higher quality handwashing facility (beta = 0.88), improved

drinking water source (beta = 0.60), and more months of drinking water availability (beta =

0.46).

Table 3: Bivariate coefficient estimates for the relationship between household WASH conditions and mental well-being

Mental well-being outcome	Household WASH indicator	B	Std. error	95% CI	p-value
Anxiety scale	Main drinking water source	-0.06	0.32	-0.69, 0.57	0.85
	Location of drinking water source	-2.04	0.79	-3.58, -0.50	0.01
	Availability of drinking water	-0.47	0.19	-0.85, -0.10	0.01
	Sanitation facility	-0.38	0.36	-1.08, 0.32	0.29
	Sanitation facility shared with other households	-0.17	0.31	-0.79, 0.44	0.58
	Location of sanitation facility	-1.04	0.75	-2.51, 0.43	0.17
	Handwashing facility status	-0.44	0.29	-1.00, 0.13	0.13
Depression scale	Main drinking water source	-0.31	0.34	-0.98, 0.36	0.37
	Location of drinking water source	-2.04	0.84	-3.69, -0.39	0.02
	Availability of drinking water	-0.18	0.21	-0.58, 0.22	0.37
	Sanitation facility	-0.27	0.38	-1.02, 0.47	0.47
	Sanitation facility shared with other households	-0.55	0.33	-1.20, 0.11	0.10
	Location of sanitation facility	0.07	0.80	-1.49, 1.63	0.93
	Handwashing facility status	-0.71	0.31	-1.31, -0.11	0.02
Emotional distress scale	Main drinking water source	-0.30	0.61	-1.50, 0.91	0.63
	Location of drinking water source	-4.06	1.51	-7.02, -1.11	0.01
	Availability of drinking water	-0.66	0.37	-1.39, 0.06	0.07
	Sanitation facility	-0.67	0.68	-2.00, 0.67	0.33

	Sanitation facility shared with other households	-0.67	0.60	-1.85, 0.51	0.26
	Location of sanitation facility	-0.98	1.43	-3.79, 1.82	0.49
	Handwashing facility status	-1.15	0.55	-2.24, -0.07	0.04
WHO-5 well-being scale*	Main drinking water source	0.59	0.36	-0.12, 1.31	0.11
	Location of drinking water source	2.92	0.90	1.16, 4.67	0.00
	Availability of drinking water	0.46	0.22	0.04, 0.89	0.03
	Sanitation facility	-0.25	0.41	-1.05, 0.54	0.53
	Sanitation facility shared with other households	0.27	0.36	-0.43, 0.97	0.45
	Location of sanitation facility	0.46	0.86	-1.22, 2.13	0.60
	Handwashing facility status	0.88	0.33	0.24, 1.52	0.01

* The WHO-5 well-being scale, unlike the other three indicators, reflects higher well-being with a greater score

WASH insecurity and mental well-being (Aim 2)

Water insecurity, and sanitation insecurity to a lesser extent, were associated with lower mental

well-being outcomes (Table 4). A one-point increase of the water insecurity scale, indicating

greater insecurity in the availability and quality of drinking water, was associated with nearly a

one-point increase on the depression scale. Emotional distress scores rose by 0.21 points for

each additional point of sanitation insecurity, meaning greater barriers to safe and available

sanitation facilities led to greater emotional distress. The WHO-5 shows similar results; one

additional point on the water insecurity scale reduced it by 0.45 points, while one additional

point of sanitation insecurity reduced it by 0.10.

Table 4: Bivariate coefficient estimates for the relationship between WASH insecurity and mental well-being

Mental well-being outcome	Water insecurity				Sanitation insecurity			
	B	Std. error	95% CI	p-value	*B*	Std. error	95% CI	p-value
Anxiety scale	0.75	0.10	0.55, 0.95	< 0.001	0.10	0.01	0.07, 0.12	< 0.001
Depression scale	0.94	0.11	0.73, 1.16	< 0.001	0.12	0.01	0.09, 0.14	< 0.001
Emotional distress scale	1.69	0.20	1.31, 2.08	< 0.001	0.21	0.03	0.16, 0.26	< 0.001
WHO-5 well-being scale*	-0.45	0.12	-0.68, -0.21	< 0.001	-0.10	0.02	-0.14, -0.07	< 0.001

* The WHO-5 well-being scale, unlike the other three indicators, reflects higher well-being with a greater score

Mediation by WASH insecurity (Aim 3)

There were significant differences when water and sanitation insecurity were added separately

to the household conditions-mental well-being models to assess mediation (Aim 3; Table 5,

Table 6). Most mediated coefficients differed by greater than 10% from their corresponding

model in aim 1. When considering "location of drinking water source" on anxiety, the

unmediated coefficient was -2.04, where the model's coefficient mediated on water insecurity

was reduced to -1.65. For "handwashing facility status" on emotional distress, the coefficient

mediated on sanitation insecurity rose in magnitude from -1.15 to -2.23. Some associations

switched direction altogether. Collinearity also arose; all models including "availability of

drinking water" or "location of sanitation facility" were collinear, suggesting that these variables

were extremely associated with both water and sanitation insecurity.

Table 5: Coefficient estimates for the SEM model between household WASH conditions and mental well-being with water insecurity as a mediator

Mental well-being outcome	Household WASH indicator	Water insecurity			
		B	Std. error	95% CI	p-value
Anxiety scale	Main drinking water source	**0.01**	0.36	-0.69, 0.71	0.98
	Location of drinking water source	**-1.65**	0.82	-3.26, -0.04	0.05
	Availability of drinking water*	**-0.37**	0.23	-0.82, 0.09	0.12
	Sanitation facility	**-0.47**	0.39	-1.24, 0.29	0.23
	Sanitation facility shared with other households	**-0.01**	0.34	-0.68, 0.67	0.99
	Location of sanitation facility*	**-1.16**	0.81	-2.76, 0.43	0.15
	Handwashing facility status	**0.02**	0.32	-0.61, 0.64	0.96
Depression scale	Main drinking water source	**0.06**	0.38	-0.68, 0.81	0.87
	Location of drinking water source	**-1.72**	0.87	-3.43, -0.01	0.05
	Availability of drinking water*	**-0.05**	0.25	-0.53, 0.43	0.84
	Sanitation facility	-0.27	0.41	-1.08, 0.54	0.52
	Sanitation facility shared with other households	**-0.09**	0.36	-0.80, 0.62	0.81
	Location of sanitation facility*	**0.19**	0.86	-1.50, 1.88	0.82
	Handwashing facility status	**0.25**	0.34	-0.41, 0.91	0.46
Emotional distress scale	Main drinking water source	**0.14**	0.68	-1.20, 1.48	0.84
	Location of drinking water source	**-3.35**	1.56	-6.42, -0.29	0.03
	Availability of drinking water*	**-0.42**	0.44	-1.29, 0.44	0.34
	Sanitation facility	**-0.75**	0.74	-2.21, 0.71	0.31
	Sanitation facility shared with other households	**-0.06**	0.65	-1.34, 1.22	0.93
	Location of sanitation facility*	-0.99	1.54	-4.01, 2.04	0.52
	Handwashing facility status	**0.26**	0.61	-0.93, 1.44	0.67

WHO-5 well-being scale**					
	Main drinking water source	0.64	0.41	-0.17, 1.45	0.12
	Location of drinking water source	3.19	0.94	1.34, 5.04	0.00
	Availability of drinking water*	0.45	0.27	-0.08, 0.97	0.10
	Sanitation facility	-0.25	0.45	-1.13, 0.64	0.59
	Sanitation facility shared with other households	**0.01**	0.40	-0.77, 0.79	0.98
	Location of sanitation facility*	**0.42**	0.94	-1.43, 2.26	0.66
	Handwashing facility status	**0.60**	0.37	-0.13, 1.32	0.11

† Coefficients that differ greater than 10% from their corresponding unmediated coefficient in Table 2 have been bolded

* The results of "availability of drinking water" and "location of sanitation facility" (results in red) were found to be collinear when adjusting for both insecurity indexes

** The WHO-5 well-being scale, unlike the other three indicators, reflect higher well-being with a greater score

Table 6: Coefficient estimates for the SEM model between household WASH conditions and mental well-being with sanitation insecurity as a mediator

Mental well-being outcome	Household WASH indicator	Sanitation insecurity			
		B	Std. error	95% CI	p-value
Anxiety scale	Main drinking water source	0.04	0.63	-1.19, 1.27	0.95
	Location of drinking water source	-0.91	1.67	-4.19, 2.37	0.59
	Availability of drinking water*	-0.69	0.42	-1.52, 0.14	0.10
	Sanitation facility	-0.01	0.69	-1.38, 1.35	0.98
	Sanitation facility shared with other households	0.06	0.61	-1.14, 1.25	0.93
	Location of sanitation facility*	1.49	1.42	-1.30, 4.27	0.30
	Handwashing facility status	-0.88	0.55	-1.96, 0.20	0.11
Depression scale	Main drinking water source	-0.89	0.66	-2.18, 0.41	0.18
	Location of drinking water source	-0.77	1.75	-4.20, 2.67	0.66
	Availability of drinking water*	-0.43	0.44	-1.30, 0.43	0.33
	Sanitation facility	-0.22	0.73	-1.64, 1.21	0.77
	Sanitation facility shared with other households	-0.31	0.63	-1.54, 0.93	0.63
	Location of sanitation facility*	1.62	1.48	-1.30, 4.53	0.28
	Handwashing facility status	-1.38	0.57	-2.51, -0.25	0.02
Emotional distress scale	Main drinking water source	-0.86	1.18	-3.18, 1.45	0.47
	Location of drinking water source	-1.67	3.13	-7.82, 4.49	0.60
	Availability of drinking water*	-1.13	0.80	-2.69, 0.43	0.16
	Sanitation facility	-0.21	1.30	-2.76, 2.34	0.87
	Sanitation facility shared with other households	-0.33	1.14	-2.56, 1.90	0.77
	Location of sanitation facility*	3.16	2.66	-2.07, 8.38	0.24

	Handwashing facility status	**-2.23**	1.03	-4.26, -0.21	0.03
WHO-5 well-being scale**	Main drinking water source	**0.23**	0.75	-1.25, 1.71	0.76
	Location of drinking water source	**2.38**	1.99	-1.53, 6.30	0.23
	Availability of drinking water*	**0.63**	0.50	-0.35, 1.62	0.21
	Sanitation facility	**0.78**	0.83	-0.84, 2.41	0.35
	Sanitation facility shared with other households	**0.49**	0.73	-0.94, 1.92	0.50
	Location of sanitation facility*	**-1.50**	1.69	-4.82, 1.83	0.38
	Handwashing facility status	**-0.36**	0.66	-1.65, 0.93	0.58

† Coefficients that differ greater than 10% from their corresponding unmediated coefficient in Table 2 have been bolded

* The results of "availability of drinking water" and "location of sanitation facility" (results in red) were found to be collinear when adjusting for both insecurity indexes

** The WHO-5 well-being scale, unlike the other three indicators, reflect higher well-being with a greater score

Discussion

As one of few quantitative studies focused on WASH and mental well-being, our research is a novel addition to existing literature. We (1) analyzed the relationship between WASH conditions and mental well-being and (2) analyzed WASH insecurity's effects on mental well-being. We also (3) identified mediation effects that WASH insecurity has on the relationship between WASH conditions and mental well-being. Overall, we found that poor WASH conditions and security were associated with poor mental well-being scores.

Our findings indicate that poorer household WASH conditions are associated with poorer mental well-being. This association was found in all but one model. Similarly, poorer WASH security was associated with poorer mental well-being in all models observed. We also found that the relationship between household WASH conditions and mental well-being was mediated by WASH insecurity. These results were often over 10% different from their unmediated models, and there was no visible pattern to explain the magnitude or directional changes observed between these models.

Our findings are similar to those found in other studies on the associations between WASH conditions and mental well-being [17-18, 26-27]. In addition, they suggest that WASH insecurity mediates this relationship; household WASH conditions influence perceived WASH insecurity, which in turn influences mental well-being [12, 15]. The unpredictable effect changes and collinearity found in our mediated models point to the multifaceted relationship between WASH and psychosocial outcomes. Mental well-being is likely influenced by a composite of many

conditions and experiences that are inextricably linked and difficult to consider using current

frameworks [35].

In order to better address health equity holistically, it is necessary for programs and policies to

consider and quantify the relationships between WASH improvements and non-traditional

factors such as WASH insecurity and mental well-being. WASH has typically been studied by its

effects on physiological health outcomes, especially diarrheal disease [3-6], despite the WHO's

definition of health being "a state of complete physical, mental and social well-being and not

merely the absence of disease or infirmity" [10]. There is a body of literature exploring WASH

and mental well-being, though there is a lack of quantitative and impact-based research [12].

Furthermore, the metrics used are often oversimplified and fail to ascertain barriers and

conditions over a presence or lack of WASH conditions [15]. By not considering factors beyond

WASH quality and physiological health, current frameworks omit the other forms of well-being

outlined by the WHO [35]. Further research is needed to quantify the complex relationships

between WASH conditions, WASH insecurity, and mental well-being in order to encapsulate a

holistic approach to health equity.

Our study contributes to this area of research by quantifying the relationships between WASH

conditions, insecurity, and mental well-being. The *Andilaye* Trial data can also be considered

high-quality by its design as a longitudinal intervention study, trained enumerators, and secure

data entry procedures.

Our study is limited by frequent issues of collinearity in some mediated models. Male

respondent data was infrequent despite inclusion in the study. While the vast majority of the

literature places WASH and mental well-being burdens on women, future studies may benefit from a wider variety of experiences and comparisons.

Among rural and peri-urban households in the Bahir Dar Zuria, Fogera, and Farta districts of the Amhara region of Ethiopia, poorer WASH conditions and poorer WASH security were associated with decreased mental well-being. The relationship between WASH conditions and mental well-being appears to be mediated by WASH insecurity, giving insight into the complex relationships between WASH factors and mental well-being. Future research should broaden its scope to more nuanced definitions of WASH conditions and include mental well-being outcomes.

References

1. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet. 2012;380(9859):2095–2128.

2. Prüss-Ustün A, Bartram J, Clasen T, Colford JM, Cumming O, Curtis V, Bonjour S, Dangour AD, De France J, Fewtrell L, Freeman MC, Gordon B, Hunter PR, Johnston RB, Mathers C, Mäusezahl D, Medlicott K, Neira M, Stocks M, et al. Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: A retrospective analysis of data from 145 countries. Tropical Medicine & International Health. 2014;19(8):894-905.

3. Wolf J, Prüss-Ustün A, Cumming O, Bartram J, Bonjour S, Cairncross S, et al. Systematic review: Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. Tropical Medicine & International Health. 2014;19(8):928–942.

4. Benova L, Cumming O, Campbell OMR. Systematic review and meta-analysis: association between water and sanitation environment and maternal mortality. Tropical Medicine & International Health. 2014;19(4):368–387.

5. Strunz EC, Addiss DG, Stocks ME, Ogden S, Utzinger J, Freeman MC. Water, Sanitation, Hygiene, and Soil-Transmitted Helminth Infection: A Systematic Review and Meta-Analysis. PLoS Medicine. 2014;11(3).

6. Altherr FM, Nute AW, Zerihun M, Sata E, Stewart AE, Gessese D, Melak B, Astale T, Ayenew G, Callahan EK, Chanyalew M, Gashaw B, Waller LA, Tadesse Z, Nash SD. Associations between water, sanitation and hygiene (WASH) and trachoma clustering at aggregate spatial scales, Amhara, Ethiopia. Parasites & Vectors. 2019;12(1).

7. JMP. Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. 2017.

8. Vedachalam S, Macdonald LH, Shiferaw S, Seme A, & Schwab KJ. Underreporting of high-risk water and sanitation practices undermines progress on global targets. Plos One. 2017;12(5).

9. Jerneck M, van der Voorden C, Rudholm C. Sanitation and Hygiene Behaviour Change at Scale: Understanding Slippage. 2016.

10. World Health Organization. Basic Documents: Forty-ninth edition. 2020.

11. Galderisi S, Heinz A, Kastrup M, Beezhold J, Sartorius N. Toward a new definition of mental health. World Psychiatry. 2015;14(2):231-233.

12. Sclar G, Penakalapati G, Caruso B, Rehfuess E, Garn J, Alexander K, et al. Exploring the relationship between sanitation and mental and social well-being: A systematic review and qualitative synthesis. Social Science & Medicine. 2018;217:121–134.

13. Bisung E, Elliott SJ. Psychosocial impacts of the lack of access to water and sanitation in low- and middle-income countries: a scoping review. Journal of Water and Health. 2016;15(1):17–30.

14. Henley P, Lowthers M, Koren G, Fedha PT, Russell E, Vanuum S, et al. Cultural and socio-economic conditions as factors contributing to chronic stress in sub-Saharan African communities. Canadian Journal of Physiology and Pharmacology. 014;92(9):725–732.

15. Caruso BA, Clasen TF, Hadley C, Yount KM, Haardörfer R, Rout M, Dasmohapatra M, Cooper HL. Understanding and defining sanitation insecurity: women's gendered experiences of urination, defecation and menstruation in rural Odisha, India. BMJ Global Health. 2017;2(4).

16. Wutich A. Intrahousehold Disparities in Women and Mens Experiences of Water Insecurity and Emotional Distress in Urban Bolivia. Medical Anthropology Quarterly. 2009;23(4):436–454.

17. Caruso BA, Cooper HL, Haardörfer R, Yount KM, Routray P, Torondel B, Clasen T. The association between womens sanitation experiences and mental health: A cross-sectional study in Rural, Odisha India. SSM - Population Health. 2018;5:257–266.

18. Hirve S, Lele P, Sundaram N, Chavan U, Weiss M, Steinmann P, Juvekar S. Psychosocial stress associated with sanitation practices: experiences of women in a rural community in India. Journal of Water, Sanitation and Hygiene for Development. 2015;5(1):115–126.

19. Rehm J, Shield KD. Global Burden of Disease and the Impact of Mental and Addictive Disorders. Current Psychiatry Reports. 2019;21(2).

20. World Health Organization. Ethiopia | Water, Sanitation and Hygine (WASH). 2020.

21. UNICEF. Water, sanitation and hygiene (WASH). N.D.

22. Central Statistical Agency (CSA) [Ethiopia] and ICF. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: CSA and ICF. 2016.

23. Alemu F, Kumie A, Medhin G, Gebre T, Godfrey P. A socio-ecological analysis of barriers to the adoption, sustainablity and consistent use of sanitation facilities in rural Ethiopia. BMC Public Health. 2017;17(1).

24. World Health Organization. Mainstreaming mental health in Ethiopia. 2016.

25. Alem A, Jacobsson L, Araya M, Kebede D, Kullgren G. How are mental disorders seen and where is help sought in a rural Ethiopian community? A key informant study in Butajira, Ethiopia. Acta Psychiatrica Scandinavica. 1999;100:40–47.

26. Stevenson EGJ, Ambelu A, Caruso BA, Tesfaye Y, Freeman MC. Community Water Improvement, Household Water Insecurity, and Women's Psychological Distress: An Intervention and Control Study in Ethiopia. Plos One. 2016;11(4).

27. Stevenson EG, Greene LE, Maes KC, Ambelu A, Tesfaye YA, Rheingans R, Hadley C. Water insecurity in 3 dimensions: An anthropological perspective on water and womens psychosocial distress in Ethiopia. Social Science & Medicine. 2012;75(2):392–400.

28. Delea MG, Snyder JS, Belew M, Caruso BA, Garn JV, Sclar GD, Woreta M, Zewudie K, Gebremariam A, Freeman MC. Design of a parallel cluster-randomized trial assessing the impact of a demand-side sanitation and hygiene intervention on sustained behavior change and mental well-being in rural and peri-urban Amhara, Ethiopia: Andilaye study protocol. BMC Public Health. 2019;19(1).

29. Garn JV, Delea MG, Freeman MC. Baseline Report: The impact of enhanced, demand-side sanitation and hygiene promotion on sustained behavior change and health in Amhara, Ethiopia. 2017.

30. JMP. Progress on household drinking water, sanitation and hygiene 2000-2017. 2019.

31. JMP. Core questions on water, sanitation and hygiene for household surveys. 2018.

32. Derogatis LR, Lipman RS, Rickels K, Uhlenhuth EH, Covi L. The Hopkins symptom checklist (HSCL): a self-report symptom inventory. Behav Sci. 1974;19(1):1–15.

33. Bech P. Measuring the dimension of psychological general well-being by the WHO-5. Qual Life Newsl. 2004;32:15–16.

34. Hadley C, Freeman MC. Assessing reliability, change after intervention, and performance of a water insecurity scale in rural Ethiopia. Food Security. 2016;8(4):855–64.

35. Subbaraman R, Nolan L, Sawant K, Shitole S, Shitole T, Nanarkar M, Patil-Deshmukh A, Bloom DE. Multidimensional Measurement of Household Water Poverty in a Mumbai Slum: Looking Beyond Water Quality. PLOS ONE. 2015;10(7).