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:

_____ __04/28/2020_____

Yunbo Xie Date

Trends in sanitation and hygiene behaviors amongst households residing in rural and peri-urban Amhara, Ethiopia – A longitudinal analysis of cluster-randomized trial data

By

Yunbo Xie

Master of Science in Public Health

Environmental Health

_____ _____

Mathew Freeman, MPH PhD

Committee Chair

Trends in sanitation and hygiene behaviors amongst households residing in rural and peri-urban Amhara, Ethiopia – A longitudinal analysis of cluster-randomized trial data

By

Yunbo Xie

B.A.

University of Washington

2018

Thesis Committee Chair: Mathew Freeman MPH 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 Science in Public Health

in Environmental Health and Epidemiology

2020

Abstract

Trends in sanitation and hygiene behaviors amongst households residing in rural and peri-urban Amhara, Ethiopia – A longitudinal analysis of cluster-randomized trial data
By Yunbo Xie

Background: Sustained water, sanitation, and hygiene (WASH) behaviors and practices are essential to prevent the spread of infectious diseases. The Andilaye Trial was a parallel cluster-randomized trial carried out in Ethiopia between spring 2017 and summer 2019. And longitudinal analysis was performed on this sub-study paper to compare the effectiveness of the Andilaye intervention, a novel WASH intervention, and the CLTS, government-backed, low-cost and locally acceptable approaches for improving sanitation and hygiene. The effects of the Andilaye intervention on various WASH behaviors were examined over time.

Methods: The data collection process for the parent study, the Andilaye Trial, consists of three-stage data collection processes, baseline, midline and endline. Three WASH behavioral outcomes were selected to conduct longitudinal analysis. They were latrine usage, handwashing practices and facewashing practices. We assessed the associations between the Andilaye intervention arm and these selected WASH behavioral outcomes using generalized estimating equation.

Results: The GEE models revealed that the odds ratio and the corresponding 95% confidence intervals for handwashing practices after defecation among female participants was 1.33 (1.13-1.44). The odds ratio and the 95% confidence intervals for handwashing practices before food preparation among female participants was 1.37 (1.16-1.48). And lastly, the odds ratio and the 95% confidence intervals for facewashing practices among female participants was 1.53 (1.02-1.82).

Conclusions: These results suggest that the Andilaye intervention arm may be associated with higher odds of improved handwshing and facewashing practices among females over time.

Trends in sanitation and hygiene behaviors amongst households residing in rural and peri-urban Amhara, Ethiopia – A longitudinal analysis of cluster-randomized trial data

By

Yunbo Xie

B.A.

University of Washington

2018

Thesis Committee Chair: Mathew Freeman, MPH 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 Science in Public Health

in Environmental Health and Epidemiology

2020

Contents

Introduction

Sustained water, sanitation, and hygiene (WASH) behaviors and practices are essential to prevent the spread of infectious diseases. Inadequate water, sanitation, and hygiene (WASH) access and behaviors are known key contributors to the spread of infectious diseases like NTDs. This is because without adequate WASH behaviors and practices, people are prone to exposed to various kinds of exposures that could potentially contaminate the community ecosystem and disease pandemics. For example, exposed fecal matters can be easily transferred back to people's water and food resources without proper sanitation practices (1). Although there are people in some parts of the world that have little or no awareness of good hygiene and sanitation practices, most cases are that there is a lack of safe, clean water or soap for those who are aware of the importance of WASH behaviors and practices (1). Without adequate and sustained WASH behaviors, people's livings will be negatively affected by the risks of contracting diseases as well as sexual assault and abuse especially for women and girls who defecate outdoor. Thus, it is imperative to implement WASH programs in these affected areas with an aim to increase sustained WASH behaviors among those affected populations so that a lifetime of better health can be achieved for all global citizens. Although many WASH interventions have been implemented since Sustainable Development Goal 6, Clean Water and Sanitation, was established by the United Nations General Assembly in 2015, there is a relative lack of WASH programs that target people's WASH behaviors and psychological factors associated with WASH at a community level instead of the measurement of infectious diseases at an individual level in endemic communities (2). To date, there is a need for more research on WASH programs and the effect such programs have on sustained water, sanitation, and hygiene (WASH) behaviors. In addition, there is also a relative lack of WASH interventions focusing on sanitation outcomes in Sub-Saharan Africa where only around 5% of the WASH interventions within that

region focused on sanitation outcomes (3). As a result, this paper serves to act as a sub-study to the Andilaye Trial, a cluster-randomized trial called Andilaye on sustained behavioral change in Amhara, Ethiopia. This sub-study will focus on examining the trends in sanitation and hygiene behaviors amongst households residing in rural and peri-urban Amhara, Ethiopia.

Three recent WASH-related cluster randomized trials have focused on behavioral uptake of WASH interventions and mental health outcomes. Firstly, the study conducted in Bangladesh during 2018 examined exclusively on the degree of technology and behavioral uptake among participants in the trial (4). Behavioral outcomes, including safely stored water, handwashing with soap and others, were monitored and collected from survey per month over a 20-month period.

Another study conducted in Ghana during 2019 examined exclusively on psychosocial determinants corresponding to the CLTS intervention and how CLTS could be improved. Thus, the behavioral outcomes were not reported (5).

Lastly, a cluster-randomized controlled trial conducted in rural Malawi from February to December 2018 also implemented similar WASH interventions like the Andilaye intervention (6). However, the outcome variable this Malawi study focused mostly on was the prevalence of the diarrhoeal disease in children (6). The only behavioral outcome this study examined was handwashing with soap (6). Other behavioral outcomes like latrine usage, handwashing and facewashing practices were not examined at all (6).

Thus, the limitations and gaps of present WASH cluster-randomized controlled trials lied within the mixed behavioral outcomes. Many of the WASH cluster-randomized controlled trials, like the Malawi study focused on the prevalence infectious diseases as outcome variable. Other studies that focused on mixed behavioral outcomes like handwashing and facewashing practices

were conducted in Bangladesh and Ghana. Thus, countries like Ethiopia was still in seek of a well-developed WASH-related cluster randomized trial to understand the social norms, gender norms, people's WASH behaviors and mental factors at a community level like the two studies conducted in Bangladesh and Ghaha. This is especially true given that the benefits of WASH programs depend a lot on contexts and locations. The lack of community-based research limits the adaptability of current WASH research as the effect of WASH interventions often depend on community level coverage and community level social norms (7). As a result, more WASH trials should be carried out to fill the gap of the relative lack of WASH coverage on mental and behavioral uptake at a community level.

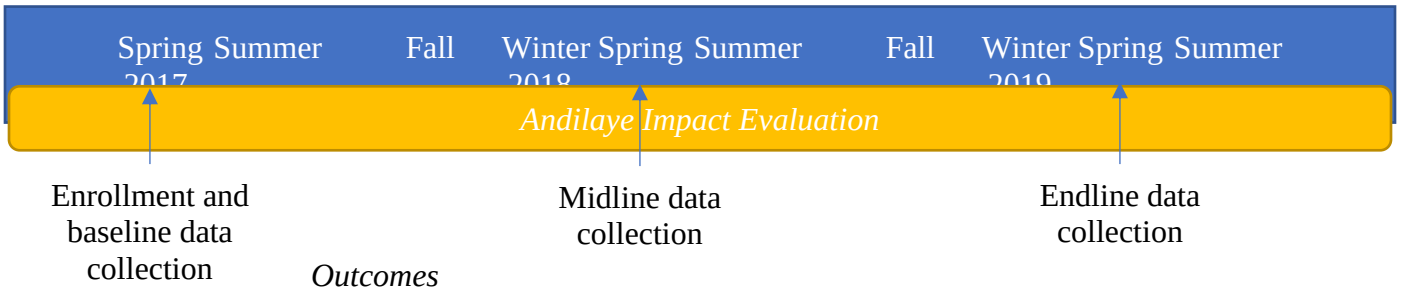
The Andilaye Trial was carried out in Ethiopia between spring 2017 and summer 2019. The parallel cluster-randomized trial selected and assigned 50 sub-districts from three purposively selected districts; half to receive the Andilaye intervention, and half to receive the standard of care sanitation and hygiene programming (7). The Intention-to-treat analysis was followed from baseline to midline to endline comparing targeted sanitation and hygiene behaviors between the intervention arm to the control arm. Despite having intention-to-treat data comparing intervention arm to the control arm at three stages of the intervention, the data was never analyzed longitudinally. In addition, most current WASH interventions also adopt intention-to-treat analysis instead of longitudinal analysis. In general, most analysis on Community-Led Total Sanitation (CLTS) programs treat pre surveys and post surveys separately using the intention-to-treat analysis. For example, the Ghaha cluster randomized trial study that examined the psychosocial determinants between CLTS arm and control arm opted in using the intention-to-treat analysis instead of focusing on the changes of the determinants over time (5). The changes of the outcome variables over time provided the data are correlated was not analyzed properly

(4). In addition, besides the lack of WASH coverage on mental and behavioral uptake, there is also a lack of comparison arms cluster-randomized trial on novel interventions and CLTS. The Ghaha cluster randomized trial examined the CLTS and the control arms (5). While the Bangladesh cluster randomized trial examined the novel intervention and the control arms (4). However, the Andilaye Trial in Ethiopia aims to compare the differences in the effectiveness of the Andilaye intervention (a novel intervention) and the CLTS. longitudinal analysis was performed on this sub-study paper to compare the effectiveness of the Andilaye intervention, a novel intervention, and the CLTS, government-backed, low-cost, and locally acceptable approaches for improving sanitation and hygiene. The research questions of the longitudinal analysis in this sub-study was two-fold: 1) to examine the effects of the Andilaye intervention on targeted sanitation and hygiene behaviors over time, and 2) to compare trends in behavior across study arms (i.e., between interventions and control clusters).

Methods

Background

The data collection process for the parent study, the Andilaye Trial, consists of three-stage data collection processes, baseline, midline and endline. The timeline below shows the timeframe between baseline to midline to endline data collection:



The behavioral outcomes selected to conduct longitudinal analysis were latrine usage, handwashing practices and facewashing practices. Two latrines usage variables were created based on answers to the three questions on latrine usage (see Appendix A for details). The third and the fourth variable, handwashing practices, dichotomous variables, were created based on answers to the two questions on handwashing (see Appendix A for details). The fifth variable, facewashing practices, a dichotomous variable, was created based on answers to the two questions on facewashing (see Appendix A for details). The table below shows the types of these five variables and how each variable was coded based on answers to questions:

Five Behavioral Outcome Variables of Interests in the model	**Reported vs. Observed**	**Variable Types**
Exclusive Latrine Usage	Reported	Dichotomous: 0 = Does not exclusively use latrine but does use latrine 1 = Does exclusively use latrine
Any Latrine Usage	Reported	Dichotomous: 0 = Does not use any latrine (openly defecate) 1 = Use any latrine

Handwashing Practices after Defecation	Reported	Dichotomous: 0 = never wash hands after defecation 1 = wash hands after defecation with soap
Handwashing Practices before Food Preparation	Reported	Dichotomous: 0 = never wash hands after food preparation 1 = wash hands after food preparation with soap
Facewashing Practices	Reported	dichotomous 0 = Never washed index children's face yesterday 1 = washed index children's face yesterday with water

Univariate Analysis

Univariate analyses were performed to the above five behavioral outcome variables as well as the variables considered as potential confounders and effect modifiers for the relationships between to the behavioral outcome variables and intervention. Those variables were sex, age,

water insecurity, presence of water at handwashing/facewashing stations, household numbers and household latrine numbers.

The distributions of these variables were examined and assessed for normality. In addition, five other behavioral outcome variables that were not of interests to include in the longitudinal model were also selected to conduct the univariate analyses. These five behavioral outcome variables were open defecation, observed hand cleanliness (composite indicator of hand cleanliness), observed facial cleanliness (composite indicator of facial cleanliness), facial cleanliness measured via a novel personal hygiene metric, and hand cleanliness measured via a novel personal hygiene metric. The first of these five other behavioral outcome variables, open defecation, was created based on answers to the question on open defecation (see Appendix B for details). The second variable, observed hand cleanliness, was created based on answers to six observational questions on dirts on index children's hands (see Appendix B for details). The third variable, observed facial cleanliness, was created based on answers to four observational questions on discharge/debris on index children's faces (see Appendix B for details). The fourth and the fifth variables, facial cleanliness and hand cleanliness measured via a novel personal hygiene metric, were measured using the 11-point brown scale. Overall, the table below shows the types of these five variables:

Five Other Behavioral Outcome Variables included in Univariate Analyses	**Reported vs. Observed**	**Variable Types**
Open Defecation	Reported	Dichotomous 0 = no open defecation

		1 = open defecation
Observed Hand Cleanliness	Observed	Dichotomous 0 = no dirts at all 1 = dirts observed within finger nails, finger pads or hand palms
Observed Facial Cleanliness	Observed	Dichotomous 0 = no discharge/debris at all 1 = discharge/debris present
Facial Cleanliness Measured via a Novel Personal Hygiene Metric	Reported	Discrete (1-11)
Hand Cleanliness Measured via a Novel Personal Hygiene Metric	Reported	Discrete (1-11)

Multivariate Models

After univariate analyses, Longitudinal GEE models were performed in Stata. GEE models were selected instead of GLM models because GEE models were best suited to model correlated data. And in this case, our outcome variables like latrine usage, facewashing practices and

handwashing practices were collected through three trials which suggests correlated data as there were multiple data collection processes on the same participant. Thus, GEE models were a better fit than GLM models. Mixed models were not selected because we were not interested in how much our data was correlated and we were not interested in modeling the heterogeneity in our study populations. There were a total of ten models (five for datasets with male participants only and five others for datasets with female participants only).

The formula for Model 1 (male) and 2 (female) can be presented as : $logit$(Exclusive Latrine Usageij) = β0 + β1Interventionij + β2$Ageij$ + β3household numbersij + β4household latrine numbersij + e_{ij}

The formula for Model 3 (male) and 4 (female) can be presented as: $logit$(Any Latrine Usageij) = β0 + β1Interventionij + β2$Ageij$ + β3household numbersij + β4household latrine numbersij + e_{ij}

The formula for Model 5 (male) and 6 (female) can be presented as: $logit$(Hand Washing After Defecationij) = β0 + β1Interventionij + β2$Ageij$ + β3water insecurityij + β4Presence of water at stationij + e_{ij}

The formula for Model 7 (male) and 8 (female) can be presented as: $logit$(Hand Washing Before Food Preparationij) = β1Interventionij + β2$Ageij$ + β3water insecurityij + β4Presence of water at stationij + e_{ij}

The formula for Model 9 (male) and 10 (female) can be presented as: $logit$(Facewashing with Waterij) = β0 + β1Interventionij + β2$Ageij$ + β3water insecurityij + β4Presence of water at stationij + e_{ij}

Each of two models (male and female) corresponds to each of the five behavioral outcome variables of interests. Age, household numbers, household latrine numbers, water insecurity and

presence of water at stations were treated as potential confounders in the models. Unstructured covariance structure was selected because j was small (j=3) and our data was balanced. In addition, by checking the QIC for each model with different covariance structures, models with unstructured covariance structure has the smallest QIC and thus was chosen as the best-fitting model to the data. However, robust standard errors were still employed for possibility that the working covariance structure (unstructured) was mis-specified. Robust estimators could also enable us to compare empirical standard errors and model based standard errors to correct for possible misspecification. A post hoc power calculation was also conducted based on longitudinal mixed-effects models adjusted to the final sample size, actual data variability and clustering showed that the study has a power greater than 95% to detect a minimal difference between intervention and control groups.

Ethics

Because this longitudinal study acts as the sub-study of the Andilaye Trial. Thus, only ethical approval for the Andilaye Trial was required and needed. As for the ethics for the Andilaye Trial, all study participants were provided with full details regarding the study as well as their rights as study participants. Consents were obtained orally due to low literacy rates of the study population. Confidentiality were ensured among all study participants. And the ethical approval for the Andilaye Trial was provided by Emory University, the London School of Hygiene & Tropical Medicine and locally by the ARHB.

Results

Sample size

A sample size of 1472 households with a total of 1562 individuals (1417 are female, 145 are male) were enrolled in the endline data collection and still had data from the baseline and

midline data collection. Data on exclusive latrine usage, any latrine usage, handwashing after defecation, handwashing after food preparation and facewashing with water within baseline, midline and endline trials are shown in the Supplement Table 1.

Results from univariate analyses

From the Supplement Table 1, the percentage of individuals in both handwashing after defecation and handwashing before food preparation increased by a relatively large margin. The percentage of handwashing after defecation in total population improved from 37.2% in baseline, to 43.3% in baseline and in the end, to 49.0% in endline. The changes in handwashing practices after defecation were statistically significant. Similarly, the percentages of handwashing after food preparation in total population improved from 40.0% in baseline, to 45.2% in midline and in the end, to 51.1% in endline. The changes in handwashing before food preparation were also statistically significant. Besides the handwashing after defecation and handwashing before food preparation, the improvements from exclusive latrine usage, any latrine usage and facewashing with water are not meaningfully significant with < 3% increase from baseline to endline. The percentage graph showing the trends from baseline to midline to endline data is shown below presented in Figure 1:

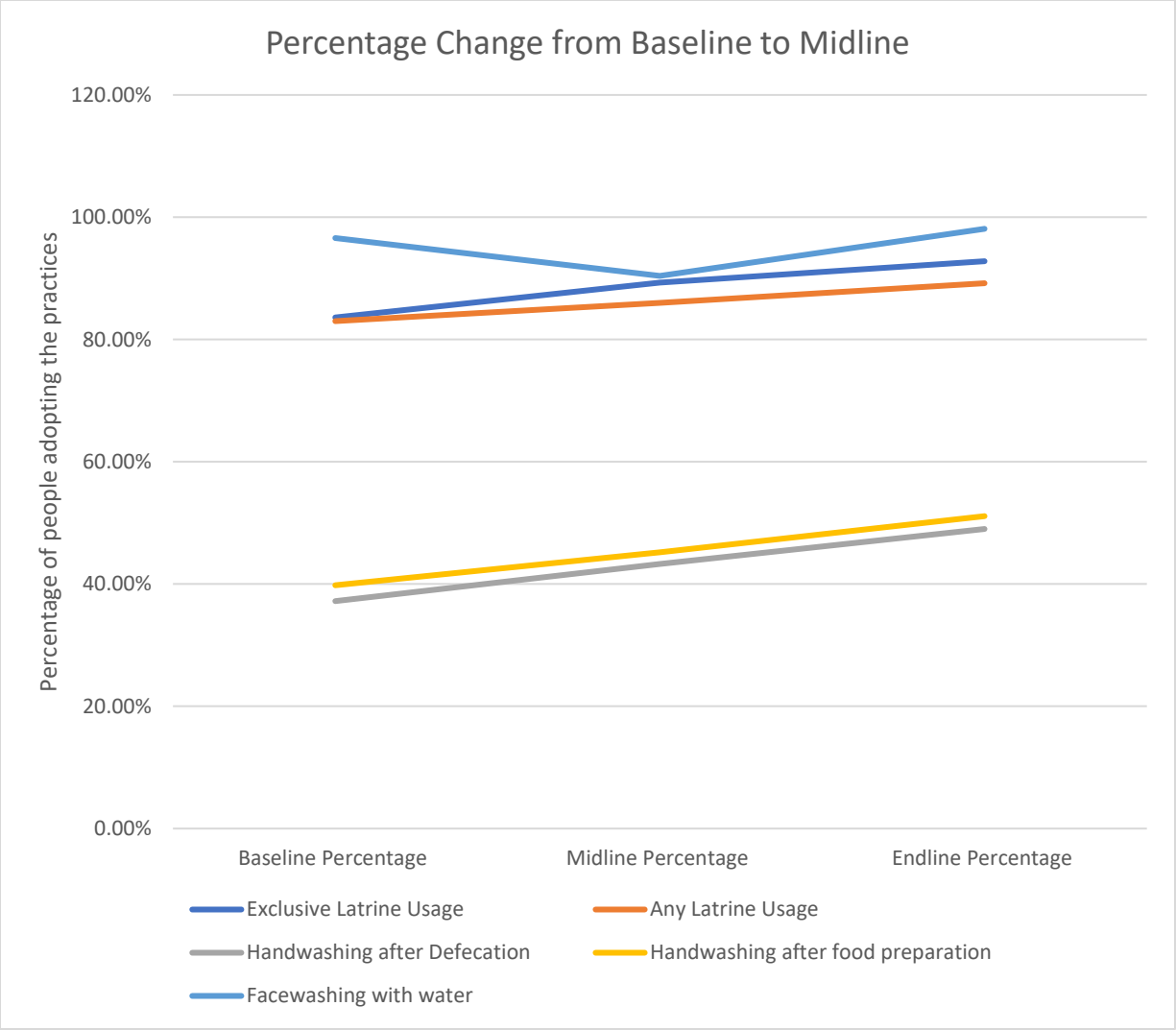


Figure 1: Percentage Change from Baseline to Midline for Outcome Variables

Results from GEE models

In addition, the Supplement Table 2 was generated summarizing the odds ratios and the 95% confidence intervals (within the parentheses) for the ORs for the ten GEE models. The GEE models revealed that the handwashing practices after defecation among female participants (odds ratio [OR] = 1.33; 95% confidence interval [CI] = 1.13 to 1.44), handwashing practices before food preparation among female participants(OR = 1.37, 95% CI of 1.16 to 1.48), and facewashing practices among female participants (OR = 1.53, 95% CI of 1.02 to 1.82) were significantly associated with the intervention arm of the Andilaye Trial. However, as shown in

the Supplement Table 2, all the odds ratios obtained among male participants indicated statistically insignificant association between the five outcome variables and the Andilaye intervention arm. Similarly, the odds ratios obtained among female participants on latrine usage (exclusive & any) also indicated statistically insignificant association between these two outcome variables and Andilaye intervention arm. Overall, The results of GEE models remained robust under GEE modeling. Model selection was facilitated in QIC using a goodness-of-fit statistic.

Discussion

This study investigated the intervention effect of the Andilaye WASH intervention on five behavioral outcome variables: exclusive latrine usage, any latrine usage, handwashing after defecation, handwashing before food preparation and facewashing with water.

Our results provided answers to our two research questions. As for the first research question, comparing trends of behavioral outcomes across study arms, Figure 1 within the results section represented the trends of behavioral changes over time across study arms. Most behavioral outcomes steadily increased from baseline to midline to endline except facewashing with water where the percentage dropped at midline data collection. As for the second research question, examining the effects of the Andilaye intervention on targeted sanitation and hygiene behaviors over time, our results from the GEE models suggested that three sanitation and hygiene behaviors were positively associated with the Andilaye intervention over time among female participants only. These three behavioral outcome variables are handwashing after defecation, handwashing before food preparation and facewashing.

Compared to other similar studies, our study shared some similarities but also presented contrasting results. In terms of similarities, the improved practices of handwashing before

defecation and facewashing with water were consistent with the results found in a study conducted in Bangladesh during 2018 examined exclusively on the degree of technology and behavioral uptake among participants over a 20-month period. However, in terms of differences, many other similar studies presented the unsustainable handwashing habits. A study conducted in Laos focusing on school-wide WASH intervention during 2018 concluded the unsustainable of improved handwashing (8). Another similar WASH intervention study conducted in Mali also observed peak handwashing practices at midline instead of endline, in which contrasted against our study result as the handwashing practices in our study peaked at endline. Old WASH intervention studies like the randomized cluster controlled trial conducted in Karachi, Pakistan in 2009 also reported similar results (9). The study conducted in Pakistan reported that although intervention households showed better handwashing technique, the difference was not statistically significant from controls (9). Our study also failed to report a statistically significant relationship between the change of latrine usage and intervention. While studies like the ones conducted in Laos in 2018 were able to come up with statistically significant relationships between WASH interventions and toilet usage in school.

The study provided evidence for the success of the Andilaye Trial on the improvement of handwashing and facewashing practices. As noted in the results section, there are evidences supporting the positive relationship between the Andilaye intervention and handwashing practices after defecation, handwashing practices before food preparation and facewashing with water. However, the study lacked statistically significant evidence to support the impact of the Andilaye Trial on latrine usage, both exclusive latrine usage and any latrine usage. The strength of the study was the reliability of the GEE models with the robust standard errors that strengthen our estimations of betas. The cluster randomization also strengthened the external validity of the

findings and the data by preventing community differences interfering with the intervention effects (10).

The study also had some limitations. Due to the variations between the sample size of male and the sample size of female, the statistical significance can hardly be met among models focused on male participants. Thus, the random error could be too much to overcome during the modeling process on male participants while resulted in statistical insignificance of models 1, 3, 5, 7, and 9, which were all models focused on male participants. In addition, all the five behavioral outcome variables were self-reported and not directly observed, potentially overestimating uptake considering the reporting bias. In addition, if the Andilaye intervention were delivered under suboptimal conditions, a limitation of efficacy could also be present (10). For future WASH cluster randomized trial, it is recommended to enroll same or similar amount of male and female participants to ensure both sample sizes of male and female participants are large enough so that random error could be neglected. In this case, according to a paper on p-value and 95% implication, the larger the sample size, the more likely a study will find a significant relationship if one exists (11).

Despite the limitations, the statistically significant results indicated that the Andilaye intervention can sustainably improve individuals' WASH behaviors, especially handwashing and facewashing practices over time in a positive way. We can see that for the Andilaye Trial, individuals in the intervention arms were more likely to wash hands after defecation and before food preparation in the end compared to individuals in the control arms over time. This result implied that the Andilaye intervention is already successful and further showed that the effects of improved WASH behaviors over time can be achieved through well-made WASH interventions like the Andilaye intervention. The result also implied that handwashing and facewashing are the

most successful WASH behaviors that were targeted by the Andilaye Trial. Thus, future WASH interventions should look upon the design of the Andilaye Trial if handwashing and facewashing practices are the WASH behaviors these interventions trying to target. However, further WASH interventions that implemented similarly in Amhara, Ethiopia, like the Andilaye Trial, should be carried out with an extra step to further target specified WASH behaviors like latrine usage as this WASH behavior is not as easily to be improved as handwashing and facewashing and require more efforts to prompt a change on those behaviors over time.

References

1. United Nation. (2014). *Water, Sanitation and Hygiene 2014* (Water Facts). UN Water.
2. United Nations Development Programme. (2020). *Goal 6: Clean Water and Sanitation.* Sustainable Development Goals.
3. Andres, L., Borja-Vega, C., Fenwick, C., de Jesus Filho, J., & Gomez-Suarez, R. (2018). Overview and meta-analysis of global water, sanitation, and hygiene (WASH) impact evaluations. The World Bank.
4. Parvez, S. M., Azad, R., Rahman, M., Unicomb, L., Ram, P. K., Naser, A. M., ... & Winch, P. J. (2018). Achieving optimal technology and behavioral uptake of single and combined interventions of water, sanitation hygiene and nutrition, in an efficacy trial (WASH benefits) in rural Bangladesh. Trials, 19(1), 358.
5. Harter, M., Inauen, J., & Mosler, H. J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. Social Science & Medicine, 245, 112705.
6. Badejo, M. A., Kadir, M., & Tembo, M. V. Developing the UNICEF Malawi school handwashing program Dr Joy Parkinson1 Mr Philip C. Mkandawire2 Dr Timo Dietrich1.
7. Delea, M. G., Snyder, J. S., Belew, M., Caruso, B. A., Garn, J. V., Sclar, G. D., ... & Freeman, M. C. (2019). 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, 19(1), 801.
8. Chard, A. N., & Freeman, M. C. (2018). Design, intervention fidelity, and behavioral outcomes of a school-based water, sanitation, and hygiene cluster-randomized trial in Laos. International journal of environmental research and public health, 15(4), 570.

9. Luby, S. P., Agboatwalla, M., Bowen, A., Kenah, E., Sharker, Y., & Hoekstra, R. M. (2009). Difficulties in maintaining improved handwashing behavior, Karachi, Pakistan. The American journal of tropical medicine and hygiene, 81(1), 140-145.
10. Harter, M., Inauen, J., & Mosler, H. J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. Social Science & Medicine, 245, 112705.
11. Thiese, M. S., Ronna, B., & Ott, U. (2016). P value interpretations and considerations. Journal of thoracic disease, 8(9), E928.

Appendix A

Latrine Usage Questions:

1. During the last two days, did you openly defecate?
2. During the last two days, did you defecate in any latrine?
3. During the last 7 days, including today, did you always exclusively use a latrine for defecation?

Handwashing questions:

1. The last time you defecated, did you clean your hands with water and soap, soapy water, or ash?
2. The last time you prepared food, did you clean your hands with water and soap, soapy water, or ash before beginning the food preparations?

Facewashing questions:

1. Yesterday, did the index children's face get cleaned by you, the child, or anyone else?
2. Yesterday, how did the index children's face get cleaned?

Appendix B

Open Defecation Questions:

1. During the last two days, did you openly defecate?.

Observed Hand Cleanliness Questions:

1. Were there any dirts observed on left hand finger nails?
2. Were there any dirts observed on right hand finger nails?
3. Were there any dirts observed on left hand finger pads?
4. Were there any dirts observed on right hand finger pads?
5. Were there any dirts observed on left hand palms?
6. Were there any dirts observed on right hand palms?

Observed Facial Cleanliness Questions:

1. Was there any discharge/debris present on the face?
2. Was there any wet nasal discharge present on the face?
3. Was there any dry nasal discharge present on the face?
4. Were there any other dirt/dust/debris present on the face?

Supplement Table 1. Baseline, midline and endline univariate statistics by sex on individual levels (person) (*n* = 1,562)

Sex	Basline					Midline					Endline				
	Exclusive Latrine Usage N(%)	Any Latrine Usage N(%)	Handwashing after Defecation N(%)	Handwashing before food preparation N(%)	Facewashing with water N(%)	Exclusive Latrine Usage N(%)	Any Latrine Usage N(%)	Handwashing after Defecation N(%)	Handwashing before food preparation N(%)	Facewashing with water N(%)	Exclusive Latrine Usage N(%)	Any Latrine Usage N(%)	Handwashing after Defecation N(%)	Handwashing before food preparation N(%)	Facewashing with water N(%)
Male	56(72.7%)	38(65.5%)	36(25.2%)	31(22.0%)	128(98.5%)	76(86.4%)	56(91.8%)	62(44.3%)	61(46.2%)	126(92.6%)	77(95.1%)	61(95.3%)	59(43.1%)	56(43.4%)	131(99.2%)
Female	691(84.6%)	498(84.7%)	543(38.4%)	589(41.5%)	1324(95.4%)	750(89.6%)	480(85.4%)	582(43.2%)	576(45.1%)	1200(93.7%)	712(92.6%)	492(99.5%)	658(49.6%)	661(51.8%)	1246(98.0%)
Total	747(83.6%)	536(83.0%)	579(37.2%)	620(39.8%)	1452(96.6%)	826(89.3%)	536(86.0%)	644(43.3%)	637(45.2%)	1281(90.4%)	789(92.8%)	553(89.2%)	717(49.0%)	717(51.1%)	1377(98.1%)

Supplement Table 2. Odds ratio on the associations between intervention/control and outcome variables among male and female participants (95% CI)

Model 1 (Exclusive latrine, male)	Model 2 (Exclusive latrine, female)	Model 3 (Any latrine usage, male)	Model 4 (Any latrine usage, female)	Model 5 (Handwashing after defecation, male)	Model 6 (Handwashing after defecation, female)	Model 7 (Handwashing before food preparation, male)	Model 8 (Handwashing before food preparation, female)	Model 9 (Facewashing with water, male)	Model 10 (Facewashing with water. female)
0.71 (-1.09 – 0.39)	0.95 (-0.32 – 0.21)	0.88 (-1.10 - 0.85)	1.22 (-0.16 – 0.56)	0.98 (-0.48 – 0.44)	1.33 (1.13 – 1.44)	1.04 (-0.37 – 0.45)	1.37 (1.16 – 1.48)	1.39 (-0.87 – 1.52)	1.53 (1.02 – 1.82)