Users of a Container-Based Sanitation Service Experience High Sanitation-Related Quality of Life: A Prospective Cohort Study in Cap Haitien, Haiti

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A thesis
submitted in partial fulfillment of the
requirements for the degree of
Master of Science

University of Washington
2025

Committee:
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Program Authorized to Offer Degree:
Epidemiology

University of Washington

ABSTRACT

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Sanitation users often value improved sanitation interventions for social benefits, such as improved safety and dignity. Some sanitation providers have started using well-being measurements to evaluate service impacts beyond infectious disease outcomes. In particular, the Sanitation Quality of Life (SanQoL) Index explores five attributes associated with sanitation wellbeing: health, disgust, shame, safety, and privacy. In this prospective cohort study we assess changes to sanitation-related quality of life among users of the EkoLakay container-based sanitation (CBS) service operating in northern Haiti.

EkoLakay staff surveyed baseline SanQoL among all households who expressed interest in joining the service. For households who proceeded with joining, follow-up visits were conducted >4 weeks after installation to determine endline SanQoL.

Between October 2023 and November 2024 EkoLakay gathered complete baseline and endline data from 291 customer households. Each SanQoL response was scored between 0 (worst) and 3 (best). The difference between baseline and endline SanQoL overall and attribute-specific scores were calculated for each household and changes to their sanitation-related quality of life were assessed using paired t-tests. Multivariate regression controlling for socio-economic factors were conducted to explore how prior sanitation access is associated with changes to sanitation-related quality of life.

The mean difference in cumulative SanQoL score between baseline and endline was 7.88 (95% CI: 7.32-8.45), representing a substantial overall improvement after joining the CBS service. Households who practiced open defecation prior to joining EkoLakay experienced the greatest improvement in SanQoL scores (mean difference 10.22, 95% CI: 9.42-11.03).

This research suggests that CBS is associated with substantially higher quality of life of users in northern Haiti, particularly among the most vulnerable who did not previously have access to any sanitation facility. The results also support the use of measurements such as SanQoL, that explore improvements to users' wellbeing, when evaluating the overall impact of sanitation interventions.

I. INTRODUCTION

The United Nations recognizes the human right to safe water and sanitation, and to realize that vision, the goal of the Sustainable Development Agenda target six (SDG6) is to ensure the availability of sustainably managed water and sanitation for all by 2030 (1,2). However, as of 2020, the UNICEF-WHO Joint Monitoring Program (JMP) estimates that nearly half of the world's population still lacks access to safely managed sanitation services and a quadrupling of efforts is needed to meet the 2030 goals (3). Accelerating progress has been particularly challenging in low- and middle-income countries and fragile contexts, where violent conflict and institutional fragility hinder sustainable development (3–5). The Citywide Inclusive Sanitation (CWIS) framework aims to shift global sectoral perspectives on improving equitable urban sanitation access. The initiative values a variety of technologies across the full sanitation service chain, beyond centralized sewage, that together can rapidly improve urban sanitation outcomes, including in fragile contexts (6).

Haiti is an extremely fragile low-income country that faces major sanitation challenges (3,7). As of 2020, an estimated 18% of the Haitian population practiced open defecation and less than 0.1% of excreta was safely managed (3,8). Densely populated urban areas pose unique challenges for providing safe sanitation, and in urban Haiti, centralized water-based technologies, such as sewers, are non-existent and would be inappropriate and unaffordable to implement due to engineering constraints (9).

Container-based sanitation (CBS) - recently recognized by the JMP as an official form of non-sewered improved sanitation - is one alternative to centralized sanitation services. CBS involves collecting waste in sealable, removable containers that are regularly transported to a safe disposal or treatment site (10). CBS services are currently being implemented in 13 countries across Africa, Asia, Europe, and Latin America (11). SOIL, a non-profit research and development organization, provides a CBS service called EkoLakay to over 3200 urban and peri-urban homes throughout Cap Haitien, Haiti (12). SOIL is currently the only safely managed sanitation provider that addresses the entire sanitation service chain, from containment to treatment, in all of Haiti.

CBS organizations like SOIL have investigated the viability of their services in an effort to make CBS more common and increase its acceptance as an appropriate solution to global gaps in safe urban sanitation provision. SOIL has found high levels of user acceptance and public demand for the EkoLakay service: one study found that over 94% of EkoLakay subscribers would recommend the service to a friend or neighbor (8,9). A study on customer attrition also found that many EkoLakay subscribers who practiced open defecation prior to joining the service and later left the service constructed their own private latrines, indicating that EkoLakay is a mechanism for sanitation behavior change and that the service builds demand for other forms of improved sanitation (8).

While sanitation interventions have the potential to reduce the burden of infectious diseases within a community, sanitation users often value improved sanitation interventions for other personal benefits, such as improved safety, cleanliness, and dignity (13,14). Some sanitation providers have thus recognized the importance of incorporating well-being measurements when assessing the impact and economic viability of their sanitation services (15,16). Little is known about the impact of CBS services on the quality of life of users and their surrounding community-members.

The Sanitation Quality of Life (SanQoL) index is one measure of sanitation well-being, initially developed in Mozambique and since validated in several urban and rural settings in countries including Ethiopia, Malawi, and Zambia (14,17,18). The index was informed by what people in low-income urban settings value most about safe sanitation services and consists of five questions that cover core quality of life attributes associated with sanitation, namely health, disgust, shame, safety, and privacy (19). Prior research using the SanQoL index has confirmed that various sanitation interventions have been associated with improvements in SanQoL, validating the potential to use this tool for impact assessments (14,16,17).

One CBS organization operating in Kumasi, Ghana recently used the SanQoL index to understand user experiences with their service in terms of both quality of service and quality of life (20). Among self-selected customers, SanQoL scores significantly increased across all five attributes, with the largest improvement in the shame category (20). While these findings provide promising evidence that CBS can improve quality of

life for users, to date, other CBS organizations operating in different contexts have yet to explore how their respective services may improve SanQoL among their users. Furthermore, there is limited evidence on the impact of improved sanitation interventions on quality life within urban centers in fragile contexts such as Haiti, where sanitation provision challenges are the greatest.

The primary aim of this study is to assess the extent of changes in sanitation quality of life among self-selected users of SOIL's CBS service, called EkoLakay, in Cap Haitien, Haiti before and after a CBS toilet is installed in their home. A secondary aim of this study is to assess which CBS households experience the greatest change in sanitation-related quality of life, particularly regarding their sanitation practices prior to joining EkoLakay. These results will contribute to the evidence-base exploring whether CBS is associated with positive change in the lives of residents in urban fragile contexts.

II. METHODS

Study Setting

The EkoLakay CBS service has been operating since 2011 in urban and peri-urban neighborhoods of Cap Haitien, Haiti. Cap Haitien is Haiti's second largest city, with a population estimated at over 274,000 as of 2015 (21). Neighborhoods served by EkoLakay are generally characterized as flood-prone, densely populated, and with low income levels and sanitation coverage. There is no sewage infrastructure in Cap Haitien, and it is estimated that only 1% of the city's waste is safely contained and treated (22). Common sanitation practices in the region include open defecation,

accessing shared or public latrines, and private flush toilets without a connection to a centralized wastewater system (8). EkoLakay is a subscription-based sanitation service, charging households a fee of about $2.50 USD per month for weekly waste collection and provision of cover material. The study coincided with a notable service expansion due to a pilot results-based financing initiative. At the start of the study period in November 2023, EkoLakay served just over 2300 households and expanded to over 3200 households by the end of the study period in November 2024.

Study Design

We conducted a prospective cohort study among households who joined the EkoLakay CBS service. Between October 1, 2023 and November 1, 2024, baseline SanQoL data was collected for all households who expressed interest in joining the service by EkoLakay customer service agents. For households who proceeded with a CBS toilet installation, endline SanQoL data was again collected by EkoLakay customer service agents during a follow-up visit any time after four weeks in the service, to allow for adjustment to a new type of sanitation prior to data collection. The outcome of interest for this study was the SanQoL Index (Table 1). The five SanQoL questions were translated by native speakers of Haitian Creole and a training was conducted with EkoLakay's customer service agents to familiarize them with the questions and the objectives of the research.

Table 1. Sanitation Quality of Life Index questions and response options with associated scores. Questions referred to primary sanitation used prior to joining SOIL's service at baseline and the EkoLakay Container Based Sanitation toilet at endline.

Attribute	**Question**	**Responses**
Disgust	How often do you feel disgusted while using the toilet?	Always = 0 Sometimes = 1 Rarely = 2 Never = 3 Refuse = NA
Disease	How often do you worry that the toilet spreads disease?	
Privacy	How often do you worry about being seen while using the toilet?	
Shame	How often do you feel ashamed about using the toilet?	
Safety	How often do you feel unsafe while using the toilet?	

Other variables collected at baseline are the number of people residing in the household, whether someone in the household owns a smartphone (used in this analysis as proxies for socioeconomic status), and urbanicity of household location defined by the EkoLakay field staff. The type of sanitation the household primarily relied on prior to joining the EkoLakay service was also recorded, including whether they used a private, shared, or public toilet, or practiced open defecation. According to the JMP sanitation service ladder, whether a sanitation facility is shared among households is an important component of sanitation safety classification, regardless of the physical infrastructure itself. Households with private sanitation facilities are recognized as having better sanitation access than those who use shared, public, or no facility at all (23).

All data were collected using the TaroWorks mobile-based data collection software, which generates a unique identifying code for each household and integrates with EkoLakay's Salesforce database upon establishing an internet connection. A minimum

sample size of 199 households was determined sufficient to conduct a paired t-test with 80% power to detect a minimum change in mean cumulative SanQoL score of one point with expected standard deviations of 5 for both scores, assuming a default correlation of 0.5 between baseline and endline measurements.

Study Subjects

The subjects of this study consisted of self-selected households who joined EkoLakay's CBS service between October 2023 and November 2024 and had a follow-up visit conducted by customer service agents at least four weeks after joining the service. During the study period, baseline SanQoL data was collected for households who joined the service, however, due to operational constraints EkoLakay service agents only completed the follow-up visits where endline SanQoL data was collected for a subset of the new customer households. Only households with both baseline and endline SanQoL data were included in this analysis. We compared the baseline demographics of those included in the analysis to those of the households without a follow-up visit using chi-squared and t-tests in order to assess the comparability of the study sample to the overall new customer population.

Data Analysis

We used R Studio version 2024.12.1.563 for all analyses (24). In addition to presenting descriptive statistics, we calculated the attribute-specific and cumulative SanQoL change over time for each household, and conducted paired t-tests to assess those differences. Finally, to assess predictors of change to SanQoL we conducted

multivariate least squares linear regression with robust standard errors to estimate the association between prior sanitation ownership and cumulative SanQoL score delta to understand which households experienced the greatest change after controlling for potential socioeconomic confounding. Missingness was handled using a complete case analysis.

Ethical Considerations

SOIL collected all data used in this analysis as part of their standard operational procedures. Respondents were informed that all questions were optional to answer and refusal to answer would not have an impact on their ability to join or retain access to the CBS service. Respondent names and contact information were initially collected as part of the intake form, at which point they were also given a unique identifying customer code. All data analyzed for this study was anonymized, using the unique customer codes generated by TaroWorks to identify respondents and link endline to baseline data. This study posed minimal risk to participants and survey questions were not sensitive in nature. This study's analysis was determined exempt by the University of Washington Human Subjects Division (IRB ID: STUDY00020302).

III. RESULTS

Descriptive Statistics

Baseline SanQoL data was collected for 1409 households who joined the service during the study period and endline SanQoL data was collected for 435 of the new customer households. The EkoLakay team did not encounter specific barriers to accessing

particular households for follow-up; instead, shifting operational priorities limited their capacity, resulting in follow-up visits to a subset of households that was largely selected at random. Among the 435 households with both baseline and endline recorded data, on average, they installed a CBS toilet 2.4 days (SD: 2.4) after expressing interest in the service and completing the intake form. Endline SanQoL data was collected an average of 71.1 days after the household had their CBS toilet installed (median: 49, IQR: 33-94).

Most customer households lived in urban service zones (67.4%) and had someone in the household who owned a smartphone (61.1%) (Table 2). The mean number of people living within each household was 4.71 (SD: 1.96). Prior to joining EkoLakay, 120 households (27.6%) reported practicing open defecation as their primary form of sanitation, followed by 113 households (26.0%) who used a latrine, and 95 households (21.8%) did not report the primary type of sanitation facility they used prior to joining the service. Only 82 (18.9%) of respondent households reported owning a private toilet prior to installing a CBS toilet in their home, compared to 128 households (29.4%) who reported using a shared toilet as their primary sanitation access. Over one third of households (155, 35.6%) reported not owning or using any type of toilet, suggesting practice of open defecation. The households included in this analysis were comparable in terms of number of residents and type of prior toilet used compared with those excluded due to lack of follow-up (Table S1 in the supplemental appendix). However, a statistically significantly higher proportion of the included households lived in a rural area, owned a smartphone, and previously used a private toilet than the excluded households.

Table 2. Characteristics of participants included in the analysis.

	Overall (N=435)
Urbanicity	
Rural	142 (32.6%)
Urban	293 (67.4%)
Number of people living in home	
Mean (SD)	4.71 (1.96)
Median [Min, Max]	4.00 [1.00, 15.0]
Type of phone owned	
Non-smartphone	168 (38.6%)
Smartphone	266 (61.1%)
Missing	1 (0.2%)
Type of toilet previously used	
Flush	47 (10.8%)
Latrine	113 (26.0%)
Open defecation	120 (27.6%)
Other	60 (13.8%)
Missing	95 (21.8%)
Ownership of toilet previously used	
Private	82 (18.9%)
Shared	128 (29.4%)
Public	32 (7.4%)
None	155 (35.6%)
Missing	38 (8.7%)

SanQoL Change Over Time

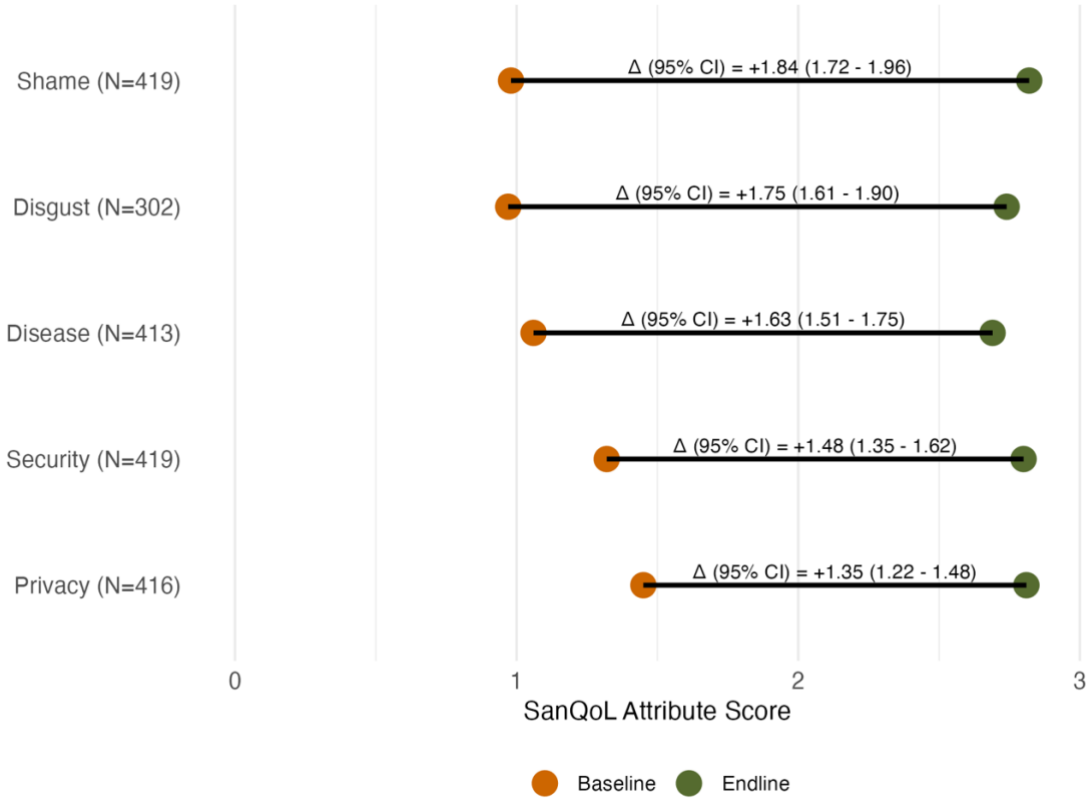
We excluded households with missing responses to any of the SanQoL attributes or covariates from the analyses involving the cumulative SanQoL score (n=144) resulting in a sample size of 291 households who provided complete responses to all attributes at both time points. Ranging from 0 (worst quality) to 15 (best quality), the mean cumulative baseline and endline SanQoL scores among the 291 households were 5.87 (SD: 4.58) and 13.87 (SD: 1.90), respectively, corresponding to a mean score increase of 7.88 (95% CI: 7.32 – 8.45). Results from paired t-tests comparing baseline and endline scores across all individual attributes as well as cumulative scores indicate that the observed changes were all statistically significant (Table 3).

Ranging from 0 (worst quality) to 3 (best quality), on average the SanQoL scores for each individual attribute increased from baseline to endline. The largest improvement was observed in the shame category, with a mean score improvement of 1.84 (95% CI: 1.72 – 1.96) among 419 respondent households, followed by the disgust category, with a mean score improvement of 1.75 (95% CI: 1.61 – 1.90) among 302 respondent households (Figure 1). The category with the least observed change was privacy, with a mean score improvement of 1.35 (95% CI: 1.22 – 1.48.

Table 3. Results of paired t-tests comparing baseline to endline SanQoL scores.

Attribute	N	Mean Difference	95% CI Lower	95% CI Upper	P-Value
Cumulative	291	7.88	7.32	8.45	<0.0001
Shame	419	1.84	1.72	1.96	<0.0001
Disgust	302	1.75	1.61	1.90	<0.0001
Disease	413	1.63	1.51	1.75	<0.0001
Security	419	1.48	1.35	1.62	<0.0001
Privacy	416	1.35	1.22	1.48	<0.0001

Figure 1. Mean change in SanQoL scores between baseline and endline for each attribute.



Predictors of SanQoL Change

When stratified by ownership status of the households' primary sanitation prior to having a CBS toilet installed, the greatest change in cumulative SanQoL scores was observed among households who reported not having access to any sanitation facility (i.e., those who likely practiced open defecation), with a mean increase of 10.22 (95% CI: 9.42 – 11.03) (Figure 2). The lowest observed change was among households who reported already owning a private toilet prior to having a CBS toilet installed, with a mean increase of 5.50 (95% CI: 3.83 – 7.17). Among households who reported not having access to any sanitation facility, the greatest improvements were observed for the shame and security attributes while those who formerly used a public toilet had the most notable improvement in the disgust attribute (Figure 3). Those who reported owning a private or shared toilet reported, on average, lower improvements to each SanQoL attribute, with the greatest increases observed for the shame and disgust attributes.

Figure 2. Mean change in cumulative SanQoL scores between baseline and endline by sanitation ownership prior to joining SOIL's CBS service.

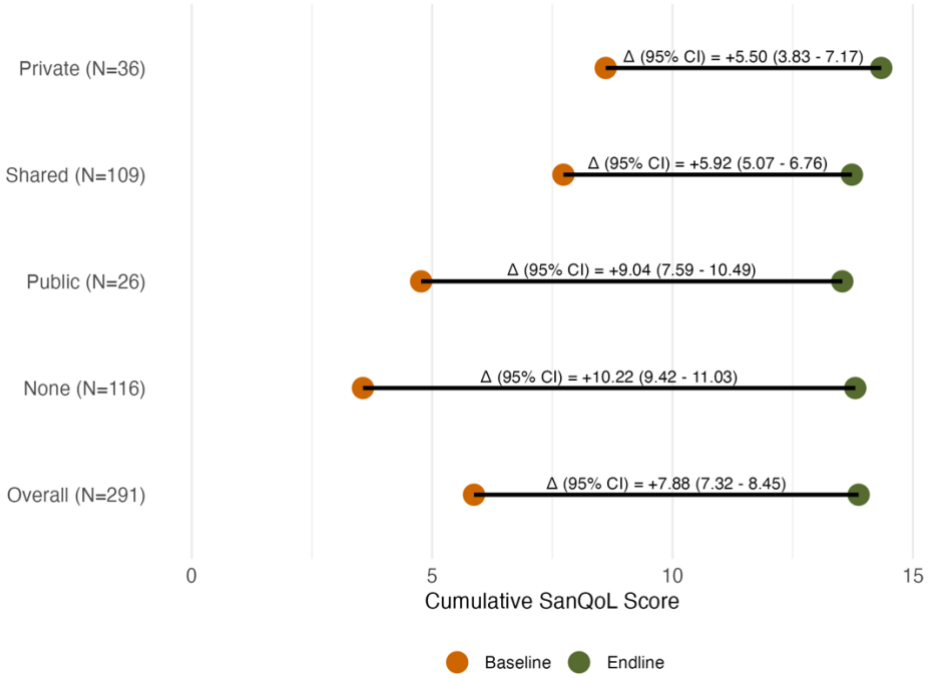
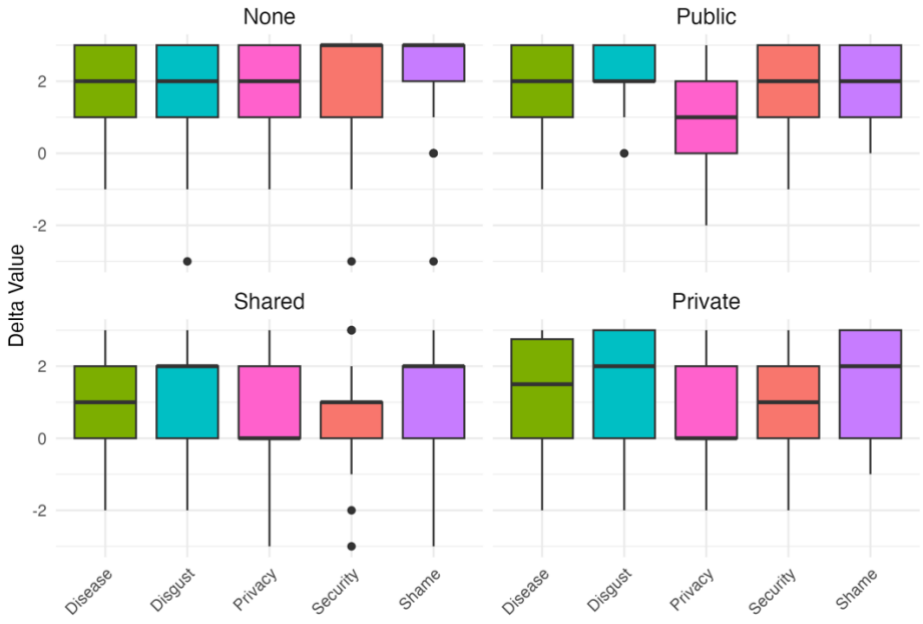


Figure 3. Distributions of change in SanQoL attribute scores by sanitation ownership prior to joining SOIL's CBS service.

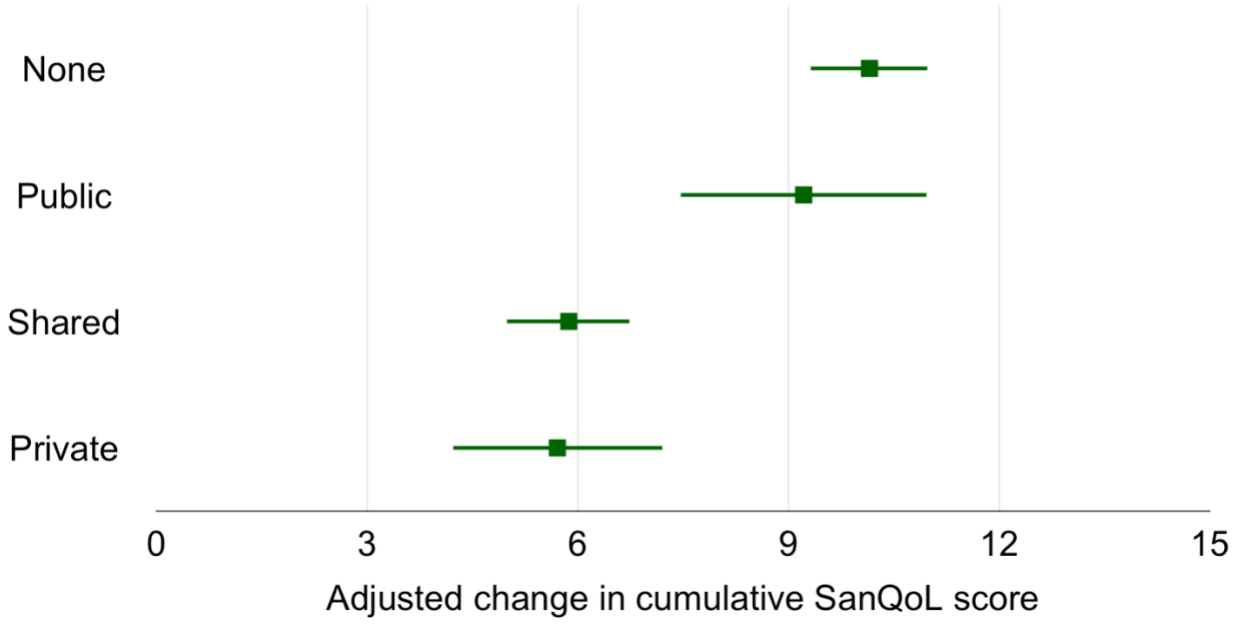


Controlling for number of household residents, urbanicity, and smartphone ownership status, the cumulative SanQoL score was 4.4 score points higher among those without a primary sanitation location prior to installing a CBS toilet compared to those who already owned a private toilet (95% CI: 2.6 – 6.3) (Table 4). Similarly, among those who primarily used a public toilet prior to installing a CBS toilet, the expected value of cumulative SanQoL score increased 3.5 score points more than those with a private toilet prior to installing a CBS toilet with the same covariate values (95% CI: 1.3 – 5.7). Figure 4 shows the absolute change in cumulative SanQoL score for households with each prior sanitation ownership status, adjusting for number of household residents, urbanicity, and smartphone ownership status. This analysis suggests that the expected change to cumulative SanQoL score after installing a CBS toilet is influenced by toilet ownership status prior to joining EkoLakay, with those who previously relied on less improved forms of sanitation experiencing the greatest improvement in sanitation-related quality of life.

Table 4. Estimated relative change in cumulative SanQoL score by subgroup according to univariate and multivariate least squares linear regression models.

Subgroup	Univariate Coefficient	Univariate P-Value	Multivariate Coefficient	Multivariate SE	Multivariate 95% CI Lower	Multivariate 95% CI Upper	Multivariate P-Value
Intercept	5.50	<0.001	4.85	1.05	2.78	6.92	<0.001
Previous Toilet: Shared (vs. Private)	0.42	0.651	0.15	0.95	-1.72	2.01	0.876
Previous Toilet: Public (vs. Private)	3.54	0.001	3.49	1.10	1.33	5.65	0.002
Previous Toilet: None (vs. Private)	4.72	<0.001	4.42	0.94	2.58	6.27	<0.001
Number of Residents in Home (+1)	0.20	0.152	0.10	0.12	-0.14	0.33	0.407
Non-Smartphone Owner (vs. Smartphone)	0.64	0.266	0.57	0.52	-0.45	1.59	0.274
Rural (vs. Urban)	1.05	0.06	0.51	0.52	-0.50	1.53	0.319

Figure 4. Estimated absolute change in cumulative SanQoL score by prior sanitation ownership, adjusted for the number of residents living in the household, smartphone ownership, and urbanicity.



IV. DISCUSSION

In this study we found substantial improvements to household sanitation-related quality of life for users who attained an EkoLakay CBS toilet, with an average overall improvement in SanQoL score of nearly 8 points out of a 15-point scale. Across all individual SanQoL attributes, household improvements to near perfect scores were observed, with the shame and disgust attributes showing the largest increases in quality of life for the overall study population. These findings align with previous research about the sanitation-related quality of life among users of a CBS service in Kumasi, Ghana, where the largest improvement among their customer base was also observed in the shame attribute (20).

While the entire study population experienced improvements to their overall and attribute-specific sanitation-related quality of life, notable differences in the magnitude of experienced improvements were observed depending on the household's sanitation practices prior to joining EkoLakay, even after adjusting for potential socioeconomic confounding factors. Consistent with expectations, those who previously relied on public facilities or open defecation experienced significantly greater improvements to their overall SanQoL score than those who had prior access to a private facility, indicating the particular benefits CBS toilets bring to those who are most vulnerable within the complex and fragile communities served by SOIL.

The overall study population experienced the least improvement in the privacy category, however those with prior access to a public facility or no facility at all experienced some

improvement, on average, while those with a private or shared facility did not experience much change upon joining EkoLakay. Those who reported previously using public toilets experienced the greatest improvement in the disgust attribute, speaking to the undesirable conditions of public toilets in the communities served by EkoLakay. The more modest improvement in the SanQoL disease category indicates that users of EkoLakay's CBS toilet perceive greater benefits to the social experience of going to the bathroom compared to the health effects of improved sanitation. Prior studies have shown that positive health outcomes associated with safe sanitation interventions may only be observed in communities upon achieving coverage of a large proportion of the population (25). These data suggest that at the household level, sanitation users similarly do not perceive extensive disease-related improvements.

The substantial overall and attribute-specific improvements observed in this study may explain a phenomenon found in a previous study on attrition among EkoLakay's customer base, whereby many households who left EkoLakay retained access to private improved sanitation. Households who join EkoLakay, but who ultimately leave, may prioritize retention of private sanitation technology that confers similar high sanitation-related quality of life (26).

An important limitation of this analysis is the quantity and timing of follow-up with households upon entering EkoLakay. Endline SanQoL data were only collected for 31% of installed households during the study period, and baseline descriptive statistics indicate they may not be representative of the overall customer population in some

aspects. For those who had a follow-up visit, endline SanQoL data was collected, on average, 2.5 months after installation, and no sooner than one month after installation. It is possible that the duration of follow-up did not adequately allow for customers to reflect on long-term benefits of the new type of sanitation, or conversely, occurred too soon after installation, reducing the possibility of a household having a negative experience with the service.

Another limitation of this study is possible favorable response bias. While the EkoLakay customer service agents assured household representatives that their responses to these questions were voluntary and would not influence their ability to join or retain access to the service, it is possible that respondents felt compelled to speak favorably about their experiences with a CBS toilet. EkoLakay's customer service agents also reported notable aversion among respondents to the translated word for "disgust" in the survey, likely explaining the relatively lower response rate to that question. A small subset of households who completed both baseline and endline SanQoL questions did not report their sanitation practice prior to joining the CBS service (8.7%). EkoLakay staff do not pressure household respondents to share their information, and lack of response to this question may be indicative of their experiences with stigma surrounding sanitation practices, particularly if they practiced open defecation. The gender of respondents was not collected for this research therefore differences in changes to sanitation-related quality of life could only be observed at the household level, according to the respondents themselves, who were presumably the heads of household. Future research on changes to sanitation-related quality of life among CBS users at the

individual level may shed light on intra-household sanitation disparities, particularly the gendered experience of sanitation. This analysis was limited only to people who chose to enroll in the EkoLakay CBS service therefore it is possible that other factors or secular trends may help to explain the observed improvements to sanitation-related quality of life beyond installation of the CBS toilet. A future randomized-control trial or controlled before-after study with a difference in differences analysis may contribute more robust evidence about the effects of CBS on household sanitation-related quality of life. Finally, as the official SanQoL Index user guide is still in development, future recommendations regarding response options and scoring procedures may differ from those employed in this study. Nonetheless, the coherence and plausibility of our findings lend support to the validity of our application of the index.

In recent years, CBS has gained recognition as an appropriate solution to urban sanitation challenges. This study contributes evidence that CBS is associated with improvements in the quality of life of people living in contexts where very few alternative sanitation options exist. This work supports the idea that it is crucial to consider the benefits of sanitation interventions, particularly container-based sanitation, beyond infectious disease outcomes, including improvements to users' dignity and safety.

ACKNOWLEDGEMENTS

The author would like to thank the members of the SOIL Research and Innovation team for their support in organizing data collection, as well as the SOIL Sales team for their efforts in gathering study data as part of their daily operations. I am also grateful to Molly Miller-Petrie for her valuable review and edits of the introduction, and to Sasha Kramer for their insightful comments and feedback throughout the development of this manuscript. Finally, I would like to thank Karen Levy and Julianne Meisner for their guidance throughout the process of completing this thesis.

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SUPPLEMENTAL APPENDIX 1

Table S1. Comparison of baseline characteristics across newly installed households included and excluded in the analysis.

	Included (N=435)	No Endline (N=974)	Total (N=1409)	p value
Urbanicity				0.007
Missing	0	5	5	
Rural	142 (32.6%)	249 (25.7%)	391 (27.8%)	
Urban	293 (67.4%)	720 (74.3%)	1013 (72.2%)	
Number of people living in home				0.063
Missing	0	5	5	
Mean (SD)	4.706 (1.961)	4.507 (1.807)	4.568 (1.857)	
Range	1.000 - 15.000	0.000 - 13.000	0.000 - 15.000	
Type of phone owned				< 0.001
Missing	1	7	8	
Non-smartphone	168 (38.7%)	498 (51.5%)	666 (47.5%)	
None	0 (0.0%)	8 (0.8%)	8 (0.6%)	
Smartphone	266 (61.3%)	461 (47.7%)	727 (51.9%)	
Type of toilet previously used				0.146
Missing	95	170	265	
Flush	47 (13.8%)	95 (11.8%)	142 (12.4%)	
Latrine	113 (33.2%)	314 (39.1%)	427 (37.3%)	
Open defecation	120 (35.3%)	241 (30.0%)	361 (31.6%)	
Other	60 (17.6%)	154 (19.2%)	214 (18.7%)	
Ownership of toilet previously used				0.011
Missing	38	72	110	
Private	82 (20.7%)	132 (14.6%)	214 (16.5%)	
Shared	128 (32.2%)	344 (38.1%)	472 (36.3%)	
Public	32 (8.1%)	97 (10.8%)	129 (9.9%)	
None	155 (39.0%)	329 (36.5%)	484 (37.3%)	