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Research Paper

Does microcredit for water and sanitation improve household welfare? Evidence from Indonesia

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ABSTRACT

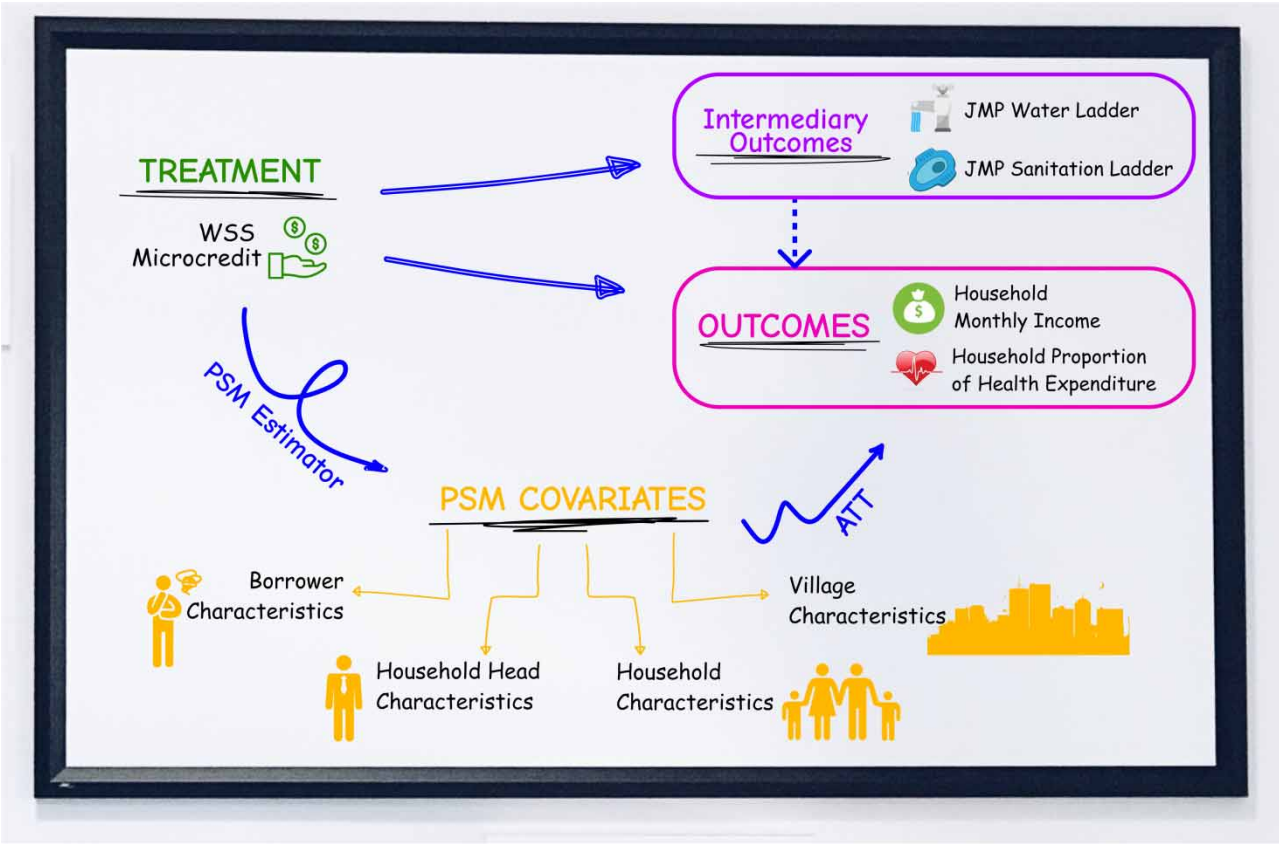
The water supply and sanitation (WSS) sector requires large household investments and expenditure. Microfinance provides an alternative financing scheme to support in reaching universal access to WSS to improve public health and well-being. Using propensity score matching to Water.org's household survey data, combined with the Village Potential's village statistics, this study aims to evaluate the impact of microcredit devoted to improvements in water and sanitation facilities towards household welfare measured by the WSS Joint Monitoring Programme (JMP) ladder status, income, and the share of health expenditure. Due to data availability limitations, the results indicated an associative relationship, as opposed to a causality relationship, between WSS microcredit participation and the respective outcomes. Participation in WSS microcredit was significantly associated with a higher JMP ladder for sanitation access but not with a JMP ladder for water access. Moreover, borrowers' participation in WSS microcredit was associated with a significantly higher monthly income and a significantly lower proportion of health expenditure. Future evaluation studies of WSS microcredit should focus on improving data collection or conducting randomized control trials. For ensuring better practices, microfinance institutions (MFIs) should conduct stringent monitoring on fund usage to assure households benefit from the expected outcomes of WSS improvements.

Key words: consumptive loan, health expenditure, household welfare, microcredit, water and sanitation, WSS (water supply and sanitation)

HIGHLIGHTS

- WSS borrowers were associated with a higher level of JMP ladder for sanitation access but not for water access.
- WSS borrowers were also associated with a significantly higher monthly income and a significantly lower proportion of health expenditure.
- Higher monthly household income is by IDR 233,180 (USD 15.55), whilst the proportion of health spending is significantly lower by 28%.
- For better practices, MFIs should conduct stringent monitoring on the fund usage to assure households benefit from WSS improvements.

GRAPHICAL ABSTRACT



INTRODUCTION

The world is facing an economic loss by 1.5% of the global GDP as a result of inadequate services of water supply and sanitation or WSS (SWA 2020). Around 55 and 29% of the world's population still lacks safely managed sanitation and drinking water services, respectively (WHO & UNICEF 2019). At the current rate of progress, the Sustainable Development Goal 6 for clean water and sanitation for all could be reached only with a significant increase in both the rate of progress and investment. However, the water sector suffers from underinvestment and poor performance records, creating heavy dependency on public funds and limiting contribution from private funds (SWA 2020), as well as mistargeting practices for the sector (Abramovsky *et al.* 2020).

One alternative to address this financing gap is microfinance, a development tool that has long been utilized to serve the lower-income households living between USD 1.25 and USD 2.00 per day and often excluded from the formal banking system as 'unbanked' (Trémolet 2012). The concept was made popular by Grameen Bank in the 1970s in Bangladesh, offering small loans for income-generating activities with only minimal collateral requirements. Globally, this could include microfinance institutions (MFIs), commercial banks, non-banking financial institutions, NGOs, credit cooperatives, or solidarity lending groups. They provide access to products such as microcredit, microsavings, and microinsurance.

Access to credit has been one of the key barriers for households to invest in their water and sanitation infrastructures (Augsburg *et al.* 2019b). Microfinance provides access to credit to finance WSS improvement facilities at the household level, such as rainwater harvesting tanks, dug wells, pumps, septic tanks, and sanitation slabs (Newman *et al.* 2014). Moreover, microfinance has facilitated more demand for WSS, such as increased willingness to pay for sanitation (Yishay *et al.* 2017; Chunga *et al.* 2018), water filters (Blanton *et al.* 2014; Guiteras *et al.* 2016), and piped water (Devoto *et al.* 2012). The demand subsequently catalyzed into higher WSS uptake and usage (Batmunkh *et al.* 2020) but has not been found to improve quality for already high-quality existing toilets (Attanasio *et al.* 2018). It has been difficult to precisely measure

the growth of this market. However, Water.org has estimated a total of USD 2.2 billion in capital for approximately 28 million recipients (SWA 2020).

As a result of their improved WSS facilities, households are expected to experience subsequent improvements in their well-being. Lehmann & Hailu (2016) provide a framework in which water supply could support household welfare, and it could also be extended to sanitation facilities similarly, using the three dimensions of health, time availability, and wealth. First, access to WSS could lead households to better health as determined by the quantity and quality of the WSS provision. Households apply good hygiene practices, and safe sources and storage of water to eliminate contamination; thereby minimizing the exposure to water-borne, water-washed, water-based, and water-related vector routes (OECD 2011). This is a result of improved health outcomes such as reductions in maternal mortality (Benova *et al.* 2014), diarrhoeal morbidity (Wolf *et al.* 2014), and stunting (Waller *et al.* 2020). Second, time availability presented by reliability and proximity to WSS access will result in households spending time more productively, with a reduction in time to walk, queue, and return multiple times within a day to suffice their needs. This loss of productive time results in three-thirds of estimated loss due to poor WSS facilities around 20 billion working days (OECD 2011). WSS contributes to wealth, such as by increasing property value and affordability according to their total income (Lehmann & Hailu 2016).

Although the water and sanitation sector has been widely presented with its contributions to economic growth (OECD 2011), there is no evidence that the microfinance sector consistently generates welfare for the participating households (Banerjee *et al.* 2015). This also applies to the water and sanitation sector for health benefits (Clasen *et al.* 2014). In terms of household welfare, only a few studies measure the impacts of WSS microfinance on business investment and consumption expenditures of food and non-food (Attanasio *et al.* 2018; Augsburg *et al.* 2019b). Loans were assessed to be beneficial for household incomes, savings, and medical expenditures (Pories 2016; Water.org 2019).

Nonetheless, limited evidence has been found to measure the impact of WSS microcredit participation on household welfare, especially in Indonesia. Therefore, this study attempts to contribute within the growing literature to pursue alternative schemes for the water and sanitation sector. The findings of this study are expected to benefit decision-makers in articulating non-public sources of finance and their role in households, along with financial institutions that may benefit from offering similar loan products to enable more households to secure better access to water and sanitation facilities.

METHODS

Data

This study uses survey data collected by Water.org in October 2019–March 2020 representing five participating MFIs in West Java and East Java. Since 2016, these institutions have been offering WSS microcredit to households in their coverage area. The survey interviewed 2,931 randomly selected households, consisting of 35% borrowers who availed the WSS loan product (treatment group) and 65% non-WSS borrower clients (control group). During the survey, the questions covered various aspects of socio-demographic, water, sanitation, and microfinance behaviour.

Amongst the five institutions, the product costing around 21–39% effective interest rate per annum can be disbursed either in cash (via one or two trenches) or in kind by collaborating with local material stores or masons. In terms of eligibility, the institutions associate different sets of requirements to select households eligible to participate in the WSS loan scheme. In general, households demanding new, or a renovation of, WSS facilities are the targeted segment, followed by having a good track record in the previous cycles and as recommended by its members for the group lending. There are specific conditionalities as well in which the client may be either new or existing clients or have tangible assets as collateral. The loan allows clients to borrow on average between IDR 370,000 and IDR 3,300,000 (USD 24.67–USD 220)[1] for a period of 1–2 years of loan term to be invested in the facility according to the loan approval process.

To complement the matching process, village characteristics were also merged for identified villages using the 2018 Village Potential (*Potensi Desa*, Podes) survey data from Statistics Indonesia (*Badan Pusat Statistik*, BPS) that included the villages' state of infrastructures and experience in shocks[2]. Podes is a data of every village in Indonesia gathered every 3–4 years, which consists of village characteristics, infrastructure, and administration.

[1] We use the conversion of USD 1 = IDR 15,000 throughout the paper.

[2] The 2018 Podes data were utilized for this study as it contains a comparable set of variables on village-level characteristics with the household survey.

Propensity score matching

These observational data were analyzed using propensity score matching (PSM). PSM estimates the causal effect that shows the net impact of the treatment by matching the treated-group sample with the control-group sample. The matching process was deployed using a set of observed characteristics (covariates) based on their likelihood in participating in the treatment. By matching treatment and control groups with similar characteristics, PSM balances the observations used in the analysis, thus eliminating confounding effects. This results in the assumption that both groups are comparable, leaving the treatment participation as the sole difference that yields variations in the outcomes (Khandker *et al.* 2010).

The ex-post nature of this research data requires a careful selection of the covariates to include time-invariant characteristics and variables that do not change as a result of the participation (endogenous), using the following function:

$$p(X_i) \equiv Pr(D_i = 1|X_i) = E(D_i|X_i)$$

where, $D = \{0,1\}$ indicates the propensity of WSS microcredit participation and X comprises the multidimensional vector of observable characteristics incorporating borrower and household characteristics. WSS microcredit should provide better household-level access to water and sanitation as intermediary outcomes; in which these improvements provide incremental values towards household welfare outcomes, as represented by the income and share of health expenditure. Water and sanitation access will be measured using the Joint Monitoring Programme (JMP) ladder categorization, which is based on the primary source of water and sanitation facility (WHO & UNICEF 2017). However, the structure of the questionnaire could not distinguish all five categories within the JMP ladder. The WSS access reported by households at the time of survey was categorized into four levels both for water and sanitation[3]. For water, we categorized the observations into the following: (1) surface water, (2) unimproved, (3) limited, and (4) basic/safely managed. Whereas for sanitation, the data were distinguished into these four categories: (1) open defaecation, (2) unimproved, (3) limited, and (4) basic/safely managed. The categorization process combined information on the primary source of water and sanitation currently used, practices of open defaecation, and time to collect water for a roundtrip including queuing.

In order to properly combine the effects of microfinance and WSS together, this study also considered the underlying factors behind the probability of households deciding to borrow from financial institutions to invest in water and sanitation facilities. Given that all respondents are already microfinance participants, in determining the matching covariates, this study refers to previous empirical findings of factors that encourage households to have better WSS facilities and to seek improved health behaviour (Bhuiya *et al.* 2010; Kumar & Vollmer 2012; Irianti *et al.* 2016; Augsburg *et al.* 2019a).

Demographic variables most often have implications in access to WSS from the head of the household as well as borrowers, namely gender, marital status, age, education, and primary occupation as farmer or labour. Other indicators that determine households' likelihood to own an improved WSS facility pertains to household composition, such as household size, and the number of children and female members. Certain indicators of ownership were also associated with possessing improved facilities, such as having livestock, agricultural land, and a house. House features also correspond to a higher likelihood for households to own improved facilities of permanent and electrified houses.

Finally, the estimation also included village characteristics, wherein the identified village names were matched with data sourced from the 2018 Podes released by Statistics Indonesia. Village characteristics are also important to consider the effect of the village condition in the treatment selection, thus reducing bias (Takahashi & Todo 2017). The village-level characteristics incorporate natural disasters to represent shock, the main income-generation activity of agriculture or manufacture, the number of base transceiver stations (BTSs), and whether a village possesses asphalt roads as an available infrastructure (Khandker & Koolwal 2016; Rahman *et al.* 2017; Cameron *et al.* 2019).

Upon determining the common support to select the sample to be analyzed, the treated group was then matched to comparable units of the control group due to similar units of $p(X)$ using the radius matching with replacement to maintain the balance. Next, the outcomes were examined to determine the average treatment effects of the treated (ATT) using the following function:

$$ATT = E(Y_i|D = 1) - E(Y_i|D = 0)$$

[3] The original five JMP ladder categories of water and sanitation access are surface water/open defaecation, unimproved, limited, basic, and safely managed.

Thus, our study offers three hypotheses. Our first hypothesis is that WSS microcredit removes the financial barriers faced by households to invest in WSS facilities, therefore leading to better WSS JMP ladder access within their households at the time of survey. Our second hypothesis is that WSS microcredit may improve household income due to better health and more productive time. Our third hypothesis is that WSS microcredit would minimize households' spending on health as a result of better health, thereby decreasing the allocation for health-related expenses.

Considering the data availability, there are various limitations that challenge the analysis to conclude a causal effect between WSS microcredit participation and the aforementioned outcomes. Notably, the data do not indicate whether the WSS improvement was made before or after the WSS microcredit acquisition. This issue of timing or sequence is essential to justify the causal inference that the WSS JMP ladder as the intermediary outcome subsequently results in better income and lower health expenditure. Furthermore, despite using WSS JMP ladder status at the time of survey as the outcome (to assure the state of outcome after treatment); the inability to determine the exact sequence turns this timing issue as a caveat in the final analysis. Moreover, the effects on household income and health expenditure can be seen only if the WSS loan was properly converted into investments in the households' WSS JMP ladder. In this study, the loan utilization data were self-reported and did not undergone through a verification process; hence, this may not lead to improvements in WSS facility and subsequent impacts.

Robustness check

Given the nature of this relatively small sample and cross-sectional, ex-post data, another step was taken to check the robustness using the propensity-based weighted regression (Kumar & Vollmer 2012) model. The propensity score was utilized to weigh balances in the distribution of covariates and results in an efficient estimation, thus making both covariate distributions similar in both groups, using the following function:

$$Y_i = \beta_0 + \beta_1 D_i + \delta_2 X_i + \gamma_i + \varepsilon_i$$

where γ denotes the estimate for $Pr(D = 1|X)$ as mentioned above, being the conditional probability of the observation participating in the treatment given the covariates. The X refers to the vector of matching covariates, whilst β_0 and β_1 are the parameters; ε is the error term. The treatment group of $D = 1$ receives a weight of $1/\gamma$, whilst the control group of $D = 0$ receives a weight of $1/(1 - \gamma)$, which will minimize the weighted sum of squares. Additionally, this study performed phone interviews with the participating financial institutions to gather institutional information, understand how the treatment was implemented in the field, and to validate the findings.

RESULTS

As indicated in Table 1, which presents the unmatched and matched sample, the WSS borrower and non-WSS borrowers have the fairly same characteristics. On average, the WSS and non-WSS borrowers are dominated by females, have a school attainment of secondary level or above, are married, and 42 years of age, and only 17% have farming or labour as their primary occupation. Amongst the household heads, they are predominantly male, married, 46 years old, slightly more than half have attained secondary education or above, and 40% are reported to be working as farmers or labourers. Meanwhile, the households mostly composed of four members, with two females and one child per household. The majority of these households do not own livestock nor agricultural land; however, the houses in which they live are owned by the family, electrified, and with permanent flooring.

As for the village characteristics, the data consisted of 227 villages across 11 districts located in West Java and East Java. These identified villages were merged into the Podes data to complement the household data. On average, the participating villages experienced less than one natural disaster in 2018. In terms of main income-generating activity, half of the villagers reported having agriculture as their main sector, and only 8% had manufacturing as their main sector. Nearly all the villages had developed infrastructures such as asphalt roads and two units of BTS that facilitated internet communication.

The PSM exercise selected 2,737 sampled households, which shows a balance between the groups, consisting of 951 borrowers who availed loan for WSS purposes (treatment group) and 1,786 of borrowers who did not borrow for WSS purposes (control group) but rather participated in other loan or savings products, reported in Supplementary Material, Appendix 1. The 23 covariates combined the determining factors behind the decision of households seeking health improvement behaviour as well as improving water and sanitation access.

Table 1 | Descriptive statistics of the variables

		Unmatched		Matched		
Variables	**Unit/description**	**WSS Borrower ($n = 997$)[a]**	**Non-WSS Borrower ($n = 1,892$)[a]**	**WSS Borrower ($n = 951$)[a]**	**Non-WSS Borrower ($n = 1,786$)[a]**	***p*-value**
Borrower characteristics						
Gender	Female = 1	0.81	0.80	0.81	0.80	0.61
Education	Secondary or above = 1	0.54	0.44	0.53	0.50	0.24
Marital status	Married = 1	0.90	0.91	0.90	0.90	0.93
Age	Years	42.37	43.18	42.37	42.42	0.93
Working as farmer/labour	Yes = 1	0.16	0.18	0.16	0.17	0.72
Household head characteristics						
Gender	Female = 1	0.09	0.08	0.09	0.08	0.75
Education	Secondary or above = 1	0.58	0.51	0.57	0.55	0.47
Married	Married = 1	0.92	0.93	0.92	0.92	0.99
Age	Years	46.44	47.04	46.49	46.69	0.71
Working as farmer/labour	Yes = 1	0.39	0.40	0.39	0.40	0.79
Household characteristics						
Number of members	Persons	4.21	4.11	4.19	4.15	0.55
Number of female members	Persons	2.08	2.04	2.08	2.06	0.64
Number of child-age members	Persons	1.40	1.30	1.39	1.35	0.38
Owns livestock	Yes = 1	0.30	0.32	0.31	0.32	0.93
Owns agricultural land	Yes = 1	0.22	0.24	0.24	0.24	0.90
Owns permanent flooring	Yes = 1	0.97	0.96	0.97	0.97	0.70
Owns the home	Yes = 1	0.97	0.96	0.97	0.97	0.93
Owns electricity	Yes = 1	0.99	0.97	0.99	0.99	0.72
Village characteristics						
Natural disaster	Frequency	1.12	0.77	0.71	0.83	0.03
Agriculture as main sector	Yes = 1	0.51	0.60	0.55	0.57	0.30
Manufacture as main sector	Yes = 1	0.14	0.08	0.08	0.09	0.36
Base Transceiver Station (BTS)	Units	2.19	1.82	2.02	2.01	0.92
Asphalt roads	Yes = 1	0.95	0.96	0.95	0.95	0.84
Outcomes						
JMP water access	Surface water = 1 Unimproved = 2 Basic/Limited = 3 Safely managed = 4	3.64	3.59	3.63	3.60	
JMP sanitation access	Open defaecation = 1 Unimproved = 2 Limited = 3 Basic/Safely managed = 4	3.84	3.76	3.85	3.77	
Household monthly income	IDR per month	2,939,731	3,269,369	2,944,741	3,272,130	

(*Continued.*)

Table 1 | Continued

Variables	Unit/description	Unmatched		Matched		p-value
		WSS Borrower ($n = 997$)[a]	Non-WSS Borrower ($n = 1,892$)[a]	WSS Borrower ($n = 951$)[a]	Non-WSS Borrower ($n = 1,786$)[a]	
Household monthly health expenditure	% of total expenditure per month	1.19	0.84	1.18	0.87	
Observation		**997**	**1,892**	**951**	**1,786**	

Source: Author's estimation.
[a]Values in the table are the average value.

Supplementary Material, Appendix 2 shows that the PSM estimator resulted in several significant factors indicating the probability of households' participation in WSS microcredit: borrowers with secondary education and electrified houses significantly increased the probability of households' participation in WSS microcredit. The number of natural disasters and BTS and the manufacturing industry as the main sector, and the ownership of asphalt roads were found significant at the village level.

The estimator results were also tested to confirm the reduction in bias, as shown in Supplementary Material, Appendix 3. Overall, the results found no significance amongst the covariates between the treated and the non-WSS borrower households, and the percentage of bias did not exceed 5% (Caliendo & Kopeinig 2005) making the data effectively define the difference in the average treatment of the WSS borrowers and their counterparts.

As shown in Table 2, the results specify the relationship of water and sanitation microfinance with various welfare outcomes. ATT examines the difference in mean between households participating in water and sanitation microcredit compared with households of no participation.[4] As for the status of water and sanitation access at the time of survey, households reported a higher significant difference in their JMP ladder access for sanitation (at 5% *p*-value). However, the status of water access was found to be an insignificant difference between WSS borrowers and non-WSS borrowers. We have also exercised the model using the binary outcome of the WSS basic ladder and the non-basic one and found consistent results (see Supplementary Material, Appendix 4). Therefore, based on our findings, we found a significantly higher JMP sanitation ladder amongst the WSS microcredit households, whilst finding no significant difference in the JMP water ladder.

Based on the ATT for income, borrowing for WSS loan purposes resulted in a positively significant improvement in household income with a difference of IDR 233,180 (USD 15.55) significant at a *p*-value of 1%, suggesting that the borrowers who availed WSS loan were able to increase their income significantly by around 8% higher than borrowers without any WSS loan product. The difference varied before and after the matching exercise, wherein the treatment effect of the unmatched data was slightly overestimated. This is consistent with previous findings from India (Pories 2016) and especially Bangladesh

Table 2 | ATT of WSS microcredit

Variable	Sample	Observations	Treated[a]	Controls[a]	Difference Treated – Controls	Standard Error	T-stat
JMP Ladder for Water (scale of 1–4)	Unmatched	2,576	3.640	3.591	0.049	0.027	1.82*
	ATT	2,512	3.626	3.604	0.021	0.030	0.72
JMP Ladder for Sanitation (scale of 1–4)	Unmatched	2,737	3.842	3.760	0.082	0.024	3.43***
	ATT	2,673	3.855	3.774	0.081	0.025	3.20***
Income (IDR)	Unmatched	2,724	3,272,130	2,941,177	330,953	70,064	4.72***
	ATT	2,660	3,267,335	3,034,155	233,180	79,572	2.93***
% Health Expenditure	Unmatched	2,741	0.866	1.181	−0.315	0.148	−2.14**
	ATT	2,677	0.881	1.177	−0.297	0.162	−1.83*

Source: Author's estimation.
[a]Values in the table are the average value.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

[4] The method can be used for continuous, ordinal (Chudgar and Quin 2012; Sun *et al.* 2018), or binary outcomes (Austin 2011).

(Water.org 2019). Households who borrowed for water and sanitation corresponded to a 10% higher income relative to their counterparts who did not borrow.

On average, treated households were found to have a relatively similar share of health expenditure with the unmatched data, as presented in Table 2. The treatment effect was found to drive a difference of −0.32 significant at a *p*-value of 5% in the unmatched data, whilst after matching, it revealed a lower difference of −0.30 at 10% *p*-value. In other words, WSS-borrowing households were able to minimize the proportion of their health expenditure by 28% compared with the borrowers of non-WSS. In per capita terms, this translates to IDR 2,926 (USD 0.20 per capita or around USD 0.86 per household) difference, meaning that the households of WSS borrowers were able to decrease their monthly health expenditure by such per month, which is slightly lower than in Bangladesh of around USD 1.29 (Water.org 2019). Overall, the result of the unmatched data was overestimated.

Robustness check

The robustness of the analysis was checked using weighted least square (WLS) with the unmatched data of similar covariates. The propensity score was used as weights to account for selection assignment differences between WSS borrowers and non-WSS borrowers to all the unmatched data. As presented in Supplementary Material, Appendix 5, the treatment shows consistent findings between the PSM results above and the WLS as noted in weighted least regression for water ladder as insignificant, sanitation ladder significant at 1%, income significant at 1%, and health proportion significant at 5%. This shows that WSS microcredit is associated with a higher proportion of households obtaining WSS improvements by 46.5%, a higher monthly income by IDR 234,087 (USD 15.61), and a reduction in the proportion of health expenditure by 32.6%. However, these estimates could not be interpreted as causal estimates due to the sources of variation in the treatment that may not be exogenous, and, hence, this study prefers to use the PSM results.

DISCUSSION

Based on the aforementioned findings, it has been indicated that the water and sanitation microfinance may be associated with better household welfare compared with those households who did not borrow for WSS purposes. The results were further analyzed using bivariate and multivariate analyses from other variables sourced from the dataset to check whether the results were sourced from health, time availability, or wealth using the framework by Lehmann & Hailu (2016), as reported in Supplementary Material, Appendix 6 and Appendix 7.

First, the study looked at the status of access to water and sanitation between both groups using the JMP ladder categories. Both groups come from the same levels within the water and sanitation basic access of over 90 and 69% with at least limited access of water and sanitation, respectively. Both for water and for sanitation facilities, the ideal level of access in the basic or safely managed category is higher for the WSS borrowers than for the non-WSS borrowers – with a 4% difference for sanitation and 2% for water.

Reflecting on the ATT findings that the WSS microcredit treatment results in significant outcome for sanitation access but not for water access, we followed up with discussions with financial institutions to gain more insight into the issue. First, households have more control on the type of facility being constructed for sanitation than for water due to many compounding factors such as the available source of water and supply provider. The skills required for making sanitation improvements can be easily acquired from local masons or even from the heads (husbands) of households. Conversely, the constructions necessary for effecting water improvements require more specialized providers ranging from regional water utilities or borewell contractors who are much harder to find, to locate the water points and depths. This arguably varies WSS microcredit, which facilitates households' ability to step up the ladder on sanitation, whilst the increase in water JMP ladder heavily depends on external factors.

Secondly, whilst the offering of the loan was intended to internalize investment for the households to build private facilities to optimize its benefits, we found that some households reported not having improved facilities amongst the WSS borrowers. Supplementary Material, Appendix 6 reveals that 29% households of the WSS borrowers still do not own water facilities within their premises; additionally, 12% still shared facilities and practised the primitive habit of open defaecation for gaining sanitation access. This finding suggests that the loan utilization did not convert into WSS investment, rather to be spent to other purposes as a result of the fungibility of the loan funds.[5]

[5] See Supplementary Material, Appendix 8 for what type of improvements were made in the last 3 years.

Furthermore, the study also found both groups reported having no sick members within the last 3 months, indicating not much difference in health incidence similar to Bangladesh (Water.org 2019), where various compounding factors were linked to household health being, such as seasonality, and no actual time-series observations. However, amongst households who had built their facilities in the last 3 years, they tend to have much lower health expenditures than those who did not make improvements (see Supplementary Material, Appendix 7).

This may be attributable to the tendency of borrowers with improvements to recover faster so that they may not incur any expenses such as purchasing over-the-counter drugs, doctor visits, or medical subscriptions that would bear a health-related cost of curative expenditure and to some extent preventive expenditure (Ashraf *et al.* 2017). Although the detailed purpose of the health expenses was not provided in the dataset, according to Indonesia's Socio-economic National Survey by BPS as a survey representative of the national population, the average proportion of curative health spending from health expenditure between 2019 and 2020 in the districts surveyed in our data is 68.2–69.3%. Whereas the remaining 30.7–31.8% was utilized for preventive health spending. Thus, the majority of health expenditure is for curative use, which is directly impacted by WSS facilities. The difference in health expenditure is also embodied in the geography type (see Supplementary Material, Appendix 7), where amongst rural areas, households who borrowed the WSS loan spent 76% less than the non-WSS borrower group, compared with a 36% difference in the urban areas. Limited health facilities in the rural areas possibly make it difficult for the non-WSS borrowers to reach the required facilities, and, thus, they need more funds to recover from their illness.

With regard to time availability, households within the WSS-borrowing group reported to spend 41% less time to access their water with an average of 1.6 min per round trip, compared to 2.2 min for non-WSS borrowers (see Supplementary Material, Appendix 6). This time availability is far lower than that in India (Pories 2016), where it took nearly 1 h per trip, but is similar to that in Bangladesh (Water.org 2019) with a difference of 0.1 mi or nearly no change at all. Given the high access to WSS facilities, it may seem that the facilities in Indonesia are located at much closer distances, which makes households insensitive to the time saved. In terms of water reliability, households who borrowed WSS loan reported consuming twice the amount of that by non-WSS borrowers, indicating they have reliable sources of water to suffice for their needs. In this case, with more efficient time, energy, and reliable water, households were able to allocate their hours to productive activities and generate more income.

Households from the WSS-borrowing group confirmed that they have a relatively low marginal cost for water than their counterparts, with an average of IDR 20 (USD 0.001) and IDR 23 (USD 0.002) per litre, respectively, which is a loud proclamation of water being more affordable. If compared against the total income, spending for water amongst the households of non-WSS was 0.6% and that amongst WSS households was 0.9%, indicating both fulfilling the 3% threshold (UNDP 2006) to avoid being financially burdened from the associated costs.

A further analysis of labour elaborates the comparison of both groups located in urban and rural areas. In urban areas, the difference in income between households borrowing a WSS loan and their counterparts is higher (10%) than those living in rural areas (5%) (see Supplementary Material, Appendix 7). The improvement in WSS allows more productive opportunities for those in the urban areas. This study also found that 90% of the households in the sample perceived that WSS supports their income-generation activities. Amongst those households perceiving such, the WSS borrowers' group tends to have a much higher income than its non-borrowing counterpart. This indicates that WSS improvements help them in generating more income, even directly or indirectly.

With regard to the results, there are a few limitations. First, whilst we are confident about the quality of the matching process, we prefer to interpret the findings with a caveat primarily in the sense that PSM provides only a causal interpretation from treatment towards outcome if the treatment participation is entirely observed and controlled within the model. Otherwise, the PSM assumption is violated (Kumar & Vollmer 2012). Specifically, on the JMP WSS–related outcomes, due to the lack of a timing factor of taking the loan and the reported improvements, we would interpret the WSS microcredit participation as being associated with a higher JMP sanitation access and no association with JMP water access, rather than direct causality per se. Furthermore, the effect on income and health expenditure may also be overestimated. This is indicated by some of the WSS microcredit being used towards aesthetic purposes or misutilization (e.g., business purposes); therefore not leading towards the appropriate welfare outcomes. Besides having a relatively small sample size, this study also faced challenges with the limited available data to remove bias caused by time invariance. Although the dataset also comprised baseline information to represent the ex-ante condition, no borrower IDs were available to validate the panel data to analyze the changes in the observed characteristics and outcomes. Thus, we only utilized the ex-post data to measure the effects.

Based on these findings, there are a few notable suggestions for doing more robust studies in the future. First, to measure the effectiveness of WSS microcredit, instead of the JMP ladder, future studies should ideally use WSS investment as the intermediary outcome (Augsburg *et al.* 2019b). In practice, the WSS loan product may not always produce a change in the JMP ladder, in the sense that it could be invested to upgrade or repair an existing facility (hence retaining in the same ladder). For example, an investment in a new water pump to be connected to an existing well may support households' productivity to achieve better welfare, although they remain within the same ladder category. Furthermore, especially for water improvements, the decision to invest in the type of facility depends widely on water resource availability, supplier capacity, construction cost, and household capacity-to-pay, which all together determine whether the intended improvement leads to a change in their ladder category. By using WSS investment as the proxy, the analysis would concentrate on whether such treatment would implicate households to obtain better outcomes.

Reflecting on the timing notion of the WSS improvement in sequence to the loan acquisition, this study used only ex-post data, which limited the ability to check whether WSS microcredit causes WSS improvement and subsequently result in better socio-economic outcomes. If possible, using baseline as an ex-ante data could represent a comparable pre-treatment condition to better analyze the differences between WSS and non-WSS borrowers after the credit was imposed. Finally, future studies may also use randomized control trials (RCTs) to randomize the sample into WSS and non-WSS borrowers by design and collect the required data upon the WSS microcredit treatment. The RCTs would give a golden standard of the impact evaluation method and eliminate confounding factors that would concentrate the results solely on the WSS microcredit impacts (Duflo 2016). We hope that this study would initiate future studies on how the WSS microcredit scheme results in such intended outcomes.

Given some of the WSS borrower households reporting not stepping up the JMP ladder especially for water, there should be more stringent monitoring of fund utilization by financial institutions or possibly a joint approach with local officials or supply providers. This collaboration could assure households to use their funds for the intended purposes and at the same time lend support to the targeting for the WSS microfinance market, which so far has solely been done by financial institutions. Systematic targeting can enhance the number of those households without existing facilities to make investments and benefit most from the outcomes.

CONCLUSIONS

This study was aimed to examine a WSS intervention in the form of a microcredit to support households' welfare through improved WSS facilities. The study results indicated that WSS microcredit significantly correlated to a higher sanitation JMP ladder, whilst there was no correlation to the water JMP ladder compared with their counterparts. Moreover, households that received WSS microcredit were found to be significantly correlated with a higher income and lower allocation for health compared with their counterparts without WSS microcredit. However, the current study could find only associative relationships between WSS microcredit and the outcomes, as well as caveats of the magnitude to household income and health expenditures, due to the unavailability of data on the timing of WSS microcredit and WSS investment. Also, there was a lack of verified WSS microcredit utilization. Finally, regarding the practices in WSS microcredit, it is important to assure households of the loan results in WSS investment and/or improvement, for which the MFIs could conduct more stringent verifications or collaborate with WSS supply providers. By providing such assurance, households will more likely benefit from the expected outcomes from WSS improvements.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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