



Research Paper

Increasing latrine sales among poor households in rural Cambodia using targeted subsidies: a randomized control trial

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ABSTRACT

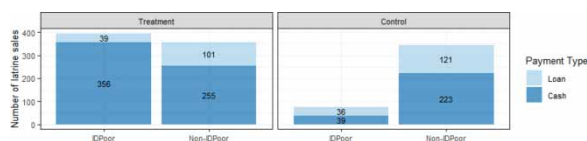
Because improved sanitation can improve public health but is lacking in many rural areas, many organizations use sanitation marketing to increase latrine coverage. In rural Cambodia, iDE has facilitated the sale of more than 395,000 pour-flush latrines since 2011 but recognizes that market actors are not incentivized to sell to the poorest households. Using a randomized controlled trial, in which poor households in treatment villages were offered partial latrine subsidies, this study investigated how subsidies affected latrine sales and program cost-effectiveness. Results show latrine sales among poor households that were offered subsidies increased by 14–16% compared to those that were not offered subsidies. Also, no significant effect on latrine sales among non-poor households was found, although lower village-level latrine coverage can reduce latrine sales to non-poor households. Cost-effectiveness analysis shows the increase in sales and thus economies of scale from subsidies yield lower per-latrine program costs compared to non-subsidy costs (\$38 vs. \$54). Well-targeted latrine subsidies can significantly increase latrine sales among poor households with minimal impact on latrine sales to non-poor households and favorable program cost reductions. However, subsidies must not be introduced into a market before baseline sanitation coverage is achieved to avoid market distortion effects.

Key words: cost-effectiveness, latrine coverage, market distortion, marketing, randomized controlled trial, sanitation

HIGHLIGHTS

- Latrine sales among poor households that were offered subsidies increased by 14–16%.
- Subsidies for poor households can increase latrine sales without affecting sales to non-poor households.
- Increased latrine sales from subsidies can lower per-latrine program costs.
- Subsidies must not be introduced too early to avoid market distortion effects.
- Local market knowledge is required to accurately target latrine subsidies.

GRAPHICAL ABSTRACT



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INTRODUCTION

Safely managed sanitation is a goal of many localities, countries and the [United Nations \(2017\)](#). The first step in achieving safely managed sanitation is installing and regularly using a toilet, which captures all feces produced by a household and contains that feces when connected to either a storage vessel (e.g., a pit, a septic tank) or a sewer pipeline to prevent it from entering the environment untreated ([Strande & Brdjanovic 2014](#)). In rural areas around the world, this capture and containment is typically achieved by improved pit latrines installed at each household ([Strande & Brdjanovic 2014](#)). Because latrine coverage (the percentage of households in a given context that have continuous access to a toilet) must be relatively high (>60%) to improve public health, increasing latrine coverage is a focus of many sanitation programs globally ([Cronin et al. 2017](#)).

However, high latrine coverage has been difficult to achieve in many contexts, particularly rural areas where materials and services are typically more difficult to access and more expensive ([Mara et al. 2010](#)). The relatively high cost of rural sanitation, which can exceed half of a household's annual income, is a common cause of low latrine coverage and thus poor rural sanitation ([Mara et al. 2010](#)). Thus, sanitation markets must be developed to provide affordable products that provide safe and durable sanitation systems to rural households.

To increase rural latrine coverage, various methods have been used and generally aim to improve sanitation supply and demand ([Venkataramanan 2017](#)) via different financing, market-based, or behavioral techniques. Financing methods typically operate through households or businesses by increasing affordability and broadly include subsidies, discounts, microfinance loans, and output-based aid, all of which reduce or defer the cost of constructing, operating, or maintaining a latrine ([Willets & Powell 2016](#)). Financing methods can also target certain demographics (e.g., women, poor, disabled) to increase equity ([USAID 2019](#)). Market-based methods typically operate through private businesses that sell or install latrines by developing the supply chain for sanitation technologies and broadly focus on traditional commercial business principles, including capacity building, profit maximization and market efficiency ([UNICEF 2020](#)). Behavioral methods attempt to change what households or communities do or prefer through education or community mobilization and include participation, social pressure, and peer monitoring through programs like Community Health Clubs and Community-Led Total Sanitation (CLTS) ([Pattanayak et al. 2009](#)). While many of these methods can increase latrine coverage when implemented individually, an integrated strategy that uses multiple methods has become standard practice for current and future sanitation programs ([Venkataramanan 2017](#)); researching these methods individually and together can improve the outcomes of their implementation.

Latrine subsidies

A financing method that is typically provided directly to households to purchase hardware (e.g., constructing household latrines), latrine subsidies provide one of the largest absolute increases in latrine coverage (16%) of all types of sanitation interventions and rarely reduce latrine coverage (95% CI: 8–24%); these positive outcomes are uncommon with other types of sanitation interventions ([Garn et al. 2017](#)). Latrine subsidies are pervasive and currently valued in billions of dollars globally ([Andres et al. 2019](#)). Full subsidies were used early in sanitation development programs but were quickly recognized to be unsustainable and can reduce a household's use and maintenance of their latrines ([Garn et al. 2017](#)). Having now become commonplace, partial subsidies delivered to specific segments of the market improve the affordability of a latrine, allowing households that could otherwise not afford a latrine to purchase a latrine.

Despite their ubiquity and potential benefits, many problems with latrine subsidies have been documented. Most importantly, subsidies typically fail to benefit those who they should be designed for – the poor – due to improper targeting ([Andres et al. 2019](#)). Subsidies can also cause unintended effects in a sanitation market, such as market distortion (e.g., reducing latrine purchasing among households that do not receive a subsidy) and a decrease in latrine purchasing where subsidies were previously available but no longer are ([Andres et al. 2019](#)). Thus, proper targeting and careful consideration of potential market distortion effects are required for subsidies to increase latrine coverage ([Andres et al. 2019](#)).

Few studies have specifically evaluated how targeted latrine subsidies can improve latrine coverage in poor households. Targeted subsidies combined with sanitation marketing yielded increased latrine coverage among all income groups in Cambodia with no market distortion effects ([Rivera et al. 2016](#)). In India, Ghana, and other countries, combining subsidies with other interventions, like CLTS, has increased latrine coverage markedly ([Pattanayak et al. 2009](#); [Augsburg & Sainati 2020](#); [Radin et al. 2020](#)). Latrine subsidies have also been shown to increase latrine coverage among both poor households and their non-poor neighbors that did not receive a subsidy in Bangladesh ([Guiteras et al. 2015](#)). However, latrine subsidies

have not always been reported to increase latrine coverage. Although reportedly needed to allow poor Cambodian households to purchase latrines, targeted latrine subsidies integrated with loans, rebates, and material donations did not increase latrine coverage in one study (Tribbe *et al.* 2021). Another study also found that latrine subsidies incentivized households to build a latrine but were not essential to allow those households to build one financially (Kohlitz *et al.* 2021). Thus, latrine subsidies can markedly increase latrine coverage but must be implemented appropriately by targeting poor households while ensuring no market distortion effects occur.

Sanitation context in Cambodia

Approximately 80% of Cambodia's population lives in rural areas, where pour-flush pit latrines are common, and roughly 90% of poor households live in rural areas (PSI 2018). Rural households are typically accessed by small dirt roads that make transporting the waste stored in pit latrines away from households difficult and expensive. Coupled with the high economic investment required of other sanitation systems (e.g., sewers, wastewater treatment plants), on-site sanitation systems are effectively required in rural Cambodia to achieve safely managed sanitation (Harper *et al.* 2020).

Over the past two decades, rural Cambodia has experienced rapid improvements in sanitation infrastructure due to many widespread non-governmental organization (NGO) activities and government support. Access to improved sanitation infrastructure, primarily improved pit latrines, in rural areas has increased dramatically from 4% in 2000 to 71% in 2019, which has led to a commensurate decrease in open defecation from 92% in 2000 to 51% in 2015 (Harper *et al.* 2021). The Cambodian National Government is also committed to rural sanitation in their National Action Plan II (2019–2023), which specifies a target of 90% latrine coverage by 2023 (MRD 2019b). Although latrine coverage has increased markedly on average across Cambodia, only 15% of Cambodian households in the bottom wealth quintile have access to latrines, primarily due to the relatively high cost of latrines compared to their incomes and inadequate sanitation financing throughout the country (Hoo *et al.* 2022). Multiple studies and the sector as a whole also agree that bring adequate sanitation to the poorest households of Cambodia will require alternative financing methods like subsidies to achieve Sustainable Development Goal 6.2 (United Nations 2017; Kohlitz *et al.* 2021; Hoo *et al.* 2022).

Latrine subsidies have been used in Cambodia for decades albeit haphazardly (EMC 2016). In response, the Cambodian National Government requires that subsidies should be used to stimulate demand and create an enabling environment for households to purchase toilets but must only be provided to poor households if needed (MRD 2011). Unfortunately, this guidance has generally not been heeded by the Cambodian sanitation development sector (Kohlitz *et al.* 2021), except for recently, where targeted latrine subsidies produced higher latrine sales among poor households and did not reduce demand for latrines among non-poor households (Hoo *et al.* 2022). This new evidence is encouraging; however, more research on latrine subsidies in Cambodia is needed to support the efforts in redirecting the local sector and guiding other low-resource contexts with similarly untargeted subsidy practices.

iDE's sanitation marketing program

iDE is an international development organization that works to improve rural sanitation via market development. iDE's sanitation marketing efforts in Cambodia have led to the sale of more than 395,000 improved pour-flush latrines across seven provinces since 2011. iDE facilitates latrine sales (the sale and installation of latrines to a functional state) through a network of latrine business owners (LBOs) and iDE-trained sales agents (SAs). iDE's unique approach to sanitation marketing builds both demand and supply capacity to drive rapid increases in latrine coverage. In Cambodia, this process includes training LBOs to produce quality, hygienic latrines, and equipping SAs to sell latrines at a market rate that is affordable to rural Cambodian households while sufficiently profitable to pay LBOs and SAs appropriately. Despite the overall efficacy of this approach, iDE recognizes that market actors are not necessarily incentivized to reach the poorest households, who are often unable or unwilling to pay full market price for a high-quality latrine.

To address this problem, iDE has explored two mechanisms to reduce barriers for poor households to purchase latrines: targeted subsidies and sanitation financing. To determine the impact of these two mechanisms on latrine purchases among both poor and non-poor households, iDE and research partner Causal Design used a randomized controlled trial (RCT) study design, in which poor households in treatment villages were offered partial subsidies, financing and cash-only purchase options, while households in control villages were offered only financing or cash-only purchase options. The effects of latrine subsidies and their cost to administer are thus explored in this study by answering the following questions:

- Do targeted partial latrine subsidies affect latrine sales to poor households?
- Do targeted partial latrine subsidies affect latrine sales to non-poor households?
- How cost-effective are targeted subsidies, sanitation financing, or a combination of the two when attempting to increase latrine sales to poor households?

METHODS

Study design

This study describes how sanitation financing and targeted subsidies affect latrine purchases among poor rural households in Cambodia. Building on iDE's existing sanitation marketing program and established supply and sales chains, 15,721 households in 166 randomly selected villages across three districts of Kandal Province in Cambodia between November 2015 and August 2016 were assigned to the treatment or control group (83 villages each) using stratified random assignment. All households within each village were visited by SAs, and all data required for the quantitative components of this study were present on the latrine order form for each household, which the household (i.e., customer) consents to when purchasing the latrine.

Stratification determined the latrine subsidy that was offered to each household and was performed based on each household's IDPoor status, which is an identification provided to poor households by the Cambodian National Government based on a households' wealth (MRD 2019a). Households can be IDPoor1 (poorest), IDPoor2 (less poor), and Non-IDPoor. In both the treatment and control groups, all households were offered financing and cash-only purchase options for a latrine with a market price of \$56 USD. In the treatment group, subsidies of \$25 USD (44% of the latrine price) and \$12.50 USD (22%) in the form of discount vouchers were offered to IDPoor1 and 2 households, respectively (Supplementary material, Table S1). Randomization of treatment assignment at the village level reduced bias, thereby allowing the results of this study to be generalized across the target population (all non-latrine-owning households in Kandal province).

Mechanics of sales, subsidies and financing

SAs sold latrines in either group or door-to-door sales presentations. Latrine-sales presentations were made to households that did not already own a latrine as part of iDE's marketing campaign, which contacts all households in selected villages. In all villages, households could purchase a latrine either by paying cash or by applying for a 12-month loan from a local microfinance partner (MFI). If paying cash, the household paid a \$5 USD deposit at sale and paid the LBO the balance at installation. If paying via loan, the household paid the \$5 USD deposit at sale and began loan payments in the month following installation. Loan requests were submitted by SAs to the MFI, which assessed the household's credit worthiness. If declined for a loan, the household was offered to purchase the latrine in cash. Few households purchased a latrine via loan due to high loan-application rejection rates and increasing loan interest rates during the study; thus, results regarding latrines purchased through loans are not reported.

IDPoor status was verified for households that requested a subsidy. After confirmation, the SA provided the household with a discount voucher, which was submitted to the LBO after installation. The household then paid the balance to the LBO, which submitted the voucher to iDE as proof of installation. iDE then verified the installation to the designated household and then paid the voucher value to the LBO to complete the market-price transaction.

Data collection

Prior to data collection, the study design was reviewed and approved by The National Ethics Committee for Health Research in Cambodia via the Health Research Portal on 12 January 2016. To inform the study design, iDE-trained researchers surveyed all households in the three study districts to describe each household's IDPoor status; access to and ownership of latrines; latrine type; self-reported diarrheal incidence; and reason for not owning a latrine. These data allowed baseline sanitation coverage at the village level to be calculated, and showed similar rates of latrine coverage across all IDPoor households and similar higher rates of latrine coverage across non-IDPoor households (Supplementary material, Table S2).

During the study, iDE's SAs submitted latrine orders from the field using a front-end mobile application called TaroWorks. Order records were synchronized to iDE's cloud-based order management system hosted on Salesforce.com and included each household's IDPoor status; the price and subsidy status of the latrine; whether payment was made through cash or financing; and if an order was cancelled. Latrine orders were verified using a quality lot control sampling procedure to ensure the accuracy of sales figures and to prevent fraud among LBOs and SAs. A total of 1,778 latrine sales were made during the study; of these, 602 (34%) were either canceled or suspended due to loan rejection, and the remaining 1,176 (64%) were installed.

Semi-structured interviews were conducted with iDE staff and SAs during and at the end of the study to describe their selling experiences, and a household survey at the end of the study described household knowledge of latrine pricing and offerings; sales experience; perceptions of financing; perceptions and attitudes towards subsidies; general market knowledge; and demographics. Deductive and inductive coding coupled with frequency analysis were used to characterize relevant factors, and questions regarding each household's knowledge of the study were specifically characterized to determine how knowledge of the study had been communicated between the control and treatment groups. All participants in the qualitative research provided verbal consent for their participation.

Data analysis

Balancing tests were first used to ensure that the distribution of households, IDPoor individuals, and potential latrine customers were not statistically different between the treatment and control groups (Supplementary material, Table S3). Frequency analysis was then used to describe latrine sales between the treatment and control groups. Fisher's Exact test was used to determine if latrine sales were different among Non-IDPoor households in each group.

To estimate the impact of latrine subsidies by describing the difference in latrine sales between the treatment and control groups, a single-difference treatment effect model at the village level was created. This model also considered many potentially confounding factors, including village poverty rates, the prevalence of prior sanitation subsidies, and prior negative experiences with sanitation solutions, to control for their potential impact on latrine sales. As measured by the pre-study survey, only data that described households that did not have improved sanitation when presented with the opportunity to buy a latrine (henceforth 'customers') were included in the model:

$$\text{Latrines}_i = \beta_0 + \beta_1 \text{Subsidy}_i + \beta_2 \text{Houses}_i + \beta_3 \text{Customers}_i + \beta_4 \text{IDPoor}_i + \beta_5 \text{District}_i + \beta_6 \text{PriorSubsidy}_i \\ + \beta_7 \text{PriorFreeLatrine}_i + \beta_8 \text{PriorBadExperience}_i + \beta_9 \text{MonthSold}_i + \beta_{10} \text{SalesAgent}_i + \varepsilon_i$$

where in each village i , *Latrines* is the number of latrine sales (i.e., latrines sold and installed to a functional state) per customer; *Subsidy* is a binary variable that describes whether the latrine subsidies of this study were offered or not; *Houses* is the number of households; *Customers* is the percentage of households with no latrine access and sufficient available land to install a latrine; *IDPoor* is the percentage of households that are IDPoor (i.e., IDPoor1 or IDPoor2); *District* is the administrative district; *PriorSubsidy* is a binary variable that describes whether a latrine subsidy had been offered before according to the Village Chief; *PriorFreeLatrine* is a binary variable that describes whether a free latrine had been offered before according to the Village Chief; *PriorBadExperience* is a binary variable that describes whether bad experiences with latrine sales had been encountered before according to the Village Chief; *MonthSale* is the month that a latrine was sold during the study; *SalesAgent* is the SA that sold a latrine; β_j are the model coefficients of each input variable; and ε_i is the model error. Robust standard errors describe the accuracy of each coefficient based on a confidence level of 90%, and p-values less than 0.1 are considered statistically significant.

Two interaction effects models were also created to estimate the relationships between (1) the subsidies and baseline latrine coverage and (2) the subsidies and the poverty within a village. In each of these models, one interaction term ($\beta_{11} \text{Subsidy} * \text{Coverage}_i$ or $\beta_{11} \text{Subsidy} * \text{IDPoor}_i$) was added to the treatment effect model above, where *Coverage* is the baseline latrine coverage in each village i .

To describe whether the latrine subsidies' impact on sales offset the additional costs of the subsidies, the cost-effectiveness ratio (CER) calculated per latrine sold for the treatment and control groups as well as for prospective, scaled-up versions of the treatment and control groups are calculated. The CER only describes iDE's costs, not the total economic value of the latrines, and is calculated as follows:

$$\text{CER} = \frac{\text{Fixed costs} + (\text{Marginal costs} * \text{number of latrines sold})}{\text{Number of latrines sold}}$$

Costs were either fixed or marginal, where fixed costs include the operational, administrative, and staff costs required to implement the subsidy program over this ten-month study, and marginal costs include the added cost of selling a single latrine, which includes sales-agent commissions, the average cost to process a loan, and the average subsidy value paid out (treatment group only) during the study.

Scaled treatment (subsidized) and control (non-subsidized) estimates of latrine cost assume countrywide implementation across 4,971 villages. To model latrine sales at scale using the treatment and control designs, results from this study were scaled up by scaling the number of SAs, number of days worked per month, and various other program metrics appropriately.

RESULTS AND DISCUSSION

Latrine sales

Latrine sales to IDPoor households were more than five times higher in treatment villages than control villages (395 vs. 75; Figure 1; Supplementary material, Table S3), and sales to IDPoor1 and IDPoor2 households in treatment villages were 6.5 and 4.3 times those in control villages (196 vs. 30; 203 vs. 47), respectively. Also, sales to non-IDPoor households were similar in both groups (356 in treatment group vs. 344 in control group; $p = 0.59$ in Fisher’s Exact test; Figure 1). Thus, latrine subsidies appear to have markedly increased latrine sales to IDPoor households while not affecting those to non-IDPoor households, supporting results from the literature (Kohlitz *et al.* 2021; Hoo *et al.* 2022).

In the treatment effects models of latrine sales, statistically significant effects on latrine sales were observed for IDPoor households specifically, and across villages as a whole, but not for Non-IDPoor households. When subsidies were offered, latrine sales increased overall by 14.3%, and by 16.9 and 14.7% among IDPoor1 and IDPoor2 households, respectively (Table 1). The finding that subsidies did not alter demand among non-IDPoor households is also confirmed by the model ($p > 0.1$; Table 1) and supports results from the literature (Hoo *et al.* 2022). These results highlight the strong impact that targeted latrine subsidies can have on latrine sales to poor households without impacting sales to non-poor households.

In addition to subsidies, other variables affected the likelihood of selling a latrine. A household being offered a latrine subsidy in the past increased the likelihood of selling a latrine by 11.1% to IDPoor1 households and 12.4% across all households (Supplementary material, Table S5). Also, past negative experiences with latrine programs reduced sales across all households (-11.9%, Supplementary material, Table S5). Fewer potential latrine customers also reduced the likelihood of selling

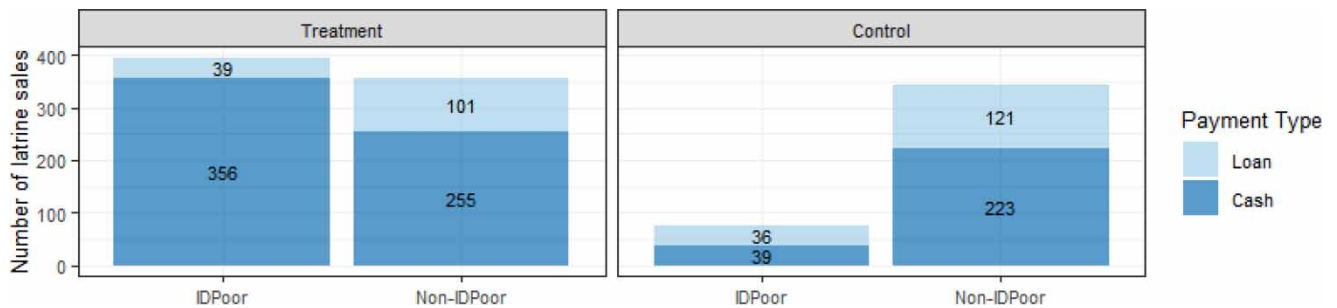


Figure 1 | Total latrine sales by payment type, IDPoor status, and group.

Table 1 | Selected coefficients of variables in treatment effects model of latrine sales at the village level by IDPoor status and for all households

Variable	Percent change in latrines sold to			
	Non-IDPoor	IDPoor1	IDPoor2	All households
Subsidies offered to IDPoor households	-0.002 (0.04)	0.169*** (0.059)	0.147*** (0.050)	0.143** (0.062)
Offered latrine subsidy in the past	0.05 (0.03)	0.111* (0.062)	-0.04 (0.06)	0.124* (0.065)
Had negative experience with latrine program in the past	-0.084** (0.037)	-0.091* (0.055)	-0.02 (0.04)	-0.119** (0.052)
Constant	0.283*** (0.100)	0.08 (0.30)	0.08 (0.12)	0.2 (0.2)
Observations	143	140	142	150
R-squared	0.23	0.21	0.29	0.18

Additional variable coefficients are shown in Supplementary material, Table S4. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

a latrine, as expected (−47.8%, Supplementary material, Table S5). Other variables, such as the total number of households, sales agent, and month of sale, did not affect the likelihood of latrine sales based on IDPoor status. The lack of effect by the month of sale contradicts a finding from the literature, which highlights that willingness to pay varies by month (Harper *et al.* 2021).

The interaction effects models show that lower baseline latrine coverage may be associated with lower non-poor latrine sales, suggesting that implementers should delay the introduction of subsidies until markets have matured in order to minimize distortions (Supplementary material, Table S6). Also, a higher IDPoor1 percentage in a given village may slightly increase the number of latrine sales among IDPoor1 households (Supplementary material, Table S7), which intuitively follows from more potential customers producing higher sales rates. This effect was not found among IDPoor2 households, which cannot be explained by the data but may be due to reduced effectiveness of the smaller subsidy offered to IDPoor2 households. No other significant interaction effects were found among Non-IDPoor, IDPoor2, or all households.

Qualitative results from debriefs with iDE staff and household surveys at the end of the study showed that few (14%) non-IDPoor or control-group households were aware of the targeted subsidy offered to IDPoor households in the treatment group during this study. Thus, unintended knowledge transfer from treatment to control villages about the subsidies was minimal and thus unlikely to affect the study's results.

Considered together, these results suggest that well-targeted subsidies can significantly increase latrine sales among poor households while maintaining the integrity of the sanitation market for households that do not qualify for the subsidy. Additionally, high loan rejection rates (34% in this study) make alternative financing largely unattainable for household sanitation systems, including latrines, and thus give subsidies the opportunity for more impact.

Cost-effectiveness

Despite the program costs per latrine in the treatment group having a marginal cost of nearly \$10 USD more than those in the control group, the CER in the treatment group was markedly lower due to more latrine sales and thus a lower fixed programmatic cost per latrine in the treatment group (Figure 2 and Supplementary material, Table S5). In this study, SAs in the treatment group sold 755 latrines for a program cost of \$153 USD per latrine on average compared to 421 latrines for \$254 USD per latrine on average in the control group (Figure 2). In the scaled estimates, program costs per latrine are projected to be approximately \$38 with the subsidy compared to \$54 without the subsidy; the lower program costs per latrine in the scaled estimates are due to economies of scale (Figure 2). Combined with the latrine-sales results above, this CER analysis shows that the latrine subsidies offered in this study increase latrine sales more efficiently than no subsidies when targeting IDPoor households while not adversely affecting sales to unsubsidized customers.

Limitations

Factors surrounding SAs likely affected this study's results. Negative effects on SA morale led to turnover every two to three months due to (1) diminishing latrine sales in the study region due to high baseline latrine coverage in study villages and (2) sales protocols that favored the study's methodology, not maximizing sales. Villages were also revisited regardless of sales probability to ensure that sufficient households were included in this study. In a real sales program, SAs and managing directors would be able to take steps (e.g., not visiting villages with high latrine coverage) to maximize sales. Also, SAs may have put more effort into sales in treatment villages because they could use subsidies as a sales tool. Thus, incentivizing SAs to sell

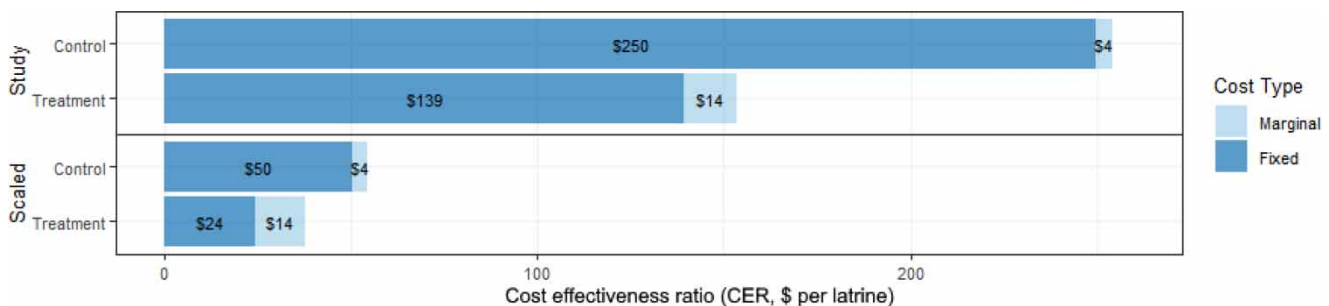


Figure 2 | Cost-effectiveness ratios by group for study and scaled up to entire iDE sanitation marketing program.

to the poorest households or villages with higher latrine coverages will be required to successfully use sanitation marketing methods to bring safe sanitation to the poorest households.

Kandal province had some of the highest latrine coverage in Cambodia (66%) during this study compared to other Cambodian provinces (45%), making it more difficult to sell latrines due to a lower ratio of potential customers in each village. However, while not currently representative of rural Cambodia, this type of challenging environment likely represents the future of Cambodia's rural sanitation sector as latrine coverage continues to rise nationwide.

Additionally, many sanitation development programs that included latrine subsidies have been conducted in Kandal province previously. Qualitative evidence from SAs and iDE staff that worked on these programs indicated that poor implementation of past latrine programs may have made households wary of this study's efforts. Additionally, past experience with programs that provided latrines free of charge would affect households' expectations and willingness to pay for latrines. While this experience is not representative of most of Cambodia currently, it is again likely representative of Cambodia in the future, highlighting that future latrine programs should consider this changing landscape when calculating latrine-sales expectations.

Finally, potential inaccuracies in the IDPoor system or outdated IDPoor cards could also exclude poor households from the subsidy. While likely rare, the presence of such occurrences would have led to a downward bias in results, potentially underestimating subsidy effects.

CONCLUSIONS

Given the benefits of widespread improved sanitation in rural communities, ensuring that subsidies improve sanitation across all demographics is critical when considering approaches to improving sanitation at scale. Despite the increased marginal costs of administering subsidies, latrine subsidies that accurately target poor households can increase latrine sales markedly (14.3% in this study) and more efficiently (\$153 vs. \$254 USD of program cost per latrine in this study) compared to sanitation programs that do not use subsidies without adversely affecting sales to non-poor households. Additionally, due to the randomized selection of villages, within which all households were visited, and similarities in culture, economy, social structure, and lifestyle, the results of this study are generalizable to the rural populations in other Cambodian provinces and in nearby countries including Thailand, Lao PDR, and Vietnam (Mensah & Chen 2013).

Based on this study's results, we highlight the following implications for sanitation policy making and implementation:

Subsidies must be necessary and well-targeted, which can be challenging

Because not all contexts require subsidies to achieve high latrine coverage rates (Pattanayak *et al.* 2009), subsidies must first be deemed necessary to ensure that all households can purchase a latrine. Targeting subsidies at poor households then requires a trusted and accurate system like Cambodia's IDPoor system. Such systems are not common in most countries and thus must be developed to increase the sector's ability to target latrine subsidies (and perhaps other forms of financing and subsidies). Until then, other programs that attempt to implement latrine subsidies must proceed cautiously when designing subsidy verification and study protocols.

Subsidies can yield operational efficiencies compared to financing

The sector, particularly in Cambodia, has long focused on providing financing to consumers of water, sanitation, and hygiene (WASH) products, including latrines. During this study and in iDE's experience more generally, slow loan processing times and high rejection rates typically make sanitation financing at scale difficult. In contrast, well-targeted subsidies can increase sales while being simple and inexpensive to administer, making them an attractive alternative to financing when targeting poor households. However, these conclusions are likely to be highly contextual and should be tested in a specific context before being applied in practice.

Latrine coverage changes latrine sales

While latrine subsidies can markedly increase latrine sales among poor households, lower latrine coverage is weakly associated with lower latrine sales to non-poor households. Implementers and policy makers should thus avoid introducing latrine subsidies before there is baseline sanitation coverage in a given region to avoid unintended market distortions.

Familiarity with the local market is critical

Local knowledge of and iDE's long-standing presence and commitment to Cambodia's rural sanitation market was integral to the success of this study. Experienced local SAs and management teams ensure accurate data collection and the ability to manage operational challenges associated with administering latrine subsidies.

For governments, funders, and implementors to achieve their goals, including Sustainable Development Goal 6.2 (United Nations 2017), well-targeted subsidies should be considered and will likely become increasingly important to introduce at the proper time along with, policy, product, and service delivery solutions.

DATA AVAILABILITY STATEMENT

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

CONFLICT OF INTEREST

The authors declare there is no conflict.

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