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Learning to Dislike Safe Water Products: Results from a Randomized Controlled Trial of the Effects of Direct and Peer Experience on Willingness to Pay

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S *Supporting Information*

ABSTRACT: Low-cost point-of-use (POU) safe water products have the potential to reduce waterborne illness, but adoption by the global poor remains low. We performed an eight-month randomized trial of four low-cost household water treatment products in Dhaka, Bangladesh. Intervention households (n = 600) received repeated educational messages about the importance of drinking safe water along with consecutive two-month free trials with each of four POU products in random order. Households randomly assigned to the control group (n = 200) did not receive free products or repeated educational messages. Households' willingness to pay for these products was quite low on average (as measured by bids in an incentive-compatible real-money auction), although a modest share was willing to pay the actual or expected retail price for low-cost chlorine-based products. Furthermore, contrary to our hypotheses that both one's own personal experience and the influence of one's peers would increase consumers' willingness to pay, direct experience significantly decreased mean bids by 18−55% for three of the four products and had no discernible effect on the fourth. Neighbor experience also did not increase bids. Widespread dissemination of safe water products is unlikely until we better understand the preferences and aspirations of these at-risk populations.

■ INTRODUCTION

Contaminated drinking water contributes to the deaths of some 1.8 million children under the age of five every year.[1] Although some researchers remain unconvinced that household-based water treatment can achieve dramatic reductions in diarrheal illness,[2] a number of randomized controlled studies have shown that point-of-use (POU) safe water technologies such as water filters and chlorine can reduce waterborne disease morbidity.[3−5] However, adoption of these technologies remains very low among the global poor,[6,7] and unless their appeal to vulnerable populations is increased they cannot substantively reduce the diarrheal burden.[8]

We present results from a randomized field experiment that tested how hands-on experience and the experience of one's peers affect demand for these potentially life-saving technologies. Water treatment products are what economists call "experience goods" whose value is determined through their use.[9] After a free trial we expect consumers will increase their demand for products that consumers like, while they will decrease demand for products they find hard to use, that have unwanted side effects, or that appear ineffective. As these products are, in fact, effective (evidence on this below), we hypothesized that demand would rise for many or all of them. We also hypothesized a role for social influences: if a consumer likes a safe water product after experience with it, their neighbors and peers may similarly learn about the product's value. Such diffusion of innovations can cause demand to increase for new technologies[10−12] and can increase the adoption of health behaviors.[13−16]

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■ MATERIALS AND METHODS

Experimental Design. From January to September 2009 we conducted this research in low-income sections of the densely populated mixed-income community of Mirpur in Dhaka, Bangladesh (see Supporting Information (SI) for a map of study area). The baseline sample consisted of 800 households with a child of age <5 years, drawn from 800 distinct compounds (collections of 6−20 households that share a common water tap and latrine).

During the baseline survey enumerators explained the health risks of untreated local water. Enumerators then delivered presentations of four POU products in a randomized order. At the end of the baseline survey, 600 of 800 households were randomly chosen as intervention households and were provided one of four POU products selected at random for a two-month trial. The remaining 200 control households received no products. Randomization appeared successful: the chi-squared test *p*-value was 0.67 in a probit regression predicting treatment status as a function of baseline household characteristics (see SITable S1).

At the end of each two-month trial period enumerators visited each intervention household for a follow-up survey to measure self-reported product usage and updated product preferences (survey questions about how much they liked a product after trying it out for two months). Each household was then assigned a new product in random order. The cycle was repeated four times, so that over 8 months every intervention household experienced a two-month trial with each of the four products in random order. The control households received no surveys during these intermediate rounds.

Eight months following the baseline survey, we revisited all 800 households and ran a real-money auction to measure how experience with the products affected willingness to pay (WTP) for them. Concurrent with this 8-month follow-up, we identified the nearest neighbor of all households with a child under 5 years of age, generally within the same compound. These neighbor households were not previously enrolled in the study, either as interventions or controls. We introduced the products and ran an identical auction to measure the neighbors' willingness to pay for the safe water products. The difference in willingness to pay between the neighbors of intervention households and of control households is an estimate of social spillovers in demand for POU technologies.

Setting. The study area is a crowded urban community where the majority of per capita household incomes were less than the global poverty line of $2 (in purchasing power parity) per day. Most residences have cement floors (82%) and corrugated iron roofs (92%) with shared walls. The most common source for drinking water at baseline was reported to be piped water (73% of treatments; 76% of controls; $p = .52$). Water quality tests taken during the course of the study revealed that the source water was contaminated with *E. coli* in the vast majority (83%) of visits to control households. More details on the study setting and water quality testing and analysis can be found in a companion article.[17]

The Four POU Products. The four POU water treatment products are (1) locally produced and marketed liquid sodium hypochlorite (branded as Water Guard by BioChemical), (2) sodium dichloroisocyanurate tablets (branded as Aquatabs by Medentech, Ltd.), (3) a combined flocculant-disinfectant powdered mixture (branded as PUR Purifier of Water by the Procter & Gamble Company), and (4) a siphon-driven porous ceramic filter (branded as the CrystalPur Filter by the international nongovernmental organization Enterprise Works/VITA, now part of Relief International; a companion article[17] has more information about the products). Each product dramatically reduces concentrations of pathogen indicators in drinking water.[18−21] A recent meta-analysis of 31 POU product studies yields a pooled estimate of 42% (95% CI: 33−50%) reduction in diarrheal disease risk.[22] A range of liquid and tablet chlorine products (under various brand names) were available locally at the time of our study. The first three products (the "chemical products") are consumable goods, whereas the filter is a durable good with an expected lifespan of 1−2 years barring breakage.

Outcome Measure. The outcome of interest for this analysis is willingness-to-pay for the POU technologies. We measured willingness-to-pay using a Becker-DeGroot-Marschak (BDM) auction.[23] In this auction each household bids its own money for each product. Participants win the product if their bid is above a (random) price hidden inside an envelope, and end up paying the price in the envelope as opposed to their own bid. Participants submitted bids on all four safe water products but could win at most one product: the eligible product and its accompanying price were both hidden inside the envelope. Because a bid affects whether someone wins a product, but *not* how much they pay if they win, this auction provides incentives for respondents to truthfully report their willingness to pay (at least if participants understand and believe all the instructions). That is, it is not in the best interests of a respondent to name a higher price than what the product is worth to her, because she may end up paying a higher amount than her actual willingness to pay. Similarly, if a participant understates her true willingness to pay, she might lose the opportunity to buy the auctioned product at a price she was, in fact, willing to pay. We gave auction participants up to seven days to gather funds if needed and allowed them to ask any questions prior to participating in the auction to ensure their understanding. The products auctioned included 1 bottle of Water Guard (enough for two weeks or longer), one sleeve of Aquatabs (enough for 10 days), five sachets of PUR (enough for five days), and a filter that would typically last a year or two. (See the SI for our translated auction protocol and instructions.)

Data Analysis. Our auction measured the demand curve for each product; that is, the share of respondents willing to pay any given price (with their own money out of pocket). We estimate two sample *t*-tests of mean willingness to pay for each of the four POU products across intervention and control households to estimate the effect of direct experience on willingness to pay. However, it is possible that the effect of experience is not a uniform shift in the demand curve and, thus, a simple comparison of means will hide important differentiation of tastes among the experienced intervention respondents. We therefore also examine the entire distribution of willingness to pay for both intervention and control households, as well as for neighbors of interventions and neighbors of controls, by performing Kolmogorov−Smirnov tests. Finally, producers considering introducing new products to a market care more about having a sufficient number of consumers willing to pay a given price than about mean willingness to pay. Assuming a 10% market share is sufficient to motivate entry of new products, we also test for changes in the

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90th percentile of willingness to pay in the auction using quantile regression.

Ethics Statement. Participants were briefed as to the details of the study and given the opportunity to ask questions and receive answers to those questions. Enumerators obtained informed written consent from each respondent prior to inclusion in the study. This study was reviewed and approved by the Ethical Review Committee at ICDDR,B and the Committee for the Protection of Human Subjects at the University of California, Berkeley.

Role of the Funding Source. The sponsors of the study had no role in data analysis, data interpretation, or writing of the report. All authors had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of data analysis. D.L. and S.L. had final responsibility for the decision to submit for publication.

RESULTS

We interviewed 755 of the original 800 participant households at the 8 month exit survey and they participated in the auction. The rate of attrition between baseline and 8-month exit interviews was not statistically different between the intervention group (95%) and control group (94%; p-value = 0.536). None of the households refused to participate in the auction. Of the 755 remaining households, we located and interviewed the nearest eligible neighbor of 744. Thus, a total of 1499 participants took part in the auction.

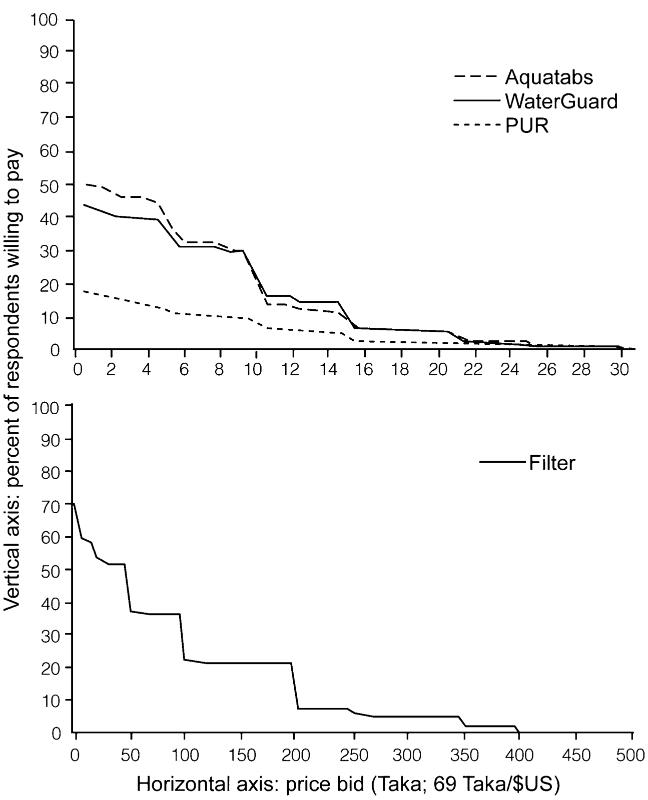

Figure 1. Willingness to pay (Demand) curves for Aquatabs, Water Guard and PUR (upper graph) and the CrystalPur siphon filter (lower graph). The vertical axis corresponds to the share of respondents willing to pay a given price; the horizontal axis represents different prices (we graph the filter separately from the chemical products since the relevant prices are much higher). As the price increases along the horizontal axis, the share willing to pay that amount decreases. Sample is intervention households at final survey (N = 568). Demand measures the percent of respondents bidding at least that price for one bottle of Water Guard (sufficient for 2 weeks or longer), a sleeve of Aquatabs (sufficient for roughly 10 days), five sachets of PUR (sufficient for roughly 5 days), or one filter.

Table 1. Direct Experience Effects on Auction Willingness to Pay at Endline, Intervention Households (With Experience with All Products) versus Controls[a]

	original households only (interventions + controls)		
	(1)	(2)	(3)
	interventions	controls	difference (intervention− control)
Aquatabs			
mean	5.07	6.18	−1.11[c]
	(0.28)	(0.50)	(0.57)
median	1	5	−4[b]
90% percentile	15	15	0
Water Guard			
mean	4.67	5.9	−1.23[c]
	(0.27)	(0.51)	(0.56)
median	0	4	−4[c]
90% percentile	15	15	0
Pur			
mean	1.76	3.9	−2.14[b]
	(0.20)	(0.46)	(0.44)
median	0	0	0
90% percentile	10	15	−5[b]
Filter			
mean	77.33	75	2.33
	(4.45)	(7.96)	(9.00)
median	20	15	5
90% percentile	200	200	0
N	568	187	

[a]Standard errors in parentheses. Units are Taka, with a market exchange rate of 69 Taka/US$. The auction was for one bottle of WaterGuard (2 weeks' supply), one sleeve of Aquatabs (~10 days' supply), five sachets of PUR (~1 week supply), and one filter. Difference in means calculated as two sample t-tests, tests of equality for medians and 90th percentiles are based quantile regressions. [b]$P < 0.01$. [c]$P < 0.05$.

In total, 32% of all respondents "won" the auction—their named price for the randomly selected product was greater than the offer price hidden inside the envelope. Of these, 13% subsequently refused to pay for the products at this price despite having agreed to the rules of the auction (4% of all respondents). There were no statistically significant differences in this refusal rate across groups (4% of interventions, 3% of controls, and 5% of neighbors, p-value = 0.56 on three-way adjusted Wald test). The most commonly cited reason for refusal was lack of funds at home (36 of 59 responses provided).

In Figure 1 we present the demand curves for only the intervention households after they had a two month free trial with each product. All products show high dispersion in willingness to pay. For example, each product received zero bids from over 40% of experienced intervention consumers. At the same time, a significant minority were willing to pay the expected retail price for Aquatabs and for Water Guard.

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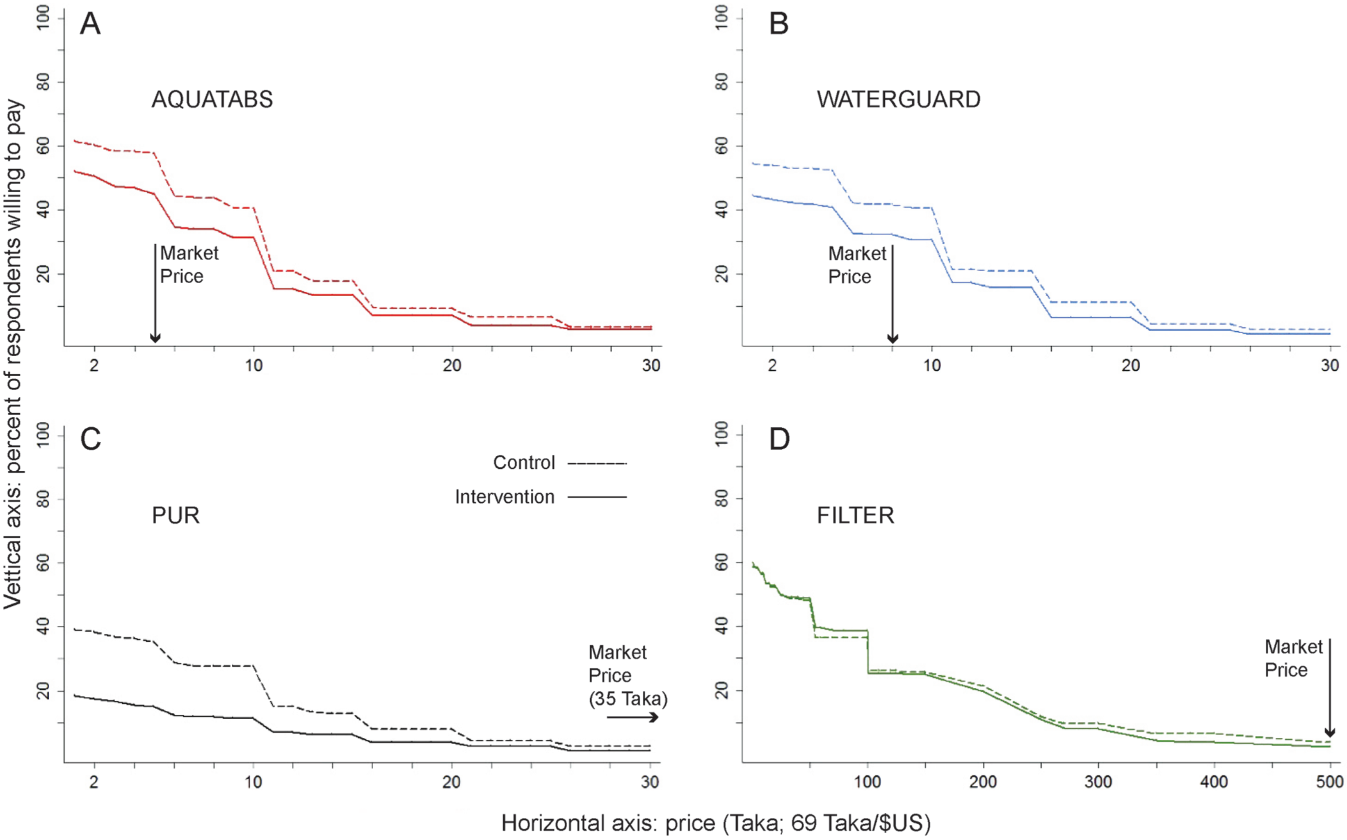

Figure 2. Willingness to Pay by Intervention Status, Four POU products. The vertical axes correspond to the share of respondents willing to pay a given price; the horizontal axes represent different prices. For any given product, as the price increases along the horizontal axis, the share willing to pay that amount decreases. Vertical lines correspond to market prices for the products. Sample is all intervention and control households at exit survey wave (N = 755). Demand measures the percent of respondents bidding at least that price for one bottle of Water Guard (sufficient for 2 weeks or longer), a sleeve of Aquatabs (sufficient for roughly 10 days), five sachets of PUR (sufficient for roughly 5 days), or one filter. Respondents who won paid their own money.

Specifically, 47% bid 5 Taka ($0.07) or more for a sleeve of Aquatabs (which would last about 10 days) and 33% bid 8 Taka ($0.12) or more for a bottle of Water Guard (which would last 2 weeks or longer).

Nearly 80% of participants bid zero for five sachets of PUR, the highest share of zero bids of any product. Correspondingly, PUR would have zero demand at its typical retail price in other nations ($0.50 for 5 sachets).

Forty two percent of respondents bid zero for the filter, while 20% bid 200 Taka ($2.90) or more. One percent (6 of 568) bid 500 Taka ($7.25).

In Table 1 we consider the effect of experience on willingness to pay for all products by comparing results from intervention households with control households. For the consumable chemical products—Water Guard, Aquatabs, and PUR—mean willingness to pay was substantially and statistically significantly lower for the experienced intervention respondents than for the control respondents. The reduction in mean willingness to pay was over 50% for a week's supply of PUR (from around 4 to 2 Taka), around 18% for a 10-day supply of Aquatabs (from about 6 to just under 5 Taka), and over 20% for a two-week supply of Water Guard (from just over 6 to about 5 Taka). At the time of our study there were about 69 Taka to a U.S. dollar.

Notably, the CrystalPur filter suffered no such penalty from experience, with mean willingness to pay near 75 Taka ($1.09) for both intervention and control respondents.

Results are similar for a nonparametric comparison of medians as based on quantile regressions (Table 1).

We do not find differences in WTP between the experienced and inexperienced potential early adopters: The 90th percentile of willingness to pay in the auction is identical for most products among intervention and control respondents (Table 1). The exception is for a week's supply of PUR, for which the 90th percentile of WTP for controls is 15 Taka ($0.21), while for the experienced intervention households the 90th percentile of WTP is lower at 10 Taka ($0.14, difference statistically significant at $P < 0.01$ in a quantile regression).

Figure 2 illustrates the share of respondents willing to pay any given price with their own money out of pocket for each POU product separately by treatment status. (The vertical lines in these graphs correspond to the expected market prices for each. There is no line for PUR since WTP is everywhere below its expected market price of 35 Taka for five sachets.) Panels A though C show that the demand curves for the chemical products among the experienced intervention households are everywhere below those of the controls (Kolmogorov−Smirnov tests reject equality of WTP distributions for all three chemical products, with p-value = 0.046 for Aquatabs, p-value = 0.093 for Water Guard, and p-value < 0.001 for PUR). For the filter, however, the experienced intervention households' demand curve overlaps with that of the controls (panel D, Kolmogorov−Smirnov test p-value = 0.899).

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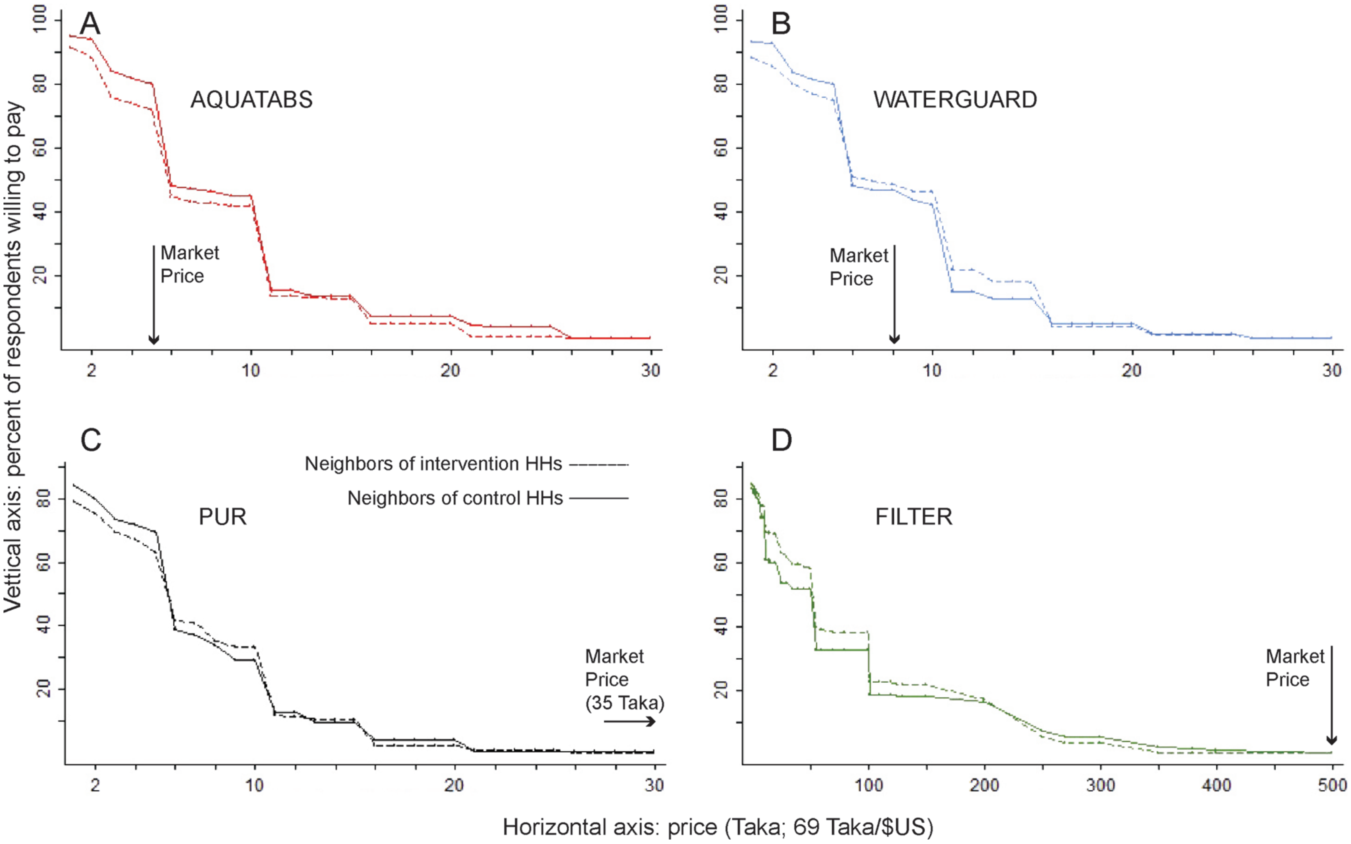

Figure 3. Neighbors of intervention households vs neighbors of controls, willingness to pay for four POU products. The vertical axes correspond to the share of respondents willing to pay a given price; the horizontal axes represent different prices. For any given product, as the price increases along the horizontal axis, the share willing to pay that amount decreases. Vertical lines correspond to market prices for the products. Sample is all neighbors of the intervention and control households at the exit survey wave (N = 744). Demand measures the percent of respondents bidding at least that price for one bottle of Water Guard (sufficient for 2 weeks or longer), a sleeve of Aquatabs (sufficient for roughly 10 days), five sachets of PUR (sufficient for roughly 5 days), or one filter. Respondents who won paid their own money.

Table 1 and Figure 2 present intention-to-treat analyses of the causal effects of experience on valuations for POU products by using the randomized assignment of compounds into intervention and control groups. We do not consider the self-selected subset of *users* of the products because doing so loses the benefits of randomization.

However, intervention households self-reported having experimented with the products at least once during free trials nearly 90% of the time, yet just 15% reported any of their current water as being treated with a product at the time of the two-month follow-up survey visits.[17] Thus, the negative effect of experience on valuations is consistent with a more general negative effect of experience on product preferences.

As we would expect given the negative effect of intervention households' direct experience (Table 1 and Figure 2), neighbors of experienced intervention households do not value POU technologies more than do neighbors of inexperienced control households. In fact, we find no evidence of peer spillovers on POU valuations (Figure 3 and Table 2; Kolmogorov–Smirnov tests fail to reject equality of distributions for all four POU products).

DISCUSSION

Although there was a range of POU products available locally during our study, none of the auctioned products were available. Nonetheless, for those products with available substitutes (Aquatabs and Water Guard), respondents may "anchor" their bids around market prices and refuse to bid above this amount. Unfortunately, our survey did not directly ask about knowledge of prices. However, we find no evidence of anchoring (i.e., there are no masses around the expected market prices in Figure 2). Furthermore, anecdotal and survey evidence suggest such problems should be minimal. The closest available substitute for Water Guard was a liquid chlorine product called Clotech that was sold in 2 or 4 L size bottles and therefore was not very suitable for household-level use. We also found very little awareness and no ownership of POU products among intervention households at baseline and among control and neighbor respondents during the auction. We therefore believe that the low willingness to pay that we find for these products reflects a general lack of demand, and was not due to respondents comparing prices and products with those available in the marketplace.

More importantly, despite 8 months' exposure to four different POU products, and repeated bimonthly visits to remind households of the dangers of unsafe drinking water, valuations decreased with hands-on experience for each of the three consumable chemical products.

Again it is possible that the intervention households came to expect free products and in turn anchored their willingness to pay around a zero price, and this explains any difference in WTP across treatment groups. In economics there is an ongoing debate about the appropriate role for subsidies on health-producing goods.[24−26] But we doubt that the negative

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Table 2. Neighbor Experience Effects on Auction Willingness to Pay at Endline: Neighbors of Intervention Households versus Neighbors of Controls[a]

	neighbor households only		
	(1)	(2)	(3)
	neighbors of interventions	neighbors of controls	difference (intervention−control)
Aquatabs			
mean	7.09	7.84	−0.76[a]
	(0.23)	(0.41)	(0.46)
median	5	5	0
90% percentile	15	15	0
Water Guard			
mean	7.66	7.44	0.22
	(0.37)	(0.23)	(0.45)
median	6	5	1
90% percentile	15	15	0
Pur			
mean	6.07	6.12	−0.04
	(0.22)	(0.36)	(0.43)
median	5	5	0
90% percentile	15	12	3*
Filter			
mean	76.09	68.82	7.27
	(3.50)	(6.38)	(7.07)
median	50	50	0
90% percentile	200	200	0
N	557	187	

[a]Standard errors in parentheses. Units are Taka, with a market exchange rate of 69 Taka/US$. The auction was for one bottle of WaterGuard (2 weeks' supply), one sleeve of Aquatabs (~10 days' supply), five sachets of PUR (~1 week supply), and one filter. Difference in means calculated as two sample *t*-tests, tests of equality for medians and 90th percentiles are based quantile regressions. [b]$P < 0.1$.

effect of experience on WTP among intervention respondents is purely one of anchoring. For one, we might expect the opposite effect that intervention respondents feel a heightened obligation to purchase a product after so many months of free trials. Second, these findings are consistent with the observed high rates of drop-out from usage during the two month trials and negative reviews about the products themselves (more details below).[17] They are also consistent with the low levels of sustained use seen with POU products more generally.[27,28]

Importantly, the filter did not lose value after experience. At the same time, demand for the filter was low overall, which does not bode well for its market viability: only 1% of experienced consumers (6 out of 568) bid 500 Taka ($7.25), a reasonable estimate of the retail price of the filter.

Taken literally, our results suggest that with this level of education on safe water products these poor communities can support a larger-than-current private market in low-cost household water treatment products such as Water Guard and Aquatabs. That is, 47% of all respondents are willing to pay the prevailing market price for a sleeve of Aquatabs (5 Taka) and 33% are willing to buy a bottle of Water Guard for 8 Taka. (These figures decline slightly to 44% and 31% if we consider only the experienced respondents. The zero demand for PUR at its prevailing market price matches the lower usage rates of PUR relative to the other products during the free trials.[17])

Although suggestive, the willingness to pay measured in our auctions may be higher or lower than expected sales at those prices for an ongoing business. In standard auctions bidders usually bid below their true willingness to pay so they retain some value if they win. This strategy is not in participant's self-interest in our auction design, but can occur if participants did not understand the rules of the auction, did not calculate all the implications of those rules, or did not trust the enumerator. Auction bids can also be below a household's willingness to pay if the woman bidding does not control much of the household's finances or if it takes a few days to gather cash for a relatively large purchase such as the water filter. (Our auction protocol took measures that aimed to address each of these points as detailed in the Materials and Methods section.) Alternatively, the auction bid can be above the sustained willingness to pay of participants who are trying to be polite to the enumerator or who intend to purchase once, but not regularly.

Even if a reasonably sized market exists for Water Guard and/or Aquatabs, the finding that direct experience reduces valuations for the consumable chemical products and shows no evidence of a beneficial effect for the filter suggests that these products may have trouble reaching a sustainable level of consumer demand in the private sector. The lack of positive spillovers in demand to neighbor households further suggests important barriers to the expansion of the POU market.

Our initial sampling strategy for the 800 intervention and control households was based on a random walk method and carried out at the level of compounds to try to minimize spillovers in product valuations between interventions and controls. If negative spillovers to nearby compounds existed, our estimate of the negative effect of experience on willingness to pay would be a lower bound and the true effect is even larger.

If POU technologies are to be distributed by the private sector, consumers must value the products sufficiently to purchase and repurchase them. Even if distribution is free, health benefits require consumers to like the products sufficiently to use them regularly. Yet again, even during the free trial, most treatment households did not use any of the POU products on most days.[17]

Inadequate understanding of the benefits of safe water cannot fully explain the low adoption rates nor willingness to pay: just 31% of intervention respondents reported their source water as "safe" to drink at baseline, and only 21% did so at exit (difference statistically significant at p-value < 0.001). Complaints about the products themselves also do not fully explain the low valuations. Taste and smell were the most commonly cited obstacles to treatment for the chemical products, and for the filter the necessary treatment time was the biggest complaint.[17] However, many more respondents did not use and were not willing to pay for these products than named such obstacles, and it is unclear if these are true barriers or merely convenient justifications for why a respondent stopped using a given product.

Our findings are subject to a few important caveats. First, it is possible that the preferences of the urban poor of Dhaka, Bangladesh with respect to water treatment may differ from other populations. Indeed, we find important differences in rates of product adoption between this study and a companion study we carried out in rural western Kenya (although that study did not include a real-money auction so we cannot say anything about relative willingness to pay).[18] Second, we did not test all POU technologies currently available and (fortunately) new products are under development.

We applaud the efforts of those developing new products for household water treatment. At the same time, past designs and marketing strategies have paid inadequate attention to the preferences of the end-users. A necessary (though not sufficient) condition of POU product adoption by the poor at scale is a better understanding of the preferences, choices, and aspirations of at-risk populations.[17,18] Product design that lowers the cost and promotes the habit of water treatment is likely to be important.[29] Marketers should experiment with messages that go beyond the standard ones about water and health to encourage uptake. We encourage further tests of marketing strategies, sales offers, and product designs as the search for ways to expand safe water access continues.

■ ASSOCIATED CONTENT

Supporting Information

Additional information as noted in the text. This material is available free of charge via the Internet at http://pubs.acs.org.

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Author Contributions

J.L., D.L., and J.A. led design of the study. J.A. led the selection of products. J.L. and M.M. led design of the survey, and M.M. led the design and testing of the auction. N.N. supervised the data collection. L.U. and S.L. directed the ICDDR,B team. J.L. led data analysis and wrote the first draft. D.L. and S.L. are guarantors for the report.

Notes

The authors declare no competing financial interest.

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