

Research Paper

Users are willing to pay for sanitation, but not as much as they say: empirical results and methodological comparisons of willingness to pay for peri-urban sanitation in Lusaka, Zambia using contingent valuation, discrete choice experiments, and hedonic pricing

James B. Tidwell

ABSTRACT

Significant investment is needed to improve peri-urban sanitation. Consumer willingness to pay may bridge some of this gap. While contingent valuation has been frequently used to assess this demand, there are few comparative studies to validate this method for water and sanitation. We use contingent valuation to estimate demand for flushing toilets, solid doors, and inside and outside locks on doors and compare this with results from hedonic pricing and discrete choice experiments. We collected data for a randomized, controlled trial in peri-urban Lusaka, Zambia in 2017. Tenants were randomly allocated to discrete choice experiments ($n = 432$) or contingent valuation ($n = 458$). Estimates using contingent valuation were lower than discrete choice experiments for solid doors (US\$2.6 vs. US\$3.4), higher for flushing toilets (\$3.4 vs. \$2.2), and were of the opposite sign for inside and outside locks (\$1.6 vs. \$ - 1.1). Hedonic pricing aligned more closely to discrete choice experiments for flushing toilets (\$1.7) and locks (-\$0.9), suggesting significant and inconsistent bias in contingent valuation estimates. While these results provide strong evidence of consumer willingness to pay for sanitation, researchers and policymakers should carefully consider demand assessment methods due to the inconsistent, but often inflated bias of contingent valuation.

Key words | contingent valuation, discrete choice experiments, financing, hedonic pricing, sanitation, willingness to pay

James B. Tidwell
Mossavar-Rahmani Center for Business and
Government,
Harvard Kennedy School of Government,
Cambridge, MA,
USA
and
World Vision,
Washington, DC,
USA
E-mail: btidwell@worldvision.org

HIGHLIGHTS

- A commonly used method for assessing willingness to pay, contingent valuation, produces inconsistently biased and often inflated values.
- While there is significant willingness to pay for some aspects of sanitation by users, methods that elicit preferences indirectly and/or through real market transactions should be used where possible to inform policymakers and the private sector.

INTRODUCTION

People who live in peri-urban areas are a large and growing proportion of the population, and the challenges of ensuring adequate sanitation in these areas are a significant public

health challenge that requires understanding and leveraging household investment to reach the sustainable development goal of 'Sanitation for All'. Peri-urban areas suffer from poor

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quality infrastructure and health outcomes are worse in these areas than either urban or rural areas (Ezeh *et al.* 2017). The number of people living in peri-urban areas is increasing rapidly around the world and is estimated to reach 2 billion people by 2035 (UN-HABITAT 2003).

Inadequate sanitation is a major cause of lost DALYs (GBD Diarrhoeal Diseases Collaborators 2017) and results in more than \$220 billion USD of economic losses annually (Lixil, WaterAid, and Oxford Economics 2016). The cost of reaching the SDG (Sustainable Development Goals) for sanitation is estimated at more than \$1 trillion USD during the SDG era (Hutton & Varughese 2016). The anticipated financing needs are greatest for urban and peri-urban areas, and the burden is expected to fall largely on governments and donors with little consideration of the role of the substantial direct household investment required of households and indeed already taking place (Danert & Hutton 2020). Along with ensuring the security of land tenure (Scott *et al.* 2013), advocating for high-quality shared sanitation to be included in the SDGs (Evans *et al.* 2017), and providing ways to increase willingness to pay through marketing messages or credit products (Ben Yishay *et al.* 2017), estimating and leveraging this demand is key to ensuring adequate sanitation for people living in peri-urban areas.

We present here the results of a study of tenant willingness to pay for higher-quality shared sanitation in peri-urban Lusaka, Zambia. Peri-urban areas are rapidly growing and present significant health and sanitation challenges globally (Nakagiri *et al.* 2016; Ezeh *et al.* 2017), and a lack of hygienic conditions, desirability, accessibility, and sustainability (Tidwell *et al.* 2018a) lead to a number of negative health and well-being impacts (Shiras *et al.* 2018). Sanitation is often not directly purchased in the market in these settings, but instead is selected along with a choice of housing in one bundled rental payment, making willingness to pay assessment more difficult. We collected data from 1,085 landlords and their tenants using both stated and revealed preference methods to estimate tenant willingness to pay and implications for sanitation promotion and service delivery in this setting.

Understanding user preferences and willingness to pay is generally done using either stated preferences (SPs), hypothetical choices expressed by users, or revealed preferences (RPs), which come through observing decisions with real-life stakes in existing markets or experimental settings.

Stated preference methods can be either direct, asking a respondent what they are willing to pay for something, or indirect, such as asking a respondent to rank or choose between alternatives, which can be used to calculate implicit willingness to pay. Stated preference methods are frequently used because they are easier and cheaper to administer and can be used to value products or services that do not yet exist. The contingent valuation method (CVM) (Mitchell & Carson 1989) is an SP method that directly elicits whether a consumer is willing to pay a proposed amount. Though CVM was originally developed for understanding preferences for environmental quality, where there was no observable market (Hanemann 1994), it has often been applied to exploring potential markets for water and sanitation products (Whittington *et al.* 1993; Altaf & Hughes 1994; Null *et al.* 2012; Sehreen *et al.* 2019). Indirect methods such as discrete choice experiments (DCEs) are being used (Quaife *et al.* 2018), where respondents are presented a series of choices between alternatives with different characteristics, which may avoid some of the potential biases of direct SP methods.

The most significant concern with using SP methods is hypothetical bias (Hausman 2012), which occurs when answers differ between hypothetical scenarios and real-life scenarios when respondents must make real money transactions. Hypothetical bias is widely recognized in the SP literature (List & Gallet 2001; Little & Berrens 2004; Murphy *et al.* 2005), and a recent meta-analysis found that CVM inflated mean WTP (Willingness to Pay) estimates by a factor of 1.79. However, CVM studies have been conducted most often in situations where consumers have no market experience (such as for air quality or presence of recreational parks), and there is less evidence about hypothetical bias for CVM in settings where consumers have purchasing experience (Hanemann 1994; Carson *et al.* 2001).

There is less evidence about the magnitude of hypothetical bias in DCEs, with some finding higher marginal WTP from SP (Johansson-Stenman & Svedsäter 2003), others suggesting they are equal (Carlsson & Martinsson 2001; Cameron *et al.* 2002; Tidwell *et al.* 2019b), and one even finding that DCEs produced lower WTP estimates due to routine behaviors resulting in increased RP values (Isacsson 2007). In addition, DCEs often predict actual health behaviors (Quaife *et al.* 2018), especially when

differences in personal preferences are taken into account in the models used (de Bekker-Grob *et al.* 2020), and that they are less subject to social desirability bias than other SP methods (Horiuchi *et al.* 2018).

Revealed preference methods aim to overcome problems of hypothetical bias by requiring monetary stakes to be associated with decision-making. The price of sanitation associated with a rental decision cannot be separately observed in the market, but by using an RP method called the hedonic pricing method (HPM), we can calculate the implicit price of each housing and sanitation attribute (Rosen 1974). However, RPs may suffer from biases and empirical challenges as well. They may be biased if choices are complex (Beshears *et al.* 2008) or when there is market failure (Hanna & Richards 2014). HPM requires pre-selecting the model used to estimate willingness to pay (van den Berg & Nauges 2012) and rare combinations of attributes and collinearity make model estimation challenging (Harrison & Rubinfeld 1978). HPM has been applied to sanitation in a few cases where a large fraction of rent was being estimated, such as for the presence of a toilet (Simiyu *et al.* 2017) or a sewer connection (Vásquez & Beaudin 2020).

SP studies, almost exclusively using CVM, have found significant willingness to pay for sanitation, including urban residents willing to pay 14% of mean monthly expenditure for high-quality on-site sanitation (Altaf & Hughes 1994) and rural households willing to pay almost a third of their annual income for a flushing toilet (Van Minh *et al.* 2013). However, RP studies have produced much smaller estimates of willingness to pay. For example, using voucher-based methods, less than 5% of a rural Tanzanian population was willing to pay even half the market price of improved latrine slabs, where the full price amounted to less than 5% of their annual income (Peletz *et al.* 2017).

Reliable WTP estimates are important for policymakers and may be used to understand the market potential of new products (Van Minh *et al.* 2013) or optimal government subsidies to drive improvements (Whittington *et al.* 1993). While a previous study using this dataset focused on the DCE results in comparison to hedonic pricing values (Tidwell *et al.* 2019b), DCEs are more complicated to design and analyze than CVM studies, and so, CVM studies would be preferable if shown to produce reliable estimates. Therefore,

in this study, we report the results the CVM approach to assessing willingness to pay for improvements in peri-urban shared sanitation quality compared to these other methods. We further suggest the reasons for differences between the approaches and implications for method selection and interpretation for policymakers.

METHODS

Study setting

The data for this study were collected as part of a trial of a behavior-change intervention targeting landlords in Bauleni Compound, a peri-urban neighborhood in Lusaka, Zambia. Bauleni has an approximate population of 64,000 people, and it is subdivided into plots of land, which were originally intended for one household. However, landowners have become *de facto* landlords, with a median of three tenant households [IQR: 2–4] living on each plot at present (Tidwell *et al.* 2019b). We surveyed 1,137 landlords, and after excluding 52 who had no current tenants, enrolled 1,085 landlords in our trial. For each landlord enrolled, data were also collected from one randomly selected adult from a tenant household living on the plot. More data about the study setting are available elsewhere (Tidwell *et al.* 2018b). There are no public toilets in the neighborhood other than in a central market, and all plots enrolled in the study had at least one toilet on the plot that could be freely accessed by the tenants, who never paid for this access other than as bundled in the monthly rent payment. Our assessment of sanitation quality in the area showed that 87% of toilets were ‘improved, but shared’, in terms of JMP classification, but often were unhygienic and structurally poor (Tidwell *et al.* 2018a). Therefore, we focused on understanding how much variation in rent was attributable to differences in sanitation quality.

Data collection and analysis

The data for this study were collected in June and July of 2017 from a total of 1,085 landlord-tenant pairs. Hedonic pricing was based on observations of the housing and toilet characteristics, while stated preference methods were

used to collect WTP data directly from tenants. Locally based enumerators were trained by our local research partner, the Center for Infectious Disease Research in Zambia (CIDRZ). Data were collected using a systematic random sample of every fourth house within Bauleni. We conducted a round of pilot data collection in a nearby neighborhood to ensure high-quality data were being collected and to generate priors from which to design the DCEs. Data were collected using ODK Collect software (Hartung *et al.* 2010), and analysis was done using R version 3.5.2 (R Core Team 2018).

The HPM used a regression analysis with the household's monthly rental payment as the dependent variables and a model that incorporates their housing attributes (including house, plot, and community-level factors). Analysis was conducted with a generalized linear model with the first model incorporating sanitation through a simple binary variable capturing the presence of a toilet and a second model that measured sanitation quality through a number of more granular measures (such as the presence of a solid door and the presence of a concrete slab). The models consisted of a standard linear combination of attributes (Champ *et al.* 2017), other than an interaction term between the presence of water on the plot and a flushing toilet in the second model, which emerged as interrelated considerations in the formative research stage (Tidwell *et al.* 2018b). For the one case where a measured attribute had another as prerequisite (i.e., a solid door is required to have inside and outside locks), we modeled this as a categorical variable and performed a *post hoc* analysis to separate out the value of inside and outside locks. We estimated both models using OLS (Ordinary Least Squares) and tested for heteroscedasticity, variance inflation due to multicollinearity, and functional form.

DCEs presented a series of six pairs of choices between rental accommodates, where housing characteristics were fixed, but with different kinds of toilets. Toilet options varied by the presence of a simple cover (not included in the contingent valuation questions, and thus not included here), flushing toilet, solid door, inside and outside locks, and price. Tenants then selected the rental accommodation that they preferred based on the toilet options presented. Additionally, tenants were randomly assigned to one of two separate groups of choice

sets that differed based on whether a water source was present on the plot, which was suggested to be an important consideration based on feedback during our piloting. DCEs were analyzed using four different logit models including fixed and random parameters and with and without price interactions, and ultimately, a random parameters model with price interaction was selected based on having the lowest AIC3 value (Andrews & Currim 2003). This analysis produced sample-level estimates of mean and standard deviation for WTP for each of the included attributes, which were calculated using the ratio of parameter estimates for each attribute to the estimate for the price attribute. More details about the HPM and DCE analysis are available elsewhere (Tidwell *et al.* 2019b).

Contingent valuation

A series of dichotomous choice contingent valuation questions were asked of each respondent to solicit their WTP for several toilet improvements based on standard guidance (Boyle 2017). We asked about upgrading from a simple hole to a flushing toilet (on a plot with a water tap – see discussion below), from a toilet without a solid door to one with a solid door (without locks on the inside or outside), and from a solid door without any locks to a solid door with both locks. These upgrades were presented as generic (unbranded) upgrades, with a generic ceramic flushing toilet seat, a basic, unfinished solid wood door, and a standard mount for a padlock (outside lock) and deadbolt lock (inside lock) shown/described. Inside and outside locks were grouped together as the anticipated willingness to pay for either was small, due to their low cost. Each of these upgrades was found in a substantial number of existing toilets in the area, but there is not a large variety of types available, and thus, heterogeneity of WTP due to differing assumptions of product quality was considered to be minimal.

Tenant household members identified as being primarily responsible for financial decision-making regarding housing choices were asked if they would be willing to pay more rent if they were hypothetically living on a plot that did not already have the improvement, but the landlord made each of three improvements. If they said yes,

they were asked if they would pay a certain amount more rent if a landlord made the improvement, with a randomly assigned monthly rent increase value of 10–50 Kw in 10 Kw (US\$1) increments (for the flushing toilet and solid door) and 5–25 Kw in 5 Kw (US\$0.5) increments (for adding locks). Tenants were reminded to consider their real-life budget constraints to reduce the possibility of hypothetical bias.

Utility was modeled using a standard approach (Hanemann & Kanninen 2001), where a combination of observed and unobserved variables are included for each individual and maximum likelihood estimation is used to estimate the parameters of the utility function and the variance of the normally distributed error term, and these values are then used to calculate WTP. Analysis was conducted using the *sbchoice* package in R, with truncated mean WTP estimated using a normal distribution (Estimation using a logistic distribution yielded similar results, and log-logistic, log-normal, and Weibull distributions performed poorly on the dataset because of the large number of positive responses to questions, even at the high end of the bid price range) and standard errors calculated using bootstrapping, except where low WTP led to errors in the bootstrapping procedure. In these cases, the Krinsky–Robb method for calculating confidence intervals (Krinsky & Robb 1986) was used instead, though it produces more conservative confidence intervals (Hole 2007). Tenant income, gender, number of household members, age, level of education, and employment type were included in the model as covariates.

Ethical considerations

Enumerators received training on following ethical procedures of data collection. They delivered the surveys in person to landlords and tenants after reading aloud an information sheet in English or a local language (Bemba or Nyanja), responding to any questions, and receiving written consent or a thumbprint with witness present if the person was unable to write their name. Participants were informed that they were allowed to terminate the survey at any time for any reason. No compensation was provided to any participant, and no personally identifying information was collected. Both the University of

Zambia Biomedical Research Ethics Committee in Lusaka, Zambia (ref: 002-02-17) and the London School of Hygiene and Tropical Medicine (ref: 12157) approved the study.

RESULTS

Sample characteristics

A total of 890 tenants were surveyed with one of the two willingness to pay methods out of the 1,085 landlords enrolled (Table 1), with fewer tenants than landlords surveyed due to challenges in scheduling a suitable follow-up time for an interview (if the selected tenant was not present

Table 1 | Sample demographic characteristics by willingness to pay method

Characteristic	CVM	DCE	p-value
Number of observations	458	432	
Gender = female	80.8%	81.9%	0.721
Age (mean (SD))	30.0 (9.0)	30.8 (9.9)	0.184
Monthly rent (Kw) (mean (SD))	481 (192)	469 (198)	0.369
Monthly household income (Kw) (mean (SD))	1,318 (1,107)	1,320 (1,071)	0.979
Number of household members (mean (SD))	3.1 (1.8)	3.2 (1.9)	0.298
Respondent education level			
Primary or less	20.5%	20.1%	0.874
Some or completed secondary	72.3%	74.5%	0.447
Beyond secondary	7.2%	5.4%	0.263
Respondent employment type			
Unemployed/housework	50.9%	48.4%	0.458
Casual worker/piece work	13.3%	13.0%	0.875
Self-employed/business	22.1%	26.4%	0.131
Formal employee	10.9%	9.0%	0.348
Retired	0.2%	0.2%	0.967
Other	2.6%	3.0%	0.726
Marital status			
Married	73.1%	73.8%	0.814
Single, never married	18.1%	16.0%	0.395
Divorced/separated	8.7%	10.0%	0.532

Note: Differences calculated between individual responses within categorical variables.

at the time of the landlord interview) or refusal by the selected tenant. Roughly equal numbers were assigned to CVM ($n = 458$) and DCE ($n = 432$) arms by random assignment within the mobile data collection software package. Demographic characteristics were well balanced between arms allocated to the different data collection methods. The mean age was 30 years old, and a majority of respondents were female (81.3%). Women were found in our formative research to be more influential in household decision-making related to sanitation quality, likely because of the larger amount of time they spent at home (Tidwell *et al.* 2018b). Due to the lack of gender balance in the sample, with more than 80% of respondents being female, each analysis was disaggregated by gender. About half (48.5%) of tenants earned less than US\$1.25 per household member per day (Median: US\$1.35, IQR: [0.79, 2.47]). Tenants paid about 36% of their monthly income for rent,

and a majority had completed some or all of secondary school.

Logistic regression models of the utility associated with each sanitation improvement by regressing respondent characteristics and bid amounts on stated willingness to pay (a binary, yes/no variable) showed little variation across covariates included in each model (Table 2). The level of income was negatively associated with absolute WTP for doors, but not for other improvements at the $p < 0.05$ level. Bid amounts were only related to rate of yes responses for flushing toilets at the $p < 0.05$ level, though overall rates of responding yes to CVM questions were low for the other two improvements. No geographic component was included in the analysis as the survey took place in one neighborhood and zones created artificially for the survey collection process showed no differences across housing covariates in earlier analyses (Tidwell *et al.* 2019b).

Table 2 | Analysis of covariates of willingness to pay for sanitation improvements

Outcome = 1 if willing to pay for toilet component at offered bid value:	Flushing toilet (Estimate (Std Err))	Solid door (Estimate (Std Err))	Inside and outside locks (Estimate (Std Err))
(Intercept)	0.359 (0.314)	-0.173 (0.321)	-0.399 (0.337)
Income (thousand Kw)	-0.011 (0.066)	-0.141 (0.071)**	-0.132 (0.072)*
Age	0.004 (0.008)	-0.001 (0.008)	-0.001 (0.008)
Sex = Male	-0.071 (0.185)	-0.126 (0.191)	-0.294 (0.196)
Education (ref: primary or less)			
Some or completed secondary	0.07 (0.161)	0.055 (0.166)	-0.13 (0.165)
Beyond secondary	0.211 (0.305)	0.149 (0.317)	-0.087 (0.316)
Employment (ref: unemployed/houseworker)			
Casual worker	0.017 (0.201)	0.09 (0.21)	-0.037 (0.214)
Self-employed/business	-0.013 (0.161)	0.198 (0.166)	0.106 (0.167)
Formal employee	0.352 (0.235)	0.335 (0.232)	0.399 (0.235)
Retired	4.803 (146.9)	-4.132 (146.9)	5.433 (146.9)
Other	-0.582 (0.408)	-0.443 (0.471)	-0.141 (0.44)
Marital status (ref: married)			
Single, never married	0.043 (0.18)	-0.132 (0.185)	0.021 (0.185)
Divorced/separated	-0.119 (0.233)	-0.256 (0.245)	-0.39 (0.256)
Bid amount	-0.009 (0.004)**	-0.005 (0.004)	0.015 (0.009)*
<i>N</i>	451	451	451
Log-likelihood	-224.24	-169.12	-108.84
Pseudo- R^2	0.2618	0.4029	0.6115

Notes: Parameter estimates from logistic regression models were used to assess individual characteristics associated with willingness to pay.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Though overall ‘yes’ response rates were only slightly decreasing for bids within each offered upgrade, differences between ‘yes’ responses for any willingness to pay and offered bids and across categories varied significantly (Figure 1). For flushing toilets, 68.7% said they were willing to pay some amount, but the number of yes responses declined to 40.1% for solid doors and 34.4% for inside and outside locks.

Willingness to pay for each of the three sanitation improvement categories was positive and statistically significant for CVM (Table 3). Mean estimates of 33.5 Kw for flushing toilets, 26.1 Kw for solid doors, and 15.6 Kw for inside and outside locks represented 7.4, 5.8, and 3.5% of median monthly rent (450 Kw [IQR: 350–550]) in the sample, which was just under half of median tenant monthly income of 1,000 Kw [IQR: 750–1,700]. All estimates were statistically significantly different from zero, and parameter

estimates were all considerably larger than those from the same improvements from HPM. WTP for adding locks to a solid door was also positive, in contrast to the results of HPM. Estimates did not vary significantly based on respondent income. A sub-group analysis of respondents with zero vs. non-zero WTP for each attribute (Supplementary Table S1) found that there were no statistically significant differences by observable characteristics.

As previously reported, WTP did not differ significantly between DCEs and HPM for flushing toilet or for inside and outside locks, though WTP for a solid door was higher in DCEs than in HPM. This may have been due to differences in how surveyors assessed solid doors (fully attached with no holes) compared to how tenants perceived them (anything that could be moved to fully block the entrance for privacy) as well as collinearity between solid doors and other infrastructure components for HPM (though tests for

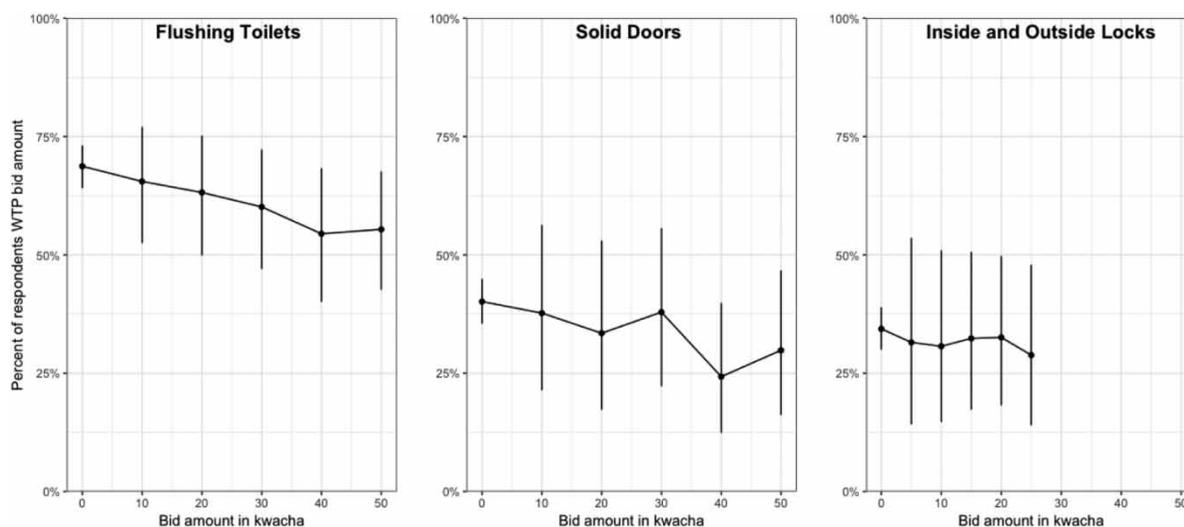


Figure 1 | Responses to contingent valuation questions by toilet improvement. Note: Proportion of respondents stating they were willing to pay for initial bid amount (zero) and randomly selected higher amount in 5 or 10 Kw increments for those responding yes to the initial bid; 10 Kw = US\$1.

Table 3 | WTP estimates for sanitation components across WTP methods

Component	Contingent valuation DCEs		Hedonic pricing			
	WTP estimate in Kwacha [95% confidence interval]		CVM – DCE	CVM – HPM	DCE – HPM	
Flushing toilet	33.5 [30.7, 35.7]	22.1 [16.9, 27.2]	16.5 [–12.3, 45.3]	11.4 [5.6, 17.2]*	17.0 [–12.0, 46.0]	5.6 [–34.9, 23.7]
Solid door	26.1 [21.7, 28.8]	33.8 [30.2, 37.3]	3.5 [–16.5, 23.5]	–7.7 [–13.3, –2.1]*	22.6 [2.1, 43.0]*	30.3 [10.0, 50.6]*
Inside and outside locks	15.6 [9.7, 20.9]	–10.7 [–16.3, –5.1]	–8.8 [–29.0, 11.3]	26.3 [18.1, 34.4]*	24.4 [3.4, 45.4]*	–1.9 [–22.8, 19.1]

Note: Values reported in Kwacha: 10 Kw = US\$1.

* $p < 0.05$.

inflation due to multicollinearity did not reject the null, aspects of toilet superstructure such as walls, doors, and a roof had VIFs of about 1.3, higher than other model parameters). For flushing toilets, CVM estimates were about 1.5 times higher than DCEs and about twice as high as HPM. For solid doors, CVM estimates were slightly lower than DCE estimates and, though the null hypothesis that CVM and HPM produced different estimates was not rejected at the $p = 0.05$ level, there was large uncertainty in the HPM estimate, and the mean estimated difference was large. For inside and outside locks, CVM estimates were much higher than DCE and HPM estimates. Notably, while estimates for the presence of inside and outside locks were positive for CVM (15.6 Kw), they were negative for both DCEs (-10.7 Kw) and for HPM (-8.8 Kw).

DISCUSSION

Estimates of WTP using the direct stated preference CVM were similar to estimates from both SPs using the indirect DCE approach and RPs estimated using the HPM for solid doors. However, CVM was much higher for flushing toilets as well as inside and outside door locks. DCEs and HPM produced generally similar WTP estimates. Poorly specified HPM parameter estimates were a challenge for each toilet characteristic examined, as there was no evidence of non-zero WTP for any particular aspect of sanitation. Standard errors were much smaller for both kinds of stated preference WTP estimates (CVM and DCE) than for HPM, which is generally the case due to the ability to control the design of stated preference methods. Hedonic pricing, based on a regression analysis and observed toilet characteristics existing in the study setting, suffered from collinearity and low prevalence of certain toilet components in HPM, leading to poorer parameter specification.

WTP generally drops off rapidly for positive prices for preventive health products and services (Cohen 2019), but the results for CVM were either level or slightly decreasing in this study for each of the examined sanitation improvements. This may be for at least two reasons. First, the range of offered prices was low relative to mean income in this population, though the prices were in line with what was seen in the market. This may have also interacted

with a second factor, the likely social desirability bias for stated willingness to pay for sanitation improvements, as we saw no change in responses even by income level. CVM may be particularly unreliable for small prices such as the amortization of an improvement through a monthly rental payment. Certainly, more study is needed on this point.

It is common in the literature to assume that while CVM may overstate WTP, that it is enough to calculate an overall inflation factor by which to proportionately reduce all estimates, though satisfactory ways to do this have not been developed (Murphy *et al.* 1998; Hensher 2010; Schmidt & Bijmolt 2019). This study provides evidence that this is not sufficient for two reasons. First, CVM displayed considerable hypothetical bias for some toilet characteristics and not others. While estimates for flushing toilets were much higher via CVM than other methods, estimates for solid doors were more comparable to other methods, at least in terms of absolute differences. We hypothesize that this is due to a social desirability bias that might exist for reporting to a researcher a desire for a flushing toilet and not for solid doors, given that there is evidence that choice experiments and other indirect preference elicitation methods are less prone to social desirability bias (Horiuchi *et al.* 2018). This bias is likely inherent to a direct elicitation stated preference method like CVM.

Second, CVM may result not just in inflated estimates of WTP, but in estimates with the wrong sign. This cannot be accounted for by merely suggesting that CVM produces inflated estimates or by suggesting a proportion by which WTP estimates should be reduced to make them better reflect real demand. This issue is not inherent to CVM, but rather results from a problem in how the standard approach applies in this particular situation, which suggests at the very least that CVM may need to be augmented by a question beyond the standard initial question ('Would you be willing to pay any amount for this item?') to also include 'Would you accept it for free?' or 'Would you prefer to have or not to have this item?' or even include negative offers (i.e., willingness to accept this state in exchange for payment). This may especially be true where a product's costs outweigh its benefits for some in a heterogeneous population.

Given these inconstant biases, we should not have grouped the inside and outside locks in the design of our

stated preference methods. While initially done to ensure that willingness to pay would be large enough to be detected from our sample size, it may have obscured a small positive willingness to pay for an inside lock with a larger negative willingness to pay for an outside lock (based on feedback from program participants). This also demonstrates that willingness to pay may be more related to user experience, rather than the actual value of the improvement made.

Over the last several decades, CVM studies argued that tenants were willing to pay 14% of mean monthly expenditure in urban Burkina Faso for high-quality on-site sanitation (Altaf & Hughes 1994), that rural households in Vietnam will pay almost a third of their annual income for a flushing toilet (Van Minh *et al.* 2013), that households in Delhi, India (Chopra & Das 2019) and Dhaka, Bangladesh have high willingness to pay for wastewater treatment services (Sehreen *et al.* 2019), and that wealthier residents of two Kenyan cities were willing to pay a cross-subsidy on their water bill to provide financing to improve sanitation services for poor customers resulting in \$200,000 and \$470,000 USD in financing annually (Acey *et al.* 2019). The results of this study suggest that such estimates are likely inflated, and may be so in a way that is difficult to simply ‘adjust for’ using some kind of assumption about a fixed inflation factor.

HPM has been used to assess the amount of rent attributable to differences in sanitation quality, with the presence of a toilet resulting in rent increases from 1.6% (Gulyani *et al.* 2012) to 18% (Tidwell *et al.* 2019b) to 60% (van den Berg & Nauges 2012). Increases of 16% from moving from a pit latrine to a flush toilet (Knight *et al.* 2004), 14% between shared and private toilets (Brueckner 2013), and 15% for the presence of solid walls and a roof (Tidwell *et al.* 2019b) have also been observed. However, the challenge of pre-specifying a model of willingness to pay means that these values are subject to the relatively unrealistic assumption that value consists of a linear combination of attribute values, and thus, using additional methods to validate HPM results may be warranted. DCEs may be more relevant for judging relative valuations of different attributes than CVM, given its inconsistent biases.

Toilets shared by several tenant households may be improved to some degree by leveraging tenant WTP. However, since willingness and ability to pay for high-quality sanitation are less than its costs for many, policy-relevant and practical approaches are urgently needed to address

this gap, including lower-cost or subsidized products, demand creation (Tidwell *et al.* 2019a) or regulatory enforcement (Antwi-Agyei *et al.* 2019) interventions, or considering ways to remove the burden of behavior from the consumer altogether (Pickering *et al.* 2019). For example, creating operational efficiencies, offering subsidies, and increasing regulatory enforcement may make adequate fecal sludge management possible in some settings (e.g., Burt *et al.* 2019).

There were several limitations in the current study. The most important is that while we can draw conclusions about WTP estimates from different preference elicitation methods, interpreting what true (often called ‘normative’) preferences are and reasons for estimates differing (e.g., due to social desirability bias) is subjective. Beyond showing where different methods agree and disagree, direct testing of these hypotheses would produce better estimates of true WTP – for example, by randomly allocating some plots to receive a particular upgrade and looking at rental prices achieved over time. Additionally, eliciting preferences via CVM and/or DCEs for attributes of rentals that were better estimated by HPM (e.g., number of rooms) or capturing the overall rental value through stated preference methods would allow for better comparison with real-world data, as HPM estimates were poorly specified in some cases for reasons described above. Second, each of these methods is subject to assumptions made by functional forms assumed and estimation methods used. Several models were estimated for each method, but different ways of constructing choice experiments, phrasing CVM questions, or categorizing plot characteristics for HPM may have led to different conclusions. However, we used standard approaches for each of these three methods to generate results that were as policy relevant as possible.

For policymakers, it is clear that CVM alone is inadequate to determine demand for services. While revealed preference methods are not feasible in many settings where new products or services are to be provided, DCEs and other less-direct methods should be considered. As was shown above, the problem is not simply that CVM estimates may be inflated, leading policymakers to rely on them to indicate perhaps only relative preferences between options, but instead may produce varying levels of bias in estimates or even estimates that are of the wrong sign. Since DCEs allow for the estimation of tradeoffs between

attributes, and hedonic pricing ensures that the overall rental fees paid are consistent with market prices, combining the results of these approaches may be the best way to accurately estimate WTP, with CVM being reserved for testing new or hypothetical products or services where presenting choices between alternative services is not a straightforward exercise. Future research should further validate this approach using DCEs where more clearly defined housing attributes (e.g., rent paid per room of housing) can be compared to results from hedonic pricing.

Despite these methodological challenges, it is clear that substantial willingness to pay for sanitation quality exists in peri-urban shared sanitation settings, and future research should build on this work by using incentive-compatible methods to firmly establish the potential market for sanitation in these marginalized communities and further validate indirect stated preference elicitation methods for estimating demand for new and existing water and sanitation products and services at low cost to those conducting the assessments.

CONCLUSION

Tenants expressed significant willingness to pay for several important aspects of higher-quality shared sanitation. However, some limitations were demonstrated with each method of willingness to pay assessment, and especially with the inconsistent bias displayed by contingent valuation. While the magnitude of these amounts will not be sufficient to reach high-quality sanitation for all, they may make a major contribution to gaps in sanitation financing when combined with demand-side approaches, strengthened markets, and subsidies. Accurate assessments of willingness to pay, likely using combinations of DCEs and appropriate revealed preference methods, will be a key consideration for peri-urban sanitation planning to reach the goal of sustainable sanitation services for all.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this paper is available online at <https://dx.doi.org/10.2166/washdev.2020.072>.

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