Willingness to pay for improved water supplies in rural Ugandan villages

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ABSTRACT

The contingent valuation method was used to estimate willingness to pay (WTP) for the operation and maintenance of an improved water source in the villages of Kigisu and Rubona in rural Uganda. The survey was conducted in August 2011 and administered to 122 households out of 400 in the community, gathering demographic information, health and water behaviors, and using an iterative bidding process to estimate WTP per 20 L for a public tap. The data were analyzed using an ordered probit model, which predicts monetary intervals for households' WTP. The model predicts a mean WTP of 356 Ugandan shillings (USD 0.183) per 20 L from a public tap. It was determined that the number of children in the home and the distance from the existing source are significant in influencing household’s WTP, while income, age, and gender are not.

Key words | contingent valuation, rural water supply improvements, Uganda, willingness to pay

INTRODUCTION

Increased access to improved water sources is recognized as critical to improving health and promoting poverty reduction in the developing world. The Millennium Development Goal 7.3 – halving the population without access to improved water and sanitation – is projected to be missed by half a billion people. Currently, 85% of those without access to improved water live in rural areas (JMP 2013). Even when new drinking water supply systems are constructed, they are often not used or maintained properly. For example, the Rural Water Supply Network website indicates that 20% of hand-pumps in Uganda are non-functional due to maintenance issues (Harvey 2007). In some countries, new construction efforts are exceeded by the rate of failure (Mu et al. 1990). In most areas of the developing world, households have access to water from a variety of sources, which vary greatly in their ease of use, quality, quantity, price, reliability and other factors. These variables combine with social, cultural, and political factors to create a complex decision-making process when it comes to household choices among water supply options.

Poor access to water is a major contributor to health and economic problems in rural Uganda, where 84% of the population lives in rural areas. As of 2011, only 72% of rural households in Uganda had access to improved water (JMP 2013). The under-five mortality rate in Uganda is 15%. Overall, mortality from diarrheal disease is 3%, resulting in an additional 29,300 deaths annually (UNICEF/WHO 2009). Although water supply improvements are expected to reduce the occurrence of waterborne diseases in Uganda, guidelines for making choices for water supply improvements are not clear. Howard et al. (2002) reports that the selection of water supply sources, e.g., piped water supplies vs. household rainwater harvesting, by poor households in urban areas in Uganda is highly variable.

Achievement of efficacy, equity, and sustainability in water supply services requires an understanding of the determinants of household preferences towards various aspects of water supply projects, including the associated willingness to pay (WTP) for water supply improvements (Whittington et al. 1991; McPhail 1993a, 1993b; Goldblatt 1999; Fujita et al. 2005; Farolfi et al. 2007; Awad & Hollander 2010). WTP estimates for water supply improvements have been found to be site specific (Wedgewood & Sansom 2003; Whittington et al. 2009). In rural Zimbabwe,
households were unwilling to pay more than 0.5% of income for protected wells because the wells were seen as only a marginal improvement over existing sources (Briscoe et al. 1990). Rural communities in Thailand and India were willing to pay significantly more than 5% for a private tap (Mu et al. 1990). An El Salvadoran community was willing to pay up to 30% of income for a private tap (Perez-Pineda 1999).

The contingent valuation method (CVM) is a survey-based technique designed to elicit WTP or willingness to accept estimates in order to determine the value of a particular environmental good or service. Respondents are asked to state their WTP contingent on the provision of some good or service. CVM has been used by donor agencies to assess the demand for improved water supply and sanitation services in developing countries. The value for such services cannot be determined using other means, such as actual behavior, because the proposed improvements currently do not exist at the location of the study. This uncertainty necessitates the use of ‘stated preference’ approaches, such as CVM, which ask individuals what they would do under alternative scenarios.

While there is considerable CVM literature on estimating WTP for improved water sources in rural communities in developing countries (Whittington et al. 1990, 1991, Altaf et al. 1993; McPhail 1993b; Whittington 2002; Ntengwe 2004; Ahmad et al. 2005), it is inconsistent with regard to the significant independent variables that drive WTP for water supply improvements. For example, in some studies, the education level of respondents has proven to be significant (Singh et al. 1993; Wedgewood & Sansom 2003; Abdul & Eatzaz 2007). Other studies reported that, while more educated respondents are generally willing to pay more than less educated respondents, this effect is statistically significant in only a few studies and the magnitude is always minor (Whittington et al. 1990; Boadu 1992; Perez-Pineda 1999). As such, the primary drivers of WTP remain largely an empirical issue, to be determined on a case-by-case basis.

There is a significant amount of research that indicates that a well-designed and implemented CVM study will produce reasonable, predictable, and reliable information (Whittington et al. 1990; Arrow et al. 1993; Whittington 1998; Carson 2000; Carson et al. 2001; Gunatilake et al. 2007). The effectiveness of CVM in WTP analysis is now widely accepted, particularly when it is used to value a familiar good such as a water supply (Boardman 2006), and a good that is primarily associated with active use values rather than nonuse (or ‘passive’ use) values, which remain more controversial (e.g., Caudill et al. 2011). However, the literature on WTP for water supply improvements and, more generally, preferences for various water supply options in Uganda, is limited. In this work, CVM is used to determine household WTP, and variables that influence WTP, for an improved water source in two rural Ugandan villages. This case study adds to a small but growing body of knowledge about specific variables relating to WTP in a rural developing nation context.

DATA AND METHODS

Study area

The CVM study was conducted in August 2011 in the villages of Kigisu and Rubona, Uganda. These villages are located in Mubende district, on the western edge of the Buganda Kingdom. Each community has a trading center, but has grown to the point where the boundary between the communities is not apparent. The population of the two villages, approximately 2,400 people and 400 households, respectively, consists primarily of subsistence farmers. Primary crops are used first as a food source and secondly for income. Coffee, plantains, and groundnuts are the primary cash crops in the study area.

Many of the available water sources are simple catchment areas for runoff, small impoundments for capturing stream flow, shallow wells, natural wetlands, or springs. The most common improved water sources are hand-pumped boreholes. Water from the boreholes is free; however, lack of coordination and planning has resulted in mechanical failure of half of the boreholes and location of the boreholes in areas that are difficult to access. Some residents pay for delivery of water from boreholes to their homes by bicycle. Residents also have access to several unimproved, open sources of fresh water that are unprotected from contamination from runoff or animal and human activities.

Kasambya, the nearest town, is more than 10 km distant to Kigisu and Rubona. Kasambya has a piped water supply with private taps and a public tap-stand. The public tap
provides water for purchase at a rate of 200 Ugandan shillings (UGX) per 20 liter (L) jerrycan, although this price varies with the seasonal rains. The villages of Kigisu and Rubona have been working with Kasambya Integrated Development and Care Foundation (KIDECAFO), a local NGO, to solicit funds for constructing an improved village water supply. The water project is proposed to serve approximately 400 households and 2,400 people. A network of public and private taps, similar to the Kasambya systems has been discussed as possible water system improvements.

Survey administration

The WTP survey was administered in-person with the cooperation of local leaders, KIDECAFO, and a group of local youth. Fifteen young adults, a combination of students in their senior-fourth year or higher (equivalent of freshman year in high school), university students, and new teachers were recruited as agents to implement the survey. Enumerators, KIDECAFO staff and several local leaders participated in two days of training. These sessions focused on helping the enumerators to understand the purpose of the survey, content, and proper questioning techniques. The sessions combined lecture and role-playing with enumerators practicing the survey on each other while being observed. These sessions served to further test the survey for proper design and translation. During the training, several changes to the survey were implemented based on feedback from the participants.

The village was divided into five sections based on major road divisions and household density. Survey agents were paired and assigned to a specific section. One of the pair would observe while the other conducted the interview. A survey administrator occasionally observed the interviews for additional quality assurance. While there was no formal sampling frame available for the area, the system was effective at covering the community with more than 30% of households being sampled. The response rate from those households sampled was 98%.

Survey design and analysis

The survey was based on recommendations from previous CVM studies such as Arrow et al. (1995), Whittington (1998, 2002), Gunatilake et al. (2007), and Nauges & Whittington (2010) and adapted from Breffle et al. (1998). The survey was designed to elicit information on demographics, health, the current water situation, and household WTP for an improved water source. The complete survey instrument is included in the Appendix (available in the online Supplementary Material http://www.iwaponline.com/washdev/004/011.pdf). The survey was conducted in Luganda, the primary language of the study area and most widely used language in Uganda.

In Uganda, it is customary for the male head of household to be responsible for financial decisions, while the female head is responsible for almost every other aspect of the family. The survey enumerators asked the first person encountered at the household if they were the person responsible for making decisions about the household’s water. By framing the question in this manner, the enumerators were able to speak to either male or female heads of household. Once the respondents were identified, the enumerator read an informed consent statement explaining the purpose of the survey, and then potential respondents were asked for consent to be interviewed.

The respondents were split almost evenly by gender (51% female and 49% male). Demographic information included level of education, age, number of people living in the household, and number of children in the household. The survey demographic results indicated that 86% of the people surveyed had seven years or less of schooling, 68% of the respondents were between the ages 25 and 50, 75% of households reported seven people or less in the household, and 75% of the households had five or fewer children.

The study employed two options for eliciting income information. Respondents were asked for their income, and that number was noted. If a respondent said they did not know their income but had indicated their occupation as farmer, they were asked to provide information about their most recent harvest, including which crops they grew and what quantity they sold during their most recent season. The local market prices for these goods were gathered, and the information was converted to an annual income for the household. In these cases, we assumed that 100% of the respondents’ income derived from farming. Approximately 92% of the population surveyed was found to engage in farming of some sort.

Respondents were asked if anyone in the household had experienced diarrhea, or other stomach upset, within the
last month. The survey revealed that 88% of households reported that someone was sick within the last month. If respondents responded positively to the question, they were asked about the frequency of these symptoms for children and adults. Respondents were asked how easy it is for them to meet current water needs. Ninety-eight percent of households said it was ‘very difficult’ for them to meet their water needs, with reasons ranging from water at current source being ‘dirty’ (53% of respondents), lack of availability of water (33%), and distance to current water source (14%). Respondents were asked if they boil or otherwise treat their drinking water and with what frequency. Eighty-eight percent of households responded that they boiled their drinking water, with 82% indicating they always boiled it.

Water use was determined by asking respondents how many containers (20 L jerrycans) they filled each day and which water sources they used. Ninety percent of households responded that they used 100 L or less per day, and 92% used less than 20 L per person per day. The preferred sources of water for the households were: pond – 69%, spring – 20%, dam – 9%, and borehole – 2%. Ninety-eight percent of households indicated that the quality of water from the preferred water source was ‘very bad’. Households were asked if they purchase water, how much they pay, and how many jerrycans they purchase. Only 25% of households responded that they purchased water. The total quantity purchased per day did not exceed 120 L, with 50% indicating they purchased 60 L or less. The total cost of water purchased daily did not exceed 3,500 UGX (US dollar (USD) 1.35), with 50% indicating they paid 1,500 UGX (USD 0.58) or less.

The distance of households surveyed to the existing water source and proposed public taps was estimated using Google Earth. The distances were measured by tracing routes along roads or paths along which we had observed people traveling to gather water. Distances to the existing water sources range from 255 m to 1,570 m, with a mean distance of 1,020 m. The distance to the proposed public tap ranged from 10 m to 1,750 m, with a mean of 460 m.

The survey described the proposed water system, including the system’s major components. The proposed system was compared to a known system from a nearby town, while stressing that a locally elected committee and not KIDECAFO or its representatives would run the proposed system. The proposed water supply system was summarized in the following. ‘The Kidecafo project would provide water to public taps located in the community. Water users would pay a fee to cover the operation and maintenance costs of the water system. All responsibility for the on-going operation, including the management of the funds, would be completely handled by a local water committee selected by your community. The WTP question was ‘If the project would place public taps only within the trading center, how many shillings would you pay for a 20 L jerrycan of water?’

An iterative bidding process was determined to be appropriate based on the sample size, previous studies’ recommendations (Breffle et al. 1998; Whittington 1998), and the common practice of negotiating in Ugandan markets and other business transactions. The UGX was valued at 2,770:1 USD at the time of the study (United Nations 2013). The smallest denomination of currency is a 50-shilling coin, but it is uncommon in practice and typically the smallest price increment is 100 UGX. Due to these factors, bidding prices of 100, 200, 400, 600, and 800 UGX were chosen. The upper level of 800 UGX was considered to be the lowest value we would expect to receive universal rejection.

To avoid any risk of starting-point bias, surveys started at either a high-bid (800 UGX) or low-bid (100 UGX) and then proceeded until the highest amount the respondent was willing to pay was recorded. In the case of ascending bids, the first ‘no’ response then indicated that the WTP for that respondent was between the most previous ‘yes’ response and the value they rejected. For those that started with the high bid, the first ‘yes’ indicated a WTP at a value between the accepted value and the previous rejection. Roughly 50% of the respondents were subjected to either a low or high starting bid.

Respondents were further questioned on their reason they were willing to pay for water. Most of the reasons can be attributed to ‘clean’ water (68%), nearness of water (10%), and water availability (5%), with some mentioning combinations of these three or all three as the reason for their WTP. It is important to note that respondents were implicitly providing WTP for water that will be used for drinking and cooking. It can be assumed that most households will continue to use the free sources for non-potable needs.
Estimation of WTP

Since WTP is a multiple response variable that has intrinsic order, an ordered qualitative response model is used in the analysis to estimate WTP as a function of household characteristics. The model can be written as

\[ WTP^* = X\beta^T + \varepsilon \]  

where \( WTP^* \) refers to the respondent’s latent (or unobserved) WTP, \( X \) is the vector of independent variables for the respondent, \( \beta \) is the vector of parameters relating the independent variables and WTP, and \( \varepsilon \) is an independently and identically distributed error term with mean zero and variance one. An individual respondent’s WTP, \( WTP_i \), lies between a lower bound (highest amount to which the response was ‘yes’ – \( WTPL_i \)) and an upper bound (lowest amount to which the response was ‘no’ – \( WTPU_i \)). The probability that true \( WTP_i \) lies between \( WTPL_i \) and \( WTPU_i \) is

\[ P(WTPL_i \leq WTP_i \leq WTPU_i) = \Phi\left(\frac{WTPU_i - WTP^*}{\sigma_i}\right) - \Phi\left(\frac{WTPL_i - WTP^*}{\sigma_i}\right) \]  

where \( \Phi \) is the standard normal cumulative distribution function and \( \sigma_i \) is the standard deviation of the distribution (Breftle et al. 1998; Greene 2011). An ordered probit model, which has a standard normal cumulative density function, is used in this analysis. This model allows the calculation of predicted probability for each WTP category and marginal effects, indicating the effect of a change in the explanatory variables on the predicted probability, for each WTP category. The ‘oprobit’ command in STATA (StataCorp 2009) was used to find the values of the parameters that maximize the log of the likelihood function

\[ \log L = \sum_{i=1}^{N} \log \left[ \Phi\left(\frac{WTPU_i - WTP^*}{\sigma_i}\right) - \Phi\left(\frac{WTPL_i - WTP^*}{\sigma_i}\right) \right] \]  

Wald and likelihood ratio (LR) tests are used to test the significance of each of the explanatory variables in the model.

RESULTS AND DISCUSSION

Table 1 shows the results of the WTP survey. The results indicate that the majority of residents are willing to pay from 100 to 400 UGX for a 20 L jerrycan of water. These results also indicate that the frequency distribution of acceptable bids varies smoothly and that the distributions for the low and high starting bids are similar, with a few exceptions. First, for the low starting bid group, 18.9% of the respondents indicated they were willing to pay 800 UGX, which is a sharp increase in WTP for the low bid group and is not in agreement with the high starting bid group. Second, more of the high starting bid group indicated they were willing to pay 400 and 600 UGX, as compared to the low starting bid group. However, starting bid was found to not be a significant variable in the model.

Expected WTP can be functionally expressed as

\[ WTP^* = 428.35 - 16.20 \text{ CHILDREN}_i + 212.395 \log (\text{DISTANCE})_i + \varepsilon \]  

where CHILDREN is the number of children in the household, and log (DISTANCE) is the natural log of distance to existing water supply in meters. A test using a dummy variable to control for starting point bias found that there was no starting point bias.

Table 2 provides the summary statistics for the WTP, estimated WTP, and the independent variables. Given that an individual’s WTP lies between a lower bound and upper bound value, statistics are reported for both. The mean of estimated WTP is 355.92 UGX and lies as expected

<table>
<thead>
<tr>
<th>WTP category (UGX)</th>
<th>Percent (total)</th>
<th>Percent (bid start – 0 UGX)</th>
<th>Percent (bid start – 800 UGX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.4</td>
<td>5.0</td>
<td>2.4</td>
</tr>
<tr>
<td>100</td>
<td>25.4</td>
<td>12.5</td>
<td>13.0</td>
</tr>
<tr>
<td>200</td>
<td>31.2</td>
<td>13.3</td>
<td>17.9</td>
</tr>
<tr>
<td>400</td>
<td>18.0</td>
<td>4.1</td>
<td>13.8</td>
</tr>
<tr>
<td>600</td>
<td>9.0</td>
<td>0.8</td>
<td>8.1</td>
</tr>
<tr>
<td>800</td>
<td>9.0</td>
<td>8.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>44.0</td>
<td>56.0</td>
</tr>
</tbody>
</table>
between the means of the upper and lower bound 95% confidence interval values of WTP. Further, comparison of the mean and confidence intervals with the results in Table 1 indicates that most of the respondents are willing to pay within one standard deviation of the mean estimated WTP.

There are few studies of WTP for water supply improvements made in rural African communities and the results are not straightforward to compare, given differences in the services offered, study time periods, and respondent populations. Nevertheless, it is worth reporting the results of these studies to provide a rough benchmark. Davis et al. (2001) reported that 60% of firms surveyed in two rural Ugandan towns were willing to pay 0.11 USD per 20 L jerrycan to access water at kiosks distributed in the communities. Goldblatt (1999) found a mean WTP of approximately USD 0.05 per 20 L for a proposed piped water supply system in two South African communities (mean WTP = 0.50 Rand/20 L; conversion of 5.5 Rand/USD in 1998). Results from Whittington et al.’s (1999) study in a Nigerian community indicate a mean WTP of about USD 0.10 per 20 L for a proposed, improved water supply. The WTPs in these three studies were calculated using appropriate currency conversions. In the present study, the mean WTP of 0.18 USD per 20 L is higher than, but within an order of magnitude of the range of WTPs found in the three previous studies.

Parameter estimates and their significance along with the t-statistics of the ordered probit model are shown in Table 3. Although the model was tested with all of the relevant variables in the survey such as sex, age, and education of respondent and household income, only number of children in the household and distance to the existing water source were found to be significant predictors of WTP.

The number of children in the household has a significant, negative impact on WTP. The negative relationship may reflect the value of labor from children who are often expected to fetch water for the household. This result could also be attributed to the notion that having more children reduces the household’s income per capita. Households’ distance to their existing primary water source has a strong, positive impact on WTP. The longer households have to travel currently to find water, the more willing they are to pay for water to be provided at the trading center, which would be closer.

A priori expectations indicated the possibility that age, sex of the respondent, education, and household income would be significant predictors of WTP. Although the survey results indicated that older people, those with a higher education, and males were willing to pay more, models run with these variables showed that they were neither independently nor jointly significant using likelihood-ratio tests.

Income also did not have a significant effect on WTP. This finding could be related to the notion that, when incomes are below a certain threshold, households value water above other items. Further, it is unlikely that income has a significant influence in WTP since the variance is not large; that is, if most are poor, income is not likely to

Table 2 | Summary statistics for the variables in the model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP low (UGX)</td>
<td>122</td>
<td>286.07</td>
<td>229.58</td>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>WTP high (UGX)</td>
<td>122</td>
<td>427.87</td>
<td>240.27</td>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>Estimated WTP (UGX) and confidence intervals</td>
<td>122</td>
<td>355.92</td>
<td>254.87</td>
<td>–23.75</td>
<td>475.72</td>
</tr>
<tr>
<td>Number of children in household</td>
<td>122</td>
<td>4.04</td>
<td>2.84</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Natural log of distance to existing water supply (km)</td>
<td>122</td>
<td>–0.0328</td>
<td>0.345</td>
<td>–1.37</td>
<td>0.451</td>
</tr>
</tbody>
</table>

Table 3 | Maximum likelihood estimates of the ordered probit model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>t-statistic (asymptotic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>428.35⁴</td>
<td>10.185</td>
</tr>
<tr>
<td>Number of children in household</td>
<td>–16.20³</td>
<td>–1.864</td>
</tr>
<tr>
<td>Log of distance to existing water supply</td>
<td>12.39⁶</td>
<td>2.996</td>
</tr>
</tbody>
</table>

Number of observations – 122.

⁴Significant at the 1% level.
³Significant at the 5% level.
have a significant impact on WTP. For the survey respondents, the mean and standard deviations of natural log of income were 5.74 and 0.519, respectively. Several studies have also indicated a lack of a significant correlation between income and WTP for improved water supplies, especially in rural areas where most income is not from wage employment but from some form of self-employment (Whittington et al. 1991; McPhail 1995a, 1995b; Goldblatt 1999). As noted before, almost all income for these rural households is from self-employment (farming, small business, labor, etc.) and is therefore unreliable. Thus, even households with higher income may not feel confident that this income level will continue into the future, such that income would not influence decisions on short-term purchases.

The respondents’ reasons for the ranking of motivations for improved water supply were also tested for their impact on WTP. The reasons included distance to source, water is unclean, and scarcity (unavailability of water). The scarcity reason was significantly positively correlated with WTP. However, since 34% of households did not mention any reason, it was not possible to test the reasons as independent variables in the model. Furthermore, the distance reason is obviously strongly correlated with distance from existing source as a motivation for improved water supply.

Overall, the model shows that in 30% of cases, the predicted WTP falls inside the actual reported WTP interval, and in 76% of cases the predicted WTP is no more than one interval away (i.e., within the three closest intervals – the one to the right, the one to the left, and the one it should fall in per reported WTP).

The null hypothesis that the estimated coefficients are jointly equal to zero is rejected at the 1% level using the LR test of zero slope coefficients. The estimated threshold levels for the different WTP categories were all significant at the 1% level. Further, Wald and LR tests confirmed that the two independent variables were significant to the model and that other variables were not significant.

**CONCLUSIONS**

Research was conducted in the villages of Kigisu and Rubona, Uganda, to collect information about demographics, health, current water situation, and WTP for an improved water source. The CVM and an iterative bidding process were used to estimate households WTP for O&M costs of an improved water source. A total of 122 interviews were conducted over two days in August 2011. The mean predicted WTP was 356 UGX (0.183 USD) per 20 L of water from a public tap. Based on the experience of the nearby communities of Kasambya and Mukaaga, which report full cost recovery for their water systems using a price of 200 UGX per 20 L, the mean WTP should be able to support similar water systems in Kigisu and Rubona.

The data were analyzed using an ordered probit model to test the relationship between independent variables and WTP. The ordered probit model demonstrated strong goodness of fit and validated the reliability of the data. The model showed that WTP is inversely related to the number of children in the home and directly related to the distance to the existing water source. Variables that previous studies have found to significantly influence WTP, such as income, gender, and age, were not significant in this study. Any efforts to convince households on the need for a clean water source nearby and encourage paying for such a system should focus their efforts on convincing households with more children. The proposed tap should also be close enough to most households to make it worthwhile to have it set up.

This study demonstrates that it is possible to implement a small-scale WTP survey in a rural village in a developing country and produce reliable and useful results.

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**REFERENCES**


McPhail, A. 1993b The ‘five percent rule’ for improved water service: Can households afford more? World Dev. 21 (6), 963–973.


StataCorp 2009 Stata Statistical Software: Release 11. StataCorp LP, College Station, TX.


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