



Willingness to pay for improved water services: evidence from Peru

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Abstract

We study the willingness to pay (WTP) for a large set of improvements in water service related to quality, continuity, and securing access for people with no house piped water during the COVID-19 pandemic. Using primary survey data from urban Peru, and the contingent valuation method, we estimate a mean WTP of around PEN 4.3 (USD 1.05), 3.7 and 1.8, respectively, for the aforementioned sets of improvements, with the combined WTP representing a 23% increase in the households' water service monthly bill. The WTP for all sets of improvements is influenced by the expenditure in bottled water (a substitute for tap water, generally perceived as unsafe) and a proxy for household assets. The influence of the individual characteristics typically scrutinized by the literature (e.g., sex, age, and education) varies with the type of improvement examined. We find a significant heterogeneity in WTP across providers and calculate the users' contribution to a water fund that could crowd-in the public investment in water services' upgrades. We further discuss the implementation of such water fund.

Keywords Access to tap water · Contingent valuation method · COVID-19 · Quality · Willingness to pay

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1 Introduction

Access to water and sanitation is essential for the fulfillment of all human rights (UN 2010). However, despite the significant increase in access to water and sanitation services recorded worldwide in the last two decades, 26% of the world's population (or 2 billion people) did not have access to safely managed drinking-water service in 2020.¹ While many developed countries have universal access, the least developed ones have the lowest coverage, with most of them reaching at most 40% of their population with both safely managed and free from contaminants drinking water (WHO/UNICEF 2021).

For the case of Peru, according to the diagnosis of the National Sanitation Plan 2022–2026, conducted by the Peruvian Ministry of Housing, Construction, and Sanitation (MVCS, for its acronym in Spanish), the prevalent perception of the providers' service is markedly negative regardless of their size, location or ownership status. Though the nationwide access to water is high (89.4% of population), using figures for 2021, users constantly report complaints about water availability and several other components of quality—such as continuity (on average, they receive water 18.6 h per day), water pressure (20.1 m of water column), water network breaks (0.5 breaks per km of water network), and blockages in sewage network (3.2 blockages per km of sewage network)—across the country.²

In this context, after eliciting the main problems with the service that water users state, we study their willingness to pay for fixing the deficiencies they reported. Having water fewer hours than necessary (15 h daily, in the sample we study) or getting tap water perceived as unsafe (83% of our sample does) could make people spend more on equipment to store water, treat water before consumption, or buy bottled water, as a result of their concerns about health risks, which could have been enhanced in times of the COVID-19 pandemic. In this setting, in which people's well-being may be compromised, valuing the water service would be useful to address the extent of users' welfare gains, had there been smaller costs of implementing the improvements compared to their willingness to pay, or in the other scenario, in which the costs exceed the willingness to pay, such valuation exercise will inform us about the scope of the government's intervention needed to close the gap in service and internalize a positive externality.

Our contribution to the literature is twofold. First, although the literature reports important work on the extent of the willingness to pay (WTP) for improved water service (see Van Houtven et al. (2017) for a survey), as well as the factors influencing such monetary value (e.g., Amoah and Moffat 2021; Makwinja et al. 2019; Chatterjee et al. 2017; Rodríguez-Tapia et al. 2017; Vásquez and Espaillet 2016; Khan et al. 2014; Tanellari et al. 2015; Tussupova et al. 2015; Vásquez et al. 2009;

¹ This figure was 39% in 2000, 34% in 2010, and 31% in 2015 (data from <https://ourworldindata.org/clean-water>, based on information from WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP). Accessed: September 20, 2023).

² Still, 10.6% of the population (or 3 million people) lack access to water. The average water access masks a substantial regional heterogeneity, with some regions attaining much lower access rates (e.g., Loreto in the Jungle: 63.6%, and Puno in the Highlands: 76.5%), a disparity that is exacerbated by the significant regional variation in the quality of the service they receive (MVCS 2021).

Venkatachalam 2004; to cite a few), most of those studies, for both developed and developing countries, have a limited geographic scope (mainly local or regional, at best). Furthermore, unlike most of studies for developing countries and even developed countries, we use a unique primary survey data for an emerging economy, Peru, which is largely urban, and where users continuously report complaints with the service.³ The representativeness of our data allows us to estimate the amount of a water fund built with the users' WTP figures (private contribution) that could crowd-in public investments aimed to close the country's gap in access to quality water infrastructure. We are one of the few large-scale studies for Latin America and the Caribbean countries and the first one for Peru, to our best knowledge.

Second, we adopt a comprehensive outlook and analyze a broader set of improvements in service (ten) than those commonly examined by the literature⁴ and considered by the Sustainable Development Goal 6 (clean water and sanitation), including: (i) water quality (related to color, turbidity, presence of particles, smell, flavor, and perceived safety); (ii) water continuity, no interruptions in service, and adequate pressure; and (iii) ensuring access via water trucks, for poor people with no house piped water in the context of the COVID-19 pandemic. Furthermore, we are able to exploit the variation in providers across the country in our estimations, a subject commonly overlooked in the literature.

In particular, after examining the users' perception about the characteristics related to water service mentioned above, we estimate the magnitude of their WTP for the related investments to improve the service. We find that users are willing to pay an aggregate amount equivalent to around 23% above their current monthly water service bill. In terms of the factors influencing their WTP, while we see some variation in the importance of sex, age, education, and satisfaction with the service across the three groups of improvements examined, only the expenditure in bottled water and a proxy indicator for assets do affect the WTP for all groups under scrutiny. We further examine the heterogeneity in the users WTP for the same set of improvements across providers and discuss about the implementation of a water fund that could be created with the water users' contributions via increases in tariffs.

The remainder of this paper proceeds as follows. Section 2 presents background information about the providers of water and sanitation services in Peru, as well as the tariff schemes and several management indicators. Section 3 describes the data. Section 4 introduces our methodology, Sect. 5 presents the main results, and Sect. 6 concludes.

³ We are aware that, as in other emerging economies, rural areas in Peru have larger gaps in access to water (24% of the households versus 5% in urban areas). However, we do not have large scale survey information for rural areas. While the estimation of the WTP for improvements in water services would be important to assess how much water is valued, it is likely that the WTP figures would be smaller and the investments (for improvements in the current water services and new infrastructure) would be larger than in urban areas. If this were the case, the discussion from a policy perspective would be around the scope of a subsidy from the public sector. The study of this topic certainly deserves further research.

⁴ Appendix Table C1 reports the number of characteristics in water (and sewerage) service examined by a sample of studies for urban areas in developed and developing countries.

2 Background information

We study the case of Peru, where 3 million people lack access to tap drinking water (2017 Census data). We focus on the urban areas of the country, where despite the relatively high access to water services (95% of its population), users across the country persistently report complaints about availability, continuity, and several other important components of the service, including water pressure and network breaks.⁵

The provision of WSS in urban Peru is based on several types of organization and operation. In urban areas with more than 15,000 inhabitants, the *EPS* are responsible for serving small, medium-sized and large cities, which account for 85% of the urban population (World Bank 2018; OECD 2021). The Peruvian National Superintendence of Sanitation Services (*SUNASS*, for its acronym in Spanish) classifies the *EPS* according to the number of connections they manage: SEDAPAL—the largest provider, 4 very large *EPS*, 14 large *EPS*, 16 medium-sized *EPS*, and 15 small *EPS*.⁶ All 50 *EPS* are publicly owned (Figure A1 in the Appendix shows their geographic scope). On the other hand, small towns with a population of between 2000 and 15,000 inhabitants, are serviced by around 450 Municipal Management Units (*UGM*, for its acronym in Spanish) administered by local governments, and Special Operators.⁷

A significant issue related to the negative perception of the *EPS* in urban Peru has to do with their limited financial sustainability, which obliges them to operate with a low budget and an abridged team, leading not only to large network losses, but also to a limited investment in the sector (OECD 2021). In terms of the *EPS* management indicators (e.g., continuity of the service, pressure, density of water network breaks, density of blockades of sewerage network, and micro measurement coverage), though we saw some improvement in the last three indicators, the continuity and water pressure has not improved much in the last decade. These indicators, together with an average operating margin of 0.52% (the second worst in the last decade), and a return on equity of -0.29% (the worst in the last decade), show deficiencies in the *EPS* management and operation, an unrelenting condition that may be affecting the consumers' perception of the quality of the service they received (see footnote 5).

⁵ As of 2020, the density of complaints per 1000 connections went from 1 to 299, with an average of 103 and a standard deviation of 73. The average density of complaints has only been worse in the previous 5 years.

⁶ In terms of the number of connections managed, the figures are as follows: SEDAPAL, more than 1 million; each very large *EPS*, between 100,000 and 1 million; each large *EPS*, between 40,000 and 100,000; each medium-sized *EPS*, between 15,000 and 40,000; and each small *EPS*, fewer than 15,000. As of 2020, the *total* number of connections managed by those providers are: SEDAPAL, 1.54 million; very large *EPS*, 0.85 million; large *EPS*, 0.84 million; medium-sized *EPS*, 0.35 million; and small *EPS*, 0.10 million.

⁷ In rural areas, with fewer than 2000 inhabitants, WSS are provided by more than 25,000 Sanitation Services Administrative Boards (*JASS*, for its acronym in Spanish) and other providers.

To deal with compelling financial and management problems, an *EPS* can be placed in a Transitory Support Regime (RAT, for its acronym in Spanish), as a temporary regime under which the Technical Agency for the Administration of the Sanitation Services (OTASS, for its acronym in Spanish), a state branch attached to the MVCS, manages these companies (e.g., elects their board and managers) (OECD 2021) to improve their operations. As of 2022, 20 *EPS* were placed under OTASS administration. Once placed under RAT, an *EPS* is assessed by SUNASS every 3 years, to decide whether it should continue under this regime or it merits returning to the original administration.

SUNASS also approves the Tariff Studies for each *EPS* and *UGM*. Tariffs should reflect the total long-run economic cost of water and sanitation services, including the costs of investment, operation, and maintenance (Rogers et al. 2002; Olmstead and Stavins 2009). To this end, based on an Optimized Master Plan (PMO, for its acronym in Spanish),⁸ SUNASS applies a hybrid regulatory scheme, which combines efficient-firm regulation, cost regulation and yardstick competition. The regulatory scheme allows tariff increments to adjust for inflation, but additional increments can be made, conditional on achieving certain management goals such as improving network coverage (Felgendreher and Lehmann 2016).

A number of consumer categories (social, domestic, commercial, industrial, and public) are identified for the tariff setting. The tariff includes a fixed charge and variable component based on actual consumption (increasing block rate). In urban areas with more than 15,000 inhabitants, tariffs are set for periods of 3–5 years (but, as mentioned earlier, they can increase if the *EPS* attains certain performance goals). Tariff setting considers additional payments such as: (i) for the Ecosystem Services Compensation Mechanism fund, to contribute to the conservation, recovery and sustainable use of ecosystem services; (ii) for the Disaster Risk Management fund, and (iii) for the Adaptation to Climate Change fund (OECD 2021). On the other hand, poor households can benefit from subsidized tariffs, funded via cross-subsidization.

Furthermore, it is important to highlight that most of the investment in water and sanitation in Peru come not from the *EPS* but from direct subsidies made annually by the MVCS, regional governments, and local municipalities (MVCS 2021). In this context, from a policy perspective, identifying the characteristics of the water service will provide information about the room for improvement and the factors underlying the users' valuation of the services. In addition to that, we aim to estimate the WTP for the upgrades valued by users, which could in turn set the ground for any subsequent increase in tariffs or a public intervention via subsidization of investments or cost of service. We elaborate on the steps needed for the implementation of a water fund to privately finance investments in water service upgrades at the end of Sect. 5.

⁸ The PMO includes a plan of investments describing which projects should be carried out, and how they will be financed. The time horizon of the PMO is up to 30 years (SUNASS 2020).

3 Data collection and study area

We focus on urban Peru, because, in addition to accounting for 81.5% of the country's population (2017 Census), water users consistently report complains related to several aspects of the service (see page foot 5). We use primary data from an extensive telephone survey conducted between August and October 2021. We chose this mode given that at that time, a strict physical distancing was mandatory in Peru due to the COVID-19 pandemic (still, if that were not the case, people would be reluctant to answer in-person interviews, as the country had witnessed the second wave of infections a few months before the survey). Even though we hardly had a better choice, this mode is not without criticisms.⁹ Compared to in-person interviews, telephone surveys exclude the use of visual aids (which may help clarify questions from respondents) and may involve a different sample frame, if the use of phones is not widespread in the area under study. In the case of Peru, the second potential limitation should not apply, since according to official statistics, in almost 97% of urban households at least one member owns a cellphone (INEI 2021b). In addition, as of 2021, according to the Peruvian telecom regulator, based on a residential survey of telecom services, there were 43.1 million of mobile telephones in a country of 33 million of inhabitants, where 88.4% of households own a smartphone (OSIPTEL 2021). Furthermore, due to the lockdown, it was more likely to find a household member in the house than it would have been the case in pre-COVID-19 times (they could be absent because of work). While we are still vulnerable to the first limitation, we aimed for clarity in the survey design of the hypothetical scenario for the CV part and we constrained the length of it (to an average of 20 min, excluding outliers).

The original sample consists of 13,700 users of water and sanitation services, from 296 districts, located in 108 provinces, spread across all 25 regions.¹⁰ The company in charge of the survey had access to anonymized phone numbers (with

⁹ While we could have considered mail or internet-based interviews, it is not clear that any of those modes is superior to telephone interviews for Peru because, the response to unsolicited postal or electronic mails is particularly low, and the Internet access is not as extended as the telephone's. Maguire (2009) mentions three sources of biases that could affect CV surveys: social desirability (the intent to appear in a more favorable fashion in the presence of the interviewer), avidity (those who are more interested in the survey topic are more likely to respond) and non-response (the composition of the sample that chose to complete the survey). The first one could affect perhaps even more strongly to in-person rather than telephone surveys. Moreover, given the topic (water), we could expect avidity to trigger in both in-person and telephone interviews (in Sect. 5, page 16, we provide evidence suggesting the absence of a significant overstatement of WTP due to the greater need for safe water in COVID-19 times). Lastly, the average response rate we got was around 60%, which is slightly smaller than the response rates the survey company in charge of the data collection registered in in-person interviews before 2019 (around 70%). From the calls that were accepted, 98.4% were made to cell phones, and the remaining 1.6% were made to land line numbers.

¹⁰ The geopolitical division of Peru includes 25 regions (akin to a US State), 196 provinces, and 1874 districts, as of December 2019. Another important distinction made when analyzing the data is among the three natural regions in Peru: The Coastal area (*Costa*), bordering the Pacific Ocean; the Highlands (*Sierra*), which is a section of the South American *Andes*; and the Jungle (*Selva*), the Peruvian section of the Amazon.

their geographic location) from all six mobile phone companies operating in Peru in 2021.¹¹ Since we know the locality the phone number is registered in, a random number for a user from the WSS provider serving that particular locality was drawn. This sample is representative at the level of provider type and urban areas (see Appendix Figure A2, for the geographic distribution of the surveyed sample).¹² That sample contains all respondents that received the Contingent Valuation (CV) questions for any three out of the six groups of improvements in water service we examined. For this paper, we restrict the analysis to the sub-sample of 2121 respondents who received CV questions on the following three sets of improvements: water quality; water continuity, no service interruptions and adequate pressure; and to secure water access for non-connected users.

The survey's questionnaire contains three sections: (i) the main features of the WSS received: type of connection, provider, use of water meter, water tanks or reservoirs, monthly service bill, knowledge of water source, treatment of waste water, satisfaction with service, service complaints, water treatment before drinking, expenditure in bottled water, and characteristics of the water received (quality and continuity); (ii) contingent valuation (CV) questions. As mentioned earlier, three groups of CV questions were chosen per respondent (see Sect. 4 for details about this selection); and (iii) the respondent's demographics and household's characteristics, including age, sex, education, economic activity, income, house ownership, household size (younger than 5, older than 18), number of floors and bathrooms, type of house wall (whether it was made of brick and mortar,¹³ our proxy for assets), and tenancy of durable goods (e.g., personal computer, automobiles, and refrigerator).

Our survey respondents are household heads (57.8%), their partners (22.1%), or any other adult responsible for the household's expenses (20.1%). Table 1 reports the main descriptive statistics of our sample ($n=2121$), split by type of provider; the last column reports the number of observations for any given feature (row). In our sample, 93% of the households have a connection to water and sanitation services, while 7% has only water service. In addition, 97.5% of water users have house connection to piped water (with a similar share across providers). The use of water

¹¹ See: <https://www.osiptel.gob.pe/media/jokj0o1g/np24052022-lineas-moviles.pdf>. Visited on July 1, 2023.

¹² The data collection was in charge of an experienced company conducting socioeconomic (in-person and telephone) surveys in Peru. Our research team trained all the pollsters. During the training, we paid special attention to explain the rationale behind the contingent valuation single-bounded and double-bounded questions, so that they could appropriately collect that information and respond to any questions from respondents. A set of pilot surveys was conducted to test the software, procedures, and clarity of the instructions, as well as to time the length of the questionnaire. The sampling errors are 2% (for SEDAPAL users), 3.7% for Very Large EPS, 6.3% for Large EPS, 11.2% for Medium-sized EPS, and 18.8% for Small EPS. Once we had defined the sample size, users from each type of provider were randomly selected until the desired number was reached.

¹³ One could argue that this variable could not properly capture the tenancy of assets in the *Sierra* and the *Selva*. However, the percent of households reporting their houses wall to be made with brick and mortar is fairly high in all three natural regions: 89% on the Coastal region, 74% in the *Sierra*, and 70% in the *Selva*.

Table 1 Basic descriptive statistics, by provider (Averages) *Source: SECOSAN Survey for Urban Peru (2021)*

| | EPS | | | | UGM | TOTAL | |
|---|---------|------------|-------|--------------|-------|-------|------|
| | SEDAPAL | Very large | Large | Medium-sized | | Small | Mean |
| <i>Water and sanitation service</i> | | | | | | | |
| Household has only water service (%) | 0.4 | 2.7 | 5.7 | 8.5 | 5.2 | 15.0 | 2121 |
| Household has water and sewage service (%) | 99.6 | 97.3 | 94.3 | 91.5 | 94.8 | 85.0 | 2121 |
| Household has a piped connection inside the house (%) | 97.5 | 98.3 | 97.7 | 97.5 | 100.0 | 96.7 | 2121 |
| Household has water meter (%) | 94.7 | 88.1 | 75.0 | 75.7 | 45.7 | 18.9 | 2121 |
| Has water reservoir (downstairs) (%) | 8.1 | 13.8 | 9.8 | 6.1 | 13.0 | 6.8 | 2121 |
| Has water tank (%) | 4.9 | 6.9 | 4.6 | 3.1 | 3.8 | 2.7 | 2121 |

Table 1 (continued)

| | EPS | | | | UGM | TOTAL | | |
|---|---------|------------|-------|--------------|------|-------|------|------|
| | SEDAPAL | Very large | Large | Medium-sized | | Small | Mean | N |
| Has upstairs water tank (%) | 29.0 | 35.2 | 30.8 | 18.0 | 23.6 | 17.5 | 25.7 | 2121 |
| Satisfaction with the service (1 to 5) ^a | 3.2 | 2.6 | 2.7 | 2.8 | 2.2 | 2.4 | 2.7 | 2121 |
| Expenditure in bottled water, last month (PEN) | 11.7 | 14.0 | 13.9 | 14.3 | 8.0 | 10.3 | 12.1 | 2121 |
| Monthly water and sanitation service bill (PEN) ^b | 76.9 | 51.7 | 43.8 | 32.0 | 21.8 | 12.3 | 43.0 | 2011 |
| <i>Water quality (color, turbidity, presence of particles, smell, flavor, and safety)</i> | | | | | | | | |
| Tap water has color ^c (%) | 9.5 | 12.1 | 25.0 | 21.9 | 30.1 | 15.1 | 16.1 | 2121 |
| Tap water is turbid ^d (%) | 12.0 | 23.2 | 24.0 | 22.0 | 22.1 | 23.6 | 20.6 | 2121 |
| Tap water has particles (%) | 8.1 | 6.2 | 14.1 | 12.3 | 14.7 | 15.3 | 11.7 | 2121 |

Table 1 (continued)

| | EPS | | | | U/GM | TOTAL | | |
|--|---------|------------|-------|--------------|------|-------|------|------|
| | SEDAPAL | Very large | Large | Medium-sized | | Small | Mean | N |
| Tap water has foul smell (%) | 11.4 | 26.9 | 25.0 | 27.4 | 42.3 | 27.7 | 23.4 | 2121 |
| Tap water has foul flavor (%) | 14.8 | 34.6 | 23.9 | 28.1 | 40.6 | 31.6 | 26.4 | 2121 |
| Tap water feels unsafe ^e (%) | 81.9 | 84.7 | 80.1 | 81.0 | 87.3 | 85.5 | 83.2 | 2121 |
| Number of problems reported for water quality (0/6) | 1.4 | 1.9 | 1.9 | 1.9 | 2.4 | 2.0 | 1.8 | 2121 |
| Positive responses to bid (0 = No; 1 = Yes) (%) | 32.0 | 39.5 | 49.3 | 43.9 | 40.6 | 50.2 | 43.1 | 2121 |
| <i>Water continuity, no interruptions in service and adequate pressure</i> | | | | | | | | |
| Daily continuity (h) | 21.7 | 15.1 | 14.2 | 16.9 | 10.7 | 10.8 | 15.3 | 2110 |
| Unsatisfied with daily continuity (%) | 17.3 | 45.2 | 49.8 | 41.7 | 55.0 | 61.8 | 44.3 | 2121 |

Table 1 (continued)

| | EPS | | | | UGM | TOTAL | | |
|---|---------|------------|-------|--------------|------|-------|------|------|
| | SEDAPAL | Very large | Large | Medium-sized | | Small | Mean | N |
| Receives water fewer than 7 days a week (%) | 5.3 | 20.7 | 15.0 | 13.6 | 35.8 | 24.8 | 17.0 | 2121 |
| Pressure of water is inadequate (%) ^a | 61.7 | 62.4 | 62.4 | 63.2 | 75.0 | 65.0 | 63.5 | 2121 |
| Experienced water service interruptions last 6 months (%) | 69.2 | 71.7 | 54.9 | 57.6 | 59.6 | 51.7 | 60.3 | 2121 |
| Number of service interruptions (last 6 months) | 3.4 | 3.6 | 2.7 | 2.3 | 2.5 | 2.6 | 2.9 | 2121 |

Table 1 (continued)

| | EPS | | | | UGM | TOTAL | |
|--|---------|------------|-------|--------------|------|-------|-------|
| | SEDAPAL | Very large | Large | Medium-sized | | | Small |
| Number of problems reported for water continuity, no interruptions and adequate pressure (0/4) | 1.5 | 2.0 | 1.8 | 1.8 | 2.3 | 1.9 | 2121 |
| Positive responses to bid (0 = No; 1 = Yes) (%) | 30.2 | 43.2 | 57.2 | 54.5 | 55.6 | 46.8 | 2121 |
| <i>Water access for 3 million people with no house piped water in times of the COVID-19 pandemic</i> | | | | | | | |
| Positive responses to first bid (0 = No; 1 = Yes) (%) | 37.2 | 44.6 | 49.4 | 40.7 | 38.1 | 43.1 | 2121 |

Table 1 (continued)

| | <i>EPS</i> | | | | <i>UGM</i> | <i>TOTAL</i> | |
|---|----------------|------------|-------|--------------|------------|--------------|-------|
| | <i>SEDAPAL</i> | Very large | Large | Medium-sized | | | Small |
| Positive responses to second bid (0 = No; 1 = Yes) (%) | 34.4 | 38.5 | 38.5 | 33.9 | 33.3 | 35.8 | 2121 |
| Positive responses to some bid (0 = No; 1 = Yes) (%) ^g | 49.1 | 58.7 | 63.8 | 54.7 | 60.7 | 56.9 | 2121 |
| <i>Individual and household characteristics</i> | | | | | | | |
| Age of respondent (years) | 47.2 | 41.3 | 42.8 | 44.2 | 43.8 | 43.9 | 2057 |
| Respondent is women (=1) (%) | 54.2 | 61.5 | 53.4 | 54.0 | 58.0 | 53.6 | 2121 |
| Education level of respondent (1 to 11) ^h | 6.7 | 7.1 | 7.0 | 6.5 | 6.0 | 6.4 | 2121 |

Table 1 (continued)

| | <i>EPS</i> | | | | <i>UGM</i> | <i>TOTAL</i> | |
|---|------------|------------|-------|--------------|------------|--------------|------|
| | SEDAPAL | Very large | Large | Medium-sized | | Small | Mean |
| Respondent has Primary education or lower (%) | 2.2 | 4.4 | 6.1 | 10.3 | 13.6 | 7.3 | 2121 |
| Respondent has secondary education (%) | 37.5 | 29.4 | 37.0 | 41.1 | 52.5 | 37.7 | 2121 |
| Respondent has post-secondary technical college education (%) | 23.4 | 19.5 | 21.5 | 21.0 | 19.2 | 21.8 | 2121 |
| Respondent has university education or higher (%) | 37.0 | 46.7 | 35.4 | 27.6 | 14.8 | 33.2 | 2121 |
| Household income brackets in PEN (1 to 11) ^a | 7.7 | 7.8 | 8.4 | 9.4 | 9.8 | 8.5 | 2121 |

Table 1 (continued)

| | <i>EPS</i> | | | | | <i>UGM</i> | <i>TOTAL</i> |
|--|------------|------------|-------|--------------|-------|------------|--------------|
| | SEDAPAL | Very large | Large | Medium-sized | Small | | |
| House wall made of bricks and mortar (1 = Yes; 0 = No) (%) | 93.3 | 89.4 | 87.1 | 68.3 | 72.9 | 58.0 | 78.2 |
| Respondent owns the house (1 = Yes; 0 = No) (%) | 48.5 | 46.4 | 53.6 | 58.9 | 64.0 | 67.1 | 56.1 |
| Share of children younger than 5 in household (%) | 3.5 | 5.4 | 5.9 | 4.9 | 6.4 | 6.4 | 5.3 |
| How important is water service to combat the spread of COVID-19 (1 to 5) | 4.7 | 4.6 | 4.5 | 4.6 | 4.7 | 4.5 | 4.6 |
| | | | | | | | 2121 |

Table 1 (continued)

| Observations | EPS | | | UGM | TOTAL | | |
|--------------|---------|------------|-------|-----|--------------|-------|------|
| | SEDAPAL | Very large | Large | | Medium-sized | Small | Mean |
| 311 | 405 | 654 | 200 | 97 | 454 | n.a | 2121 |

The number of observations smaller than 2121 is due to non-responses. We used the expansion factor to produce these statistics.

^aSatisfaction level with WSS: 1: very unsatisfied; 2: unsatisfied; 3: neutral; 4: satisfied; 5: very satisfied

^bFrom the 110 respondents with missing information, 29 do not know the amount paid, 47 do not pay for water and sanitation service, and 34 have such cost included in the rental cost

^cWater has color of tea, is whiteish, or has any other color

^dWater is turbid, during the first minutes after opening the faucet, or all the time

^eFor this question, we first defined “safe water” as not containing germs or toxic substances that could affect peoples’ health

^fMeaning that water pressure is low, very low, high, or excessively high, in regards to an “adequate” pressure

^gThis indicator is equal to 1, if the respondent accepted either the first bid or the second bid, or both

^hEducation levels: 1: illiterate; 2: kindergarten; 3: some primary; 4: primary; 5: some secondary; 6: secondary; 7: some post-secondary technical education; 8: post-secondary technical education; 9: some university; 10: university; 11: graduate

ⁱIncome brackets (PEN): 1: more than 13,000; 2: [6701, 13,000); 3: [5001, 6700); 4: [4001, 5000); 5: [3401, 4000); 6: [2801, 3400); 7: [2301, 2800); 8: [1901, 2300); 9: [1401, 1900); 10: [801, 1400); 11: less than 800

^j1: not important at all; ...; 5: very important

meter is more common among users from medium-sized and larger *EPS* (at least 75% of them have it), in clear contrast to those from small *EPS* (45.7%) and *UGM* (18.9%). In terms of in-house water storage mechanisms, a small share of households has water reservoir (or water tank) (between 4% and 9%, on average) and about 26% of them have upstairs water tank. In general, users from the largest *EPS* show the highest use of upstairs water tanks.

We further asked about the satisfaction level with the water and sanitation service (WSS). Households report a modest overall satisfaction: 2.7 (in a 1-to-5 Likert scale), with a minimum of 2.2 (for small *EPS*) and a maximum of 3.2 (for SEDAPAL, the largest provider). Therefore, even the provider with the highest satisfaction ratings is far from getting outstanding marks. The monthly amount paid for the WSS decrease with the provider size in our sample, and goes from PEN 76.9 (or USD 18.8), paid by SEDAPAL users, to PEN 12.3, paid by *UGM* users. Interestingly, respondents spend a non-negligible amount, which represents 28% of their monthly WSS bill (such figure goes from 15.2% for SEDAPAL users to 83.7% for *UGM* users). These number likely echo the users' concern about the safety of tap water (more on this, later), and suggest a substitution between piped and bottled water, a linkage we will investigate in our regression analysis.

Moving to the quality of the piped water received, we see a substantial heterogeneity in all six conditions examined (color, turbidity, presence of particles, smell, flavor, and safety). On average, between 11.7% and 26.4% of the respondents claim the tap water they receive is not crystal clear, has particles, is turbid, has foul smell, or has foul flavor (in all cases, we see a significant heterogeneity across providers), while a resounding 83.2% perceived the tap water as unsafe.¹⁴ As a result, on average, 1.8 out of 6 possible problems were reported, with SEDAPAL users reporting a smaller number of problems (1.4) than the rest of providers (1.9 to 2.4). All those six characteristics were used to examine the WTP for improvements in water quality. In the CV exercise, the rates of positive responses to the random bids faced by the respondents go from 32% (SEDAPAL) to about 50% (*UGM* and large *EPS*), with an average of 43.1%.

In regards to the second group of water attributes scrutinized (weekly availability, daily availability, water pressure and interruptions of service), households receive water 15.3 h daily on average; this figure is the highest for SEDAPAL users (21.7 h) and the lowest for *UGM* and small *EPS* users (about 11 h).¹⁵ As a result, the share of users unsatisfied with the daily hours of service raises from 17.3% (SEDAPAL) to 61.8% (*UGM*), with an average of 44.3%. We see higher levels of dissatisfaction across all providers for water pressure (63.5% of respondents report inadequate

¹⁴ Those participants who perceived the tap water as unsafe are significantly more likely to buy bottled water (50.9% vs. 41.2%) and to spend more in that purchase (PEN 13.00 vs. 10.86) than those who did not. The p-values from the respective (one-tail) tests of the mean differences are 0.0004 and 0.0244. In addition, 93% percent of respondents in our sample make some treatment to tap water (mostly boiling) before drinking it.

¹⁵ The figures from the 2020 SUNASS report mentioned earlier are close to the ones reported by our survey: 21.4 (SEDAPAL), 16.4 (very large *EPS*), 15.5 (large *EPS*), 19.7 (medium-sized *EPS*), and 14.3 (small *EPS*).

levels) and interruptions in water service (60.3% reported service interruptions during the 6 months prior to the survey). As a consequence, an average of 1.9 problems (out of 4 possible ones) were reported, with smaller reports for SEDAPAL again. The rate of positive responses to the random bids received in the CV questions fluctuates between 30.2% (SEDAPAL) and 57.2% (large *EPS*), with an average of 46.8%. Except for SEDAPAL, the rate of positive responses for all providers is higher than the one recorded for improvements in quality.

In the case of securing water access for those with no house piped water, we used a double-bound approach. Thus, the average rate of positive responses to the initial bid is equal to that for water quality. Including the second bid, the average rate of positive responses (to either the first bid, the second bid, or both) reaches 56.9%. This rather large figure could be reflecting both a concern for helping the poor (non-connected users) to secure access to water in times of the COVID-19 pandemic (altruism) and an attempt to reduce the extent of a negative externality (the spread of the COVID-19), among other reasons.¹⁶

As for the demographic characteristics of our sample, our typical respondents are in their mid-40 s, are mostly women, and have an education level equivalent to between high school graduate and some post-secondary technical education. These figures, however, mask a significant heterogeneity observed at higher levels, especially university education.¹⁷ We further gathered information on income and assets (proxied by an indicator for a house wall made of brick and mortar). In the former case, considering 11 income brackets, in general, smaller *EPS* serve lower-income households. We see a similar pattern in the latter indicator. Finally, the figures for house ownership and the share of children under 5 years of age in the household tend to be larger for smaller providers, with averages of 56.1% and 5.3%, respectively.

To sum up, though we study urban households which are by and large covered by WSS connected to a public network, we observe a considerable heterogeneity in the characteristics of the households served by different providers, as well as in several features of the service they receive, which may be summarized by a rather mediocre overall satisfaction level with the service and non-negligible complain rates with it. We believe that all of this makes the study of the water users' willingness to pay for the related service upgrades well worth pursuing.

¹⁶ In the case of Peru, we know very little about the WTP for water in pandemic times. One exception is Gómez-Lobo et al. (2022), who compare households connected and non-connected to a water network in Lima, and find that the former households were less likely to report COVID-19 infections than the latter. We found no study on WTP for water during the COVID-19 pandemic, however.

¹⁷ In the entire sample, 55% of respondents either completed post-secondary technical education or higher. Those figures are 60.3% for users from SEDAPAL, 75.8% for users from very large *EPS*, 66.2% for users from large *EPS*, 56.9% for users from medium-sized *EPS*, 48.6% for users from small *EPS*, and 33.9% for users from *UGM*.

4 Methodology

We employed the contingent valuation (CV) method, a commonly used tool to estimate the willingness to pay for improvements in water quality, both in developed and developing countries. In particular, we implemented the referendum (also called a dichotomous choice) approach, which asks for a “Yes/No” answer to a specific non-zero bid. To mitigate the starting point bias, we randomly drew the bids from a discrete set of prices.¹⁸ We further included a follow-up question about the certainty of the response to mitigate the hypothetical bias (hypothetical WTP questions may overestimate real WTP), a procedure suggested by Blumenschein et al. (2008).¹⁹

As part of our research design, we used a comprehensive survey to elicit the WTP for six groups of improvements in water service, linked to investments: (1) to ensure the quality of water service (related to color, turbidity, presence of particles, smell, flavor, and safety); (2) to increase water continuity (days of week and hours per day), avoid service interruptions, and provide an adequate pressure; (3) to improve the treatment of wastewater to avoid the contamination of rivers, lakes and the sea; (4) to mitigate the impact of a natural disaster (e.g., an earthquake or “*El Niño*” Phenomenon) on water service availability; (5) to improve the conservation and recovery of natural sources of water (e.g., rivers, lagoons or natural springs), to guarantee the water supply for the next 10 years; and (6) to secure the supply of potable water via water trucks for 3 million people with no house piped water, to ensure cleanliness and hygiene practices, such as hand washing, to prevent the spread of the COVID-19. In this paper, we focus on the first, second and sixth groups.²⁰

We asked for the marginal WTP using a single-bound dichotomous choice for groups 1 and 2 (with a ‘Yes/No’ answer), and a double-bound approach for groups 3 to 6. In the double-bound questions, an affirmative answer to an initial randomly selected bidding price expressed in PEN (say b_1) was followed by a dichotomous choice question about a second, higher price ($b_2 > b_1$), while a negative answer was followed by a lower price ($b_2 < b_1$), which was equal to 0.5, if $b_1 = 1$. The initial bids ranged from PEN 1 to 11 (or USD 2.7) to properly reflect a sensible bids’

¹⁸ As part of our research project, we conducted 42 focus groups with about 336 WSS users from all types of providers, to identify the problems with the service and the amounts that users would be willing to pay for the related improvements. The set of bids used in our CV study roughly correspond to those amounts, in particular the maximum.

¹⁹ Two alternative methods of non-market goods valuation include choice experiments and travel cost. Carson et al. (1996) conducts a meta-analysis comparing CV values with those from travel cost values. In general, the authors find lower CV values, which we can take as a lower bound, at least compared to the travel cost method. Furthermore, designing a field experiment that compares real payments with stated hypothetical WTP elicited with a cheap talk, Blumenschein et al. (2008) finds that using a follow-up question removes the hypothetical bias in the CV method.

²⁰ An interesting question to examine would be whether the WTP for water quality and continuity remains when the third group is *not* water access for the poor but any *other* improvement. We defer this to future research.

distribution.²¹ More details about the set of bids for each group (which varies) under study are presented in Sect. 5.

In our design, each respondent was asked about only *three* out of the six groups of improvements in water service, chosen in a random order. If a respondent reported any problem related to water quality (Group 1) or continuity, interruptions in service, and adequate pressure (Group 2), she received CV questions on these groups (all respondents reported at least a problem in both groups). In addition, if the respondent had access to sewage network (93% of our sample does), the third group was randomly selected from the four remaining groups.²² Thus, we have three random components in our research design: the group of improvements over which to express a marginal WTP (the third group was randomly chosen), the order in which the groups were presented to the respondent, and the bids. An ad hoc software, designed for our project, automatically randomized those conditions for each respondent. Since the three sets of WTP questions were not made independently, we can aggregate the WTP.²³

As mentioned earlier, for Groups 1 and 2, our questionnaire identified the existence of deficiencies in service in regards to the aforementioned features, before asking the CV questions. In particular, for the case of water quality (Group 1), the four related questions were: Q1: “¿Is the tap water in your household clear, or has a color, is turbid, or comes with particles?” (multiple choice answers in closed format), Q2: “¿Does the tap water in your household have a foul smell?” (Yes/No answer), Q3: “¿Does the tap water in your household have a foul flavor?” (Yes/No), Q4: “‘Safe’ water is defined as water that, because of its condition and treatment, does not have germs or toxic substances that may affect peoples’ health. ¿Do you think that the tap water in your household is safe?” (Yes/No). We then asked a follow-up question about the certainty of the response. Appendix B presents the questions used for the case of water quality.²⁴

4.1 Empirical strategy

We model the WTP for improvements in each group examined as follows. As mentioned earlier, under the double-bounded dichotomous choice approach, individual i is asked about an initial bid or price (b_1), followed by a second price (b_2), which

²¹ As part of our research project, we conducted 42 focus groups with about 336 WSS users from all types of providers. The bids used in our survey roughly respond to the values stated by those users; in particular, the maximum amount (PEN 11).

²² The 3-group sequence generated for each respondent took this form: “xyz”, where the values 123, 231, and 312, which reflect the order of each group, were equally likely. For instance, a respondent with the sequence 3,1,2 received CV questions for group 2, group 6, and group 1, in that order. The blanks mean this subject did not receive questions for groups 3, 4, and 5.

²³ In each of the three groups of WTP questions, the respondents were told that they will be asked three times (i.e., for three groups of improvements), so that, when answering, they should consider that the implementation of those improvements would reduce their disposable income by the *aggregate* amount they stated. See Appendix B.

²⁴ The questionnaires used for the other groups of improvements in water service examined are available from the authors upon request.

will be higher than b_1 , after a positive answer; and lower than b_1 , otherwise. Thus, assuming that the underlying WTP differs for both responses, we estimate the WTP for the first (WTP_{1i}) and second questions (WTP_{2i}) using binary choice models, as follows:

$$\begin{cases} \text{WTP}_{1i} = X'_{1i}\beta_1 + \varepsilon_{1i} \\ \text{WTP}_{2i} = X'_{2i}\beta_2 + \varepsilon_{2i} \end{cases}, \quad (1)$$

where X_{1i} and X_{2i} are vectors of independent variables that include the bids that were offered (b_1 and b_2 , respectively), individual i 's characteristics and her household's characteristics, potentially correlated with the WTP. Our survey collected information about these correlates.

If we let Y_{1i} and Y_{2i} denote the individual i 's answers to the first and second bids, respectively, the typical latent utility framework can be used to link those answers to the WTP equation, as follows:

$$\begin{cases} Y_{1i} = 1, \text{ if } X'_{1i}\beta_1 + \varepsilon_{1i} > b_{1i}; \text{ otherwise, } Y_{1i} = 0 \\ Y_{2i} = 1, \text{ if } X'_{2i}\beta_2 + \varepsilon_{2i} > b_{2i}; \text{ otherwise, } Y_{2i} = 0 \end{cases} \quad (2)$$

Thus, we assume that respondent i 's answer to the first bid is 'yes' (i.e., accepts the bid), if her WTP is greater than her bid value; and similarly, for the answer to the second bid. When we examine the single bounded cases (for water quality and water continuity, no interruptions and adequate pressure), only the first part of Eqs. (1) and (2) will be estimated, while when we estimate the double bounded case (water access for non-connected people), we will use both parts of those equations in the estimation. For this latter case, we estimate a bivariate *Probit* specification (where two separate sets of estimates are obtained), and a joint specification (where only one set is estimated using the Lopez-Feldman (2010)'s *doubleb* Stata module). We compute the Krinsky and Robb (1986) confidence intervals for the mean WTP from the estimations of binary choice models, using 5000 draws.

From the estimation of Eq. (1), we calculate the mean WTP for both the first and the second bids, as follows: $E(\text{WTP}) = -\frac{X'\hat{\beta}}{\hat{\beta}_{\text{price}}}$. Next section presents the acceptance rates (positive responses) for each of the bids used, and the marginal WTP for the three groups of improvements in service under scrutiny, as well as the correlates of the related WTP.

5 Results

The positive response rates for the initial bids are shown in Table 2: 44.1% for improved water quality, 49.3% for improved water continuity, no interruptions and adequate pressure, and 44.2% to secure water access for non-connected people. As expected, the average acceptance rates of the initial bid are decreasing with the bid amount (this provides some assurance for the construct validity of the study design: the law of demand holds). Note that the average acceptance rates are similar across these groups of improvements, although the frequency of the initial bids somewhat

differs, especially between water quality and water access. Further analysis of the data shows that, from the negative answers, 64%, 66% and 58%, respectively, are true zeros for the aforementioned improvements in service.

Turning to the estimation of WTP and its correlates, our base equation includes individual characteristics (age, sex and education), household-level features (percent that children under age of 5 represent in the household, an indicator for the house wall made with brick and mortar (our proxy variable for assets), ownership of the house, and expenditure in bottled water). We also include the level of satisfaction with the service and indicators for the order in which the WTP for the improvement under scrutiny was selected for the respondent (in the first or second place, with the third place being the omitted category), to control for a potential sequencing effect. Our main results are robust to the estimation of richer specifications, as we show in Sect. 5.1.

We estimate a logit regression for water quality; continuity of service, no interruptions and adequate pressure; and water access for people with no house piped water (first part of Eqs. 1 and 2)²⁵; and a bivariate *Probit* regression (Eqs. 1 and 2) and a double-bound regression for the last group of improvements examined. As mentioned earlier, we restrict our sample to those respondents who reported any problem with water quality *and* with continuity, interruptions of service, or pressure, *and* were randomly selected to get questions about contributing to secure water access for non-connected users.

Table 3 reports the results for improvements in water quality, starting with the unconditional WTP (column 1), then adding some respondent's characteristics (column 2), household-level variables (column 3), and controlling for the order in which this particular improvement in service was selected for the respondents (column 4). Using this last specification, which includes what we call the *regular* controls, we see that the WTP is positively and significantly correlated with education and expenditure in bottled water (as a likely reflection of the respondents' health concerns²⁶), a substitute for tap water. The coefficients of age, sex and the share of children under five in the household do not appear to be significantly different from zero. Furthermore, respondents with house walls made of brick and mortar, our indicator of household's assets, are willing to pay a smaller amount for improved water, which is consistent with richer households being less willing to pay for improvements in water service.²⁷ Also, though the level of service satisfaction has a positive coefficient, it is not statistically significant; house ownership is also non-significant.

Adding provider fixed effects (column 5) does not affect the significance of our main estimates. Indeed, though the specification in column 5 yields larger mean/median WTP figures, we decided to be more conservative using the one in column

²⁵ The results are similar when we estimate *Probit* models. Available upon request from the authors.

²⁶ 93% percent of our sample makes some treatment to tap water before drinking and 83% of the sample perceives the tap water as unsafe. This figure is similar across providers. Also, 50% of the sample buys bottled water regularly.

²⁷ If we included income in the specification, we would see that this variable is positively correlated with WTP (though we lose a significant number of observations due to non-responses). Results are available upon request.

Table 2 Response rates by initial bids for the improvements in water service under study

| Initial bid (PEN) | Water quality (color, turbidity, presence of particles, smell, flavor, and perceived safety) | | | Water continuity, no interruptions in service and adequate pressure | | | Water access for 3 million people with no house piped water during the COVID-19 pandemic | | |
|-------------------|--|---------------|-----------------|---|----------------|-----------------|--|---------------|-----------------|
| | No | Yes | Total | No | Yes | Total | No | Yes | Total |
| 1 | 63 (26.6) | 174 (73.4) | 237 (100.0) | 61 (29.8) | 144 (70.2) | 205 (100.0) | 170 (39.2) | 264 (60.8) | 434 (100.0) |
| 2 | | | | | | | 400 (51.2) | 382 (48.8) | 782 (100.0) |
| 3 | 150 (43.6) | 194 (56.4) | 344 (100.0) | 306 (43.7) | 394 (56.3) | 700 (100.0) | | | |
| 4 | | | | 261 (49.2) | 269 (50.8) | 530 (100.0) | 395 (66.8) | 196 (33.2) | 591 (100.0) |
| 5 | 282 (54.0) | 240 (46.0) | 522 (100.0) | 231 (60.0) | 154 (40.0) | 385 (100.0) | 144 (69.9) | 62 (30.1) | 206 (100.0) |
| 6 | 268 (63.2) | 156 (36.8) | 424 (100.0) | | | | | | |
| 7 | | | | 129 (70.5) | 54 (29.5) | 183 (100.0) | 75 (69.4) | 33 (30.6) | 108 (100.0) |
| 8 | 255 (69.9) | 110 (30.1) | 365 (100.0) | | | | | | |
| 9 | 92 (67.6) | 44 (32.4) | 136 (100.0) | 88 (74.6) | 30 (25.4) | 118 (100.0) | | | |
| 11 | 75 (80.6) | 18 (19.4) | 93 (100.0) | | | | | | |
| Total | 1185 (55.9) | 936 (44.1) | 2121 (100.0) | 1076 (50.7) | 1045 (49.3) | 2121 (100.0) | 1184 (55.8) | 937 (44.2) | 2121 (100.0) |

Row percentages in parentheses. The average overall positive responses reported in this table differ from those reported in Table 1, because back then, we used the population expansion factor, while for this table, we did not weight the observations

4 in our analysis. As shown at the bottom of Table 3, such WTP lies between PEN 4.03 and 4.52 (around USD 1.3), representing between 9.3% and 10.5% of the WSS average monthly bill. Using the Krinsky and Robb (1986) confidence intervals, we conclude that we cannot reject the hypothesis that those WTP figures are significantly greater than zero.

In the case of the improvement in water continuity, no interruptions in service, and adequate pressure, we find two sets of differences with respect to the case of water quality (see Table 4).²⁸ First, in terms of the correlates of the WTP, the sex of

²⁸ Although we use the same base specification for all sets of improvements in water service, our results are robust to alternative (more complete) specifications, as we show in Sect. 5.1.

Table 3 Logit regressions on the WTP for improved water quality (color, turbidity, presence of particles, smell, flavor, and perceived safety)

| | (1) | (2) | (3) | (4) | (5) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|
| Bid | -0.234*** (0.021) | -0.246*** (0.022) | -0.248*** (0.023) | -0.255*** (0.023) | -0.247*** (0.023) |
| Age (years) | | -0.003 (0.004) | 0.001 (0.004) | -0.000 (0.004) | 0.003 (0.005) |
| Women (= 1) | | -0.075 (0.105) | -0.080 (0.106) | -0.091 (0.108) | -0.075 (0.109) |
| Education levels (1 to 11) ^a | | 0.113*** (0.026) | 0.128*** (0.029) | 0.123*** (0.029) | 0.138*** (0.030) |
| Children under five (%) ^b | | | 0.463 (0.541) | 0.430 (0.552) | 0.280 (0.558) |
| House wall ^c | | | -0.532*** (0.132) | -0.520*** (0.136) | -0.399*** (0.141) |
| Respondent owns the house (= 1) | | | -0.086 (0.112) | -0.130 (0.115) | -0.214* (0.116) |
| Expenditure in bottled water ^d | | | 0.016*** (0.003) | 0.016*** (0.003) | 0.017*** (0.003) |
| Satisfaction with service (1 to 5) ^e | | | 0.037 (0.050) | 0.012 (0.051) | 0.066 (0.053) |
| Constant | 0.942*** (0.123) | 0.505* (0.296) | 0.401 (0.339) | 0.150 (0.355) | -0.087 (0.356) |
| Order-of-the-group fixed effects ^f | No | No | No | Yes | Yes |
| Provider fixed effects | No | No | No | No | Yes |
| Mean/Median WTP (PEN) | 4.03 | 4.37 | 4.36 | 4.34 | 4.52 |
| Krinsky and Robb 95% CIs ^g | [3.51, 4.48] | [3.88, 4.78] | [3.86, 4.78] | [3.87, 4.76] | [4.06, 4.92] |
| Pseudo R ² | 0.057 | 0.071 | 0.091 | 0.120 | 0.132 |
| Observations | 2121 | 2057 | 2057 | 2057 | 2057 |

^aEducation levels: 1: illiterate; 2: kindergarten; 3: some primary; 4: primary; 5: some secondary; 6: secondary; 7: some post-secondary technical education; 8: post-secondary technical education; 9: some university; 10: university; 11: graduate

^bShare of children under five in the household

^cHouse wall made of brick and mortar (= 1)

^dMonthly expenditure in bottled water, in PEN

^eSatisfaction level with WSS: 1: very unsatisfied; 2: unsatisfied; 3: neutral; 4: satisfied; 5: very satisfied

^fIndicators for the improvement in water quality appearing in the first or second order

^gWe used 5000 replications. Robust standard errors in parenthesis

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

the respondent is negatively and significantly correlated with the WTP (women are less prone to pay more for this type of improved services than men is) and education is not significant, while the rest of covariates have similar significance levels as in the case of water quality. Second, the point estimates of the mean/median WTP are

Table 4 Logit regressions on the WTP for improved water continuity, no interruptions in service and adequate pressure

| | (1) | (2) | (3) | (4) | (5) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|
| Bid | −0.283*** (0.030) | −0.290*** (0.030) | −0.301*** (0.031) | −0.299*** (0.031) | −0.300*** (0.032) |
| Age (years) | | −0.007* (0.004) | −0.003 (0.004) | −0.003 (0.004) | 0.000 (0.004) |
| Women (= 1) | | −0.331*** (0.102) | −0.334*** (0.104) | −0.335*** (0.104) | −0.331*** (0.106) |
| Education levels (1 to 11) ^a | | −0.017 (0.025) | 0.008 (0.027) | 0.010 (0.027) | 0.014 (0.028) |
| Children under five (%) ^b | | | 0.904* (0.540) | 0.979* (0.541) | 0.849 (0.544) |
| House wall ^c | | | −0.542*** (0.132) | −0.562*** (0.133) | −0.454*** (0.139) |
| Respondent owns the house (= 1) | | | 0.051 (0.110) | 0.060 (0.110) | −0.027 (0.113) |
| Expenditure in bottled water ^d | | | 0.015*** (0.003) | 0.015*** (0.003) | 0.015*** (0.003) |
| Satisfaction with service (1 to 5) ^e | | | −0.078 (0.048) | −0.070 (0.048) | −0.011 (0.049) |
| Constant | 1.006*** (0.128) | 1.650*** (0.297) | 1.750*** (0.342) | 1.510*** (0.348) | 1.237*** (0.358) |
| Order-of-the-group fixed effects ^f | No | No | No | Yes | Yes |
| Provider fixed effects | No | No | No | No | Yes |
| Mean/Median WTP (PEN) | 3.55 | 3.68 | 3.71 | 3.71 | 4.04 |
| Krinsky and Robb 95% CIs ^g | [3.17, 3.90] | [3.31, 4.02] | [3.33, 4.04] | [3.35, 4.05] | [3.70, 4.36] |
| Pseudo R ² | 0.044 | 0.051 | 0.074 | 0.081 | 0.101 |
| Observations | 2121 | 2057 | 2057 | 2057 | 2057 |

^aEducation levels: 1: illiterate; 2: kindergarten; 3: some primary; 4: primary; 5: some secondary; 6: secondary; 7: some post-secondary technical education; 8: post-secondary technical education; 9: some university; 10: university; 11: graduate

^bShare of children under five in the household

^cHouse wall made of brick and mortar (= 1)

^dMonthly expenditure in bottled water, in PEN

^eSatisfaction level with WSS: 1: very unsatisfied; 2: unsatisfied; 3: neutral; 4: satisfied; 5: very satisfied

^fIndicators for the improvement in water continuity, interruptions and adequate pressure appearing in the first or second order

^gWe used 5000 replications. Robust standard errors in parenthesis

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

smaller (by 11–12%) in each specification, and go from PEN 3.55 to 4.04.²⁹ This smaller mean WTP at the margin might be due to a smaller number of improvements considered in this case (four instead of six) or to the intrinsically higher valuation of water availability (and adequate pressure) with respect to quality of water.

Finally, Table 5 reports the estimates of the correlates of WTP and the mean WTP for securing water access for people with no house piped water, via water trucks. We report two sets of results. First, unlike the case of water quality and continuity (quantity), age and satisfaction with the service do appear correlated with the WTP: older people are more willing to accept the bid offered, and so do users more satisfied with the service. Moreover, the WTP is also positively influenced by users' education levels, and the coefficients of our proxy variable for assets as well as expenditure in bottled water show the same positive signs and significance as those observed for the two previous service upgrades. Second, the point estimates of the mean WTP go from PEN 1.64 to 2.03 (see bottom section of Table 5), equivalent to less than half those found for improvements in water quality.

It is worthwhile to mention that, unlike the WTP estimates for improvements in the service users actually receive, those figures may partly reflect their concern for others when it is costly to do it (altruism), in times when access to water was particularly important to stop the spread of the COVID-19 (see last row in Table 1). The statistical significance of those WTP figures (as shown by the confidence intervals) may reveal a non-trivial level of altruism among water users.³⁰ This topic, which could be a basis for cross-subsidization, is largely unexplored and certainly deserves more research.

An anonymous referee suggested that our WTP figures for the three groups of improvements reported above could be overstated because of the traumatic experience of the COVID-19 pandemic. The story would be that, in those times of greater need for (safe) water, people would be more willing to pay for getting access to water (non-users) and for any upgrade in the service (users). To verify if this is the case in our sample, we proceeded in two ways. First, we used WTP reported by previous studies (pre-COVID-19 era) in common regions to ours, adjusting for inflation. Second, using the COVID-19 infection figures at the district level for the period of our survey, we classified districts with “high” infection (above the percentile 75th) and “low” infection rates (the remaining percentiles). Our premise is that respondents from our sample living in high-infection areas would be willing to pay more (higher WTP) than those living in low-infection areas for the three groups of service upgrade examined, especially for water access and continuity. We thus added infection rates information (as well as COVID-19-related death and vaccination rates)

²⁹ We should be cautious with this interpretation, since the WTP figures across groups of improvements are not strictly comparable: the former measures improvements in quality (e.g., going from water with particles to crystal clear), while the latter asks for improvements in quantity (continuity), no interruptions in service and adequate pressure.

³⁰ We assert that the WTP figures somewhat capture altruism, because they are not affected by who the provider is, unlike with happens with water quality and continuity.

to our regressions.³¹ We did not find significant differences between our WTP and those obtained before 2019 for common areas (though the sample and water service characteristics studies are not strictly comparable to ours)³² and between the high infection areas and the low infection ones, all of which suggests a non-significant overstatement of WTP. Appendix Table C2 shows the latter results (full results are available from the authors upon request).

Furthermore, as mentioned in Sect. 4.1, since we used a double-bounded approach for this improvement in service, we also estimate a bivariate *Probit* model (see Appendix Table C3) and a double bound regression (Appendix Table C4), which is expected to yield more efficient estimates. The bivariate *Probit* yields similar WTP estimates for the first bid (in significance and magnitude) as those reported from the estimation of a logit model (around PEN 1.86), and smaller figures for the second bid (for which we cannot reject the null hypothesis of the coefficients taking the value of zero) (see bottom part of Table C3), while the double-bound regression yields WTP estimates of around PEN 2.17, which are strictly greater than zero (bottom panel of Table C4).

An important advantage of using representative data is that we can utilize our estimates to make inferences for the entire population under study: urban Peru. In addition, this can be useful to make policy prescriptions. We exploit our WTP estimates for improved water services to calculate the amount of a water fund for an improved water supply system (the “project”) that can be generated annually with the urban households’ private contributions, using the following formula:

$$\text{Water Fund (WF)} = (\text{WTP}_h \times \text{Probability to contribute} \times 12 \text{ months}) \left(1 + \frac{r}{100}\right)^t \times \text{HH}_t,$$

where WTP_h is the mean monthly WTP per household h , Probability to contribute is the percent of households willing to pay for an improved service (information that comes from the average response rates in Table 2), r is the annual adjustment rate on water tariff, and HH_t is the total number of households in urban Peru in year t (with $\text{HH}_t = \left(\frac{\text{Total urban population}}{\text{Household size}}\right)(1 + \text{urban pop. growth rate})^t$), We compute the WF for each of the three groups of improvements in service under scrutiny, from which we get the aggregate WF.³³ Using the official statistics for the population growth and household size in urban Peru, we then project the income streams from the water fund, using (arbitrary) 5% and 10% interest adjustments in water tariff. Table 6 shows the results from that calculation.

³¹ We further added a variable capturing the households’ perception of the importance of water to fight COVID-19, collected in our survey, in the logit bid regression, under the premise that if households think that water was particularly important during that period (as is the case; see last row in Table 1), this could be reflected in their WTP. In none of the cases did this variable resulted statistically significant (results available from the authors).

³² We found only two studies using the CV methodology for Peru, Fujita et al. (2005) for Iquitos in the Jungle and Tudela-Mamani et al. (2018) for Puno in the Highlands.

³³ Soto Montes de Oca and Bateman (2006) and Ahsan et al. (2021) perform a similar exercise for Mexico and Bangladesh, respectively. The former authors also conduct a cost–benefit analysis, while the latter authors use a choice experiment (with a sample of 161 respondents) instead of a survey.

Table 5 Logit regressions on the WTP for securing water access for 3 million people with no house piped water, in times of the COVID-19 pandemic

| | (1) | (2) | (3) | (4) | (5) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|
| Bid (first bid) | −0.240*** (0.033) | −0.241*** (0.034) | −0.243*** (0.034) | −0.248*** (0.034) | −0.248*** (0.035) |
| Age (years) | | −0.010*** (0.004) | −0.009** (0.004) | −0.009** (0.004) | −0.007* (0.004) |
| Women (= 1) | | −0.022 (0.102) | −0.027 (0.103) | −0.027 (0.104) | −0.025 (0.105) |
| Education levels (1 to 11) ^a | | 0.058** (0.026) | 0.061** (0.027) | 0.065** (0.027) | 0.063** (0.028) |
| Children under five (%) ^b | | | −0.127 (0.526) | −0.143 (0.530) | −0.214 (0.533) |
| House wall ^c | | | −0.411*** (0.129) | −0.420*** (0.129) | −0.420*** (0.133) |
| Respondent owns the house (= 1) | | | −0.107 (0.111) | −0.098 (0.112) | −0.117 (0.114) |
| Expenditure in bottled water ^d | | | 0.011*** (0.003) | 0.012*** (0.003) | 0.012*** (0.003) |
| Satisfaction with service (1 to 5) ^e | | | 0.119** (0.047) | 0.123*** (0.048) | 0.145*** (0.050) |
| Constant | 0.394*** (0.103) | 0.534* (0.285) | 0.376 (0.323) | 0.177 (0.335) | 0.117 (0.344) |
| Order-of-the-group fixed effects ^f | No | No | No | Yes | Yes |
| Provider fixed effects | No | No | No | No | Yes |
| Mean/Median WTP, first bid (PEN) | 1.64 | 1.87 | 1.85 | 1.86 | 2.03 |
| Krinsky and Robb 95% CIs ^g | [1.04, 2.08] | [1.30, 2.30] | [1.25, 2.28] | [1.32, 2.30] | [1.52, 2.42] |
| Pseudo R ² | 0.025 | 0.031 | 0.044 | 0.051 | 0.055 |
| Observations | 2121 | 2057 | 2057 | 2057 | 2057 |

^aEducation levels: 1: illiterate; 2: kindergarten; 3: some primary; 4: primary; 5: some secondary; 6: secondary; 7: some post-secondary technical education; 8: post-secondary technical education; 9: some university; 10: university; 11: graduate

^bShare of children under five in the household

^cHouse wall made of brick and mortar (= 1)

^dMonthly expenditure in bottled water, in PEN

^eSatisfaction level with WSS: 1: very unsatisfied; 2: unsatisfied; 3: neutral; 4: satisfied; 5: very satisfied

^fIndicators for the WTP for water access through water trucks appearing in the first or second order

^gWe used 5000 replications. Robust standard errors in parenthesis

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

As seen in the table, considering a 5% and 10% interest rate over the next 25 years for the project, the income stream would make a cumulative revenue worth PEN 20.60 billion (USD 5.08 billion) and PEN 42.44 billion (USD 10.48 billion),

Table 6 Water fund: additional revenue for improved service from our WTP estimates

| Years | WTP per month (PEN) ^{a/} | | Future value of annual Water Fund ^{b/} | | | | Present value of cumulative Water Fund (Million USD) | | |
|-------|-----------------------------------|--------|---|-----------|---------------|-----------|--|---------|-----------|
| | | | (Million PEN) | | (Million USD) | | | | |
| | Interest rate (<i>r</i>) | | | | | | Discount rate | | |
| | 5% | 10% | 5% | 10% | 5% | 10% | 5% | 8% | 10% |
| 2021 | 9.91 | 9.91 | 431.52 | 431.52 | 106.55 | 106.55 | 106.55 | 106.55 | 106.55 |
| 2026 | 12.65 | 15.96 | 600.42 | 757.66 | 148.25 | 187.08 | 641.86 | 591.93 | 709.17 |
| 2031 | 16.14 | 25.70 | 766.31 | 1220.22 | 189.21 | 301.29 | 819.19 | 755.47 | 1142.12 |
| 2036 | 20.60 | 41.40 | 978.03 | 1965.17 | 241.49 | 485.23 | 1045.52 | 964.19 | 1839.40 |
| 2041 | 26.29 | 66.67 | 1248.24 | 3164.93 | 308.21 | 781.47 | 1334.37 | 1230.58 | 2962.37 |
| 2046 | 33.56 | 107.37 | 1593.10 | 5097.16 | 393.36 | 1258.56 | 1703.04 | 1570.57 | 4770.92 |
| Total | | | 20,595.19 | 42,438.70 | 5085.23 | 10,478.69 | 5650.52 | 5219.28 | 11,530.52 |

We compute figures for each group of improvements in water service, separately, using the respective mean probability to contribute (0.441, 0.489 and 0.449, respectively); the figures reported in the table are the sum of those separate calculations

^aWe consider annual adjustments (*r*) of 5% and 10% in water tariffs. Future WTP (at year *t*) is computed using the formula: Initial WTP × (1 + $\frac{r}{100}$)^{*t*}

^bAs of 2021, the urban population in Peru was 26,914,893, the urban household size was 3.49, and the 2007–2017 average urban population growth was 2.18 (INEI, 2021a). The number of households in each year is computed as follows: $HH_t = \left(\frac{\text{Total urban population}}{\text{Household size}} \right) (1 + \text{urban pop. growth rate})^t$

respectively.³⁴ The present value of this project’s cumulative revenue generation is USD 5.65 billion and USD 11.53 billion, using a discount rate of 5% and 10%, respectively. If we utilize the 8% social discount rate (MEF 2021), commonly used to discount the present value of social projects in Peru, the present value of the project’s cumulative revenue generation will be USD 5.22 billion, which represents 14.5% of the country’s gap in access to quality water and sanitation infrastructure, estimated in around USD 36.04 billion³⁵ (Bonifaz et al. 2020). This is the amount of a water fund built with users’ intended contributions that could help crowd-in the public investment in infrastructure.

Earlier, we discussed the extent to which our WTP estimates could be inflated because of the traumatic experience during the COVID-19 pandemic. We also mentioned hypothetical bias as another potential source of bias in our estimates. Considering both possible sources of overestimation, we use the

³⁴ The aforementioned figures assume a vertical growth in water access (i.e., no new connections).

³⁵ Since the quality in the provision of the service considers different attributes (e.g. water continuity, pressure, density of breaks in the water network, density of blockages in the sewage network, among others), this figure represents only a portion of the quality gap. Thus, the indicators considered were: the percentage of the population with access to a safe water service and that with access to a safe sanitation service (from the World Bank’s World Development Indicators). ‘Safe water’ is defined as accessible water, available when needed (i.e., 24 h a day), and free of any contaminant. ‘Safe sanitation’ is defined as access to sanitation facilities not shared with other households, by which excreta are safely disposed of, on-site or transported, and subsequently treated.

lower bound of our WTP estimates—see bottom of columns 4 in Tables 3, 4 and 5 (PEN 3.87, 3.35 and 1.32, a total of PEN 8.54, which represents 86% of the average WTP figure—PEN 9.91) to calculate the income stream for our water fund. The new present value of the project’s cumulative revenue generation yields USD 4.50 billion, or 12.5% of the country’s gap in infrastructure. Thus, even considering those sources of biases in our estimates, we consider this to be a significant amount that could help crowd-in the public investment in water upgrades.

From a public policy perspective, the implementation of this water fund is feasible. As mentioned in Sect. 2, the current tariff scheme considers additional fees (the ecosystem services compensation, the disaster risk management, and the climate change adaption funds), which are supported by the Management and Delivery of Sanitation Services Main Act (El Peruano 2017). Under this legal umbrella, the implementation of the additional fee for the water fund we propose should carry on the following steps: (i) include in the current Act the item “Improvement in the quality of water service provision”; the entity responsible for this will be the Ministry of Construction, Housing and Sanitation, and the regulation of this fund would be in charge of SUNASS. (ii) Stipulate in the Law that the EPS include this item in their Optimized Master Plans and be added to their tariffs. The EPS are responsible for the administration of the fund, which should be used to further improvements in services. (iii) Approve the respective directives that lays out the implementation of this mechanism, which should consider the requirements and steps to follow its implementation and execution. From previous experiences, the implementation of this mechanism would take from 1 to 3 years, before SUNASS approves the new tariff scheme.

5.1 Robustness analysis

In this section, we examine the extent to which the WTP figures we estimated earlier remain qualitatively and quantitatively unaltered, when we include the attributes of the service examined in the regression. Table 7 reports those numbers (at the bottom of each panel), as well as the coefficient estimates but only for the additional variables (the specifications used are the same as in the previous regressions). As shown in the table, the WTP figures remain largely unaltered when we control for those attributes for all three groups of improvements in water service examined (panels A, B and C). This is also true, in general, for the magnitude of the coefficient estimates. Full results are available from the authors.

Furthermore, in the case of improvements in water quality, when we add a large set of controls, including indicator variables for households that have a backyard, households that filed a complaint to the water provider last year, households that suffered from blockades in sewerage in last 6 months, households making any type of water treatment before drinking (boiling, use of chlorine, use of water filter, or any other treatment), knowledge of the source of water, perception that water will be scarce in next 10 years, and certainty level in the answer to the WTP question, in addition to provider fixed effects, the main results remain unaltered and the WTP

estimates are essentially the same (see Appendix Table C5). This is also the case for water continuity, where the new specification includes the number of service interruptions in the last 6 months, and indicators for the house having water reservoir, upstairs tank, and water tank, instead of the water treatment indicators used for water quality above (see Appendix Table C6).

5.2 Heterogeneity analysis

We examine the heterogeneity in the WTP figures for three selected subsamples. We thus aim to know whether users have higher WTP for improvements in service implemented by different types of providers, or if users highly satisfied with their water service are distinguishably less (or more) willing to pay for further improvements in service; or if users who are very certain about their responses to the WTP question have markedly different WTP from users rather uncertain about those responses. We use the specification with the “regular” controls (from column 4 in Table 3) in this analysis.³⁶

We mentioned earlier that *EPS* facing financial and management strains are placed under a Transitory Support Regime (RAT). We thus examine whether our results differ between those 20 *EPS* placed under RAT (serving 21.3% of users in our sample) and the *EPS* with a more solid performance (78.7% of our sample). For the sake of space, we only report the coefficients of bids and the WTP figures (with the corresponding CIs) for all groups.

A priori, we should expect the water user’s WTP for improvements in water service that will directly benefit them (e.g., piped water quality and continuity) to be more correlated with the *EPS* management indicators than that for improvements that will benefit others (e.g., providing water access through water trucks for poor people with no house connection to piped water). We include the estimates with no controls (column 1) and with the regular controls (column 2) for all sample, for reference in Appendix Table C7. Looking at the specification with regular controls, we see that the WTP for users serviced by *EPS* under RAT (column 4) is significantly larger than that for users served by *EPS* with better management indicators (column 6) for the case of water quality (panel A) and continuity (panel B), but is similar for both groups of users in the case of securing water access via water trucks for the poor (panel C). Specifically, the related ratios of mean WTP is 1.54 (water quality), 2.15 (water continuity/quantity) and 1.07 (water access via water trucks). These results are in line with our expectations and are consistent with users believing that *EPS* under RAT could actually implement those improvements. These results are exploratory. Further research is needed to examine, for instance, the role of the

³⁶ Estimating a logit regression using the specification with the regular controls and adding the variable “certainty with the response to the CV question”, we find that the provider fixed effects were statistically significant for groups 1 and 2, whereas satisfaction with the WSS and certainty with the response to the CV question were significant for group 6 (unreported results). For the heterogeneity analysis, we compare users *highly* satisfied and *highly* certain with their responses to their respective counterparts.

Table 7 Logit regressions on WTP, including controls for water attributes

| | (1) | (2) | (3) | (4) | (5) |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|
| <i>A. Water quality (color, turbidity, presence of particles, smell, flavor, and perceived safety)</i> | | | | | |
| Bid | -0.233*** (0.021) | -0.245*** (0.022) | -0.245*** (0.023) | -0.255*** (0.023) | -0.247*** (0.023) |
| Water has color (= 1) | 0.083 (0.140) | 0.025 (0.144) | 0.009 (0.145) | 0.038 (0.150) | -0.041 (0.153) |
| Water is turbid (= 1) | 0.141 (0.122) | 0.159 (0.126) | 0.117 (0.127) | 0.181 (0.133) | 0.128 (0.131) |
| Water has particles (= 1) | 0.680*** (0.155) | 0.662*** (0.156) | 0.613*** (0.158) | 0.620*** (0.167) | 0.552*** (0.166) |
| Water has foul smell (= 1) | 0.129 (0.129) | 0.118 (0.133) | 0.069 (0.135) | 0.077 (0.140) | 0.044 (0.141) |
| Water has foul taste (= 1) | 0.089 (0.128) | 0.127 (0.132) | 0.045 (0.135) | 0.073 (0.138) | 0.054 (0.140) |
| Water is unsafe (= 1) | 0.030 (0.141) | 0.104 (0.147) | 0.072 (0.149) | 0.184 (0.159) | 0.185 (0.160) |
| Mean/Median WTP (PEN) | 4.04 | 4.37 | 4.36 | 4.34 | 4.51 |
| Krinsky and Robb 95% CIs ^a | [3.51, 4.48] | [3.87, 4.79] | [3.86, 4.79] | [3.87, 4.77] | [4.03, 4.92] |
| Pseudo R ² | 0.067 | 0.081 | 0.098 | 0.127 | 0.138 |
| <i>B. Water continuity, no interruptions in service and adequate pressure</i> | | | | | |
| Bid | -0.283*** (0.030) | -0.290*** (0.031) | -0.302*** (0.031) | -0.300*** (0.031) | -0.302*** (0.032) |
| Receives water fewer than 7 days a week (= 1) | 0.385*** (0.133) | 0.374*** (0.137) | 0.338** (0.140) | 0.356** (0.142) | 0.337** (0.142) |
| Unsatisfied with no. of daily hours that receives water (= 1) | 0.560*** (0.105) | 0.554*** (0.108) | 0.512*** (0.109) | 0.564*** (0.117) | 0.471*** (0.118) |
| Has suffered water interruptions, last 6 months (= 1) | 0.123 (0.104) | 0.096 (0.107) | 0.088 (0.108) | 0.088 (0.110) | 0.172 (0.112) |
| Water has inadequate pressure (= 1) | -0.001 (0.106) | 0.026 (0.108) | 0.009 (0.109) | 0.031 (0.112) | 0.038 (0.113) |
| Mean/Median WTP (PEN) | 3.57 | 3.72 | 3.73 | 3.72 | 4.03 |
| Krinsky and Robb 95% CIs ^a | [3.18, 3.92] | [3.35, 4.06] | [3.37, 4.06] | [3.37, 4.06] | [3.70, 4.35] |
| Pseudo R ² | 0.064 | 0.069 | 0.087 | 0.095 | 0.112 |
| <i>C. Water access for 3 million people with no house piped water in times of the COVID-19 pandemic</i> | | | | | |
| First bid | -0.240*** (0.033) | -0.241*** (0.034) | -0.241*** (0.034) | -0.248*** (0.034) | -0.248*** (0.035) |
| Water is very important to prevent the spread of COVID-19 ^b | 0.188 (0.154) | 0.104 (0.157) | 0.121 (0.156) | 0.089 (0.156) | 0.143 (0.156) |
| Mean/Median WTP, first bid (PEN) | 1.63 | 1.86 | 1.85 | 1.86 | 2.02 |
| Krinsky and Robb 95% CIs ^a | [0.99, 2.07] | [1.28, 2.30] | [1.26, 2.29] | [1.29, 2.29] | [1.53, 2.42] |
| Pseudo R ² | 0.026 | 0.031 | 0.041 | 0.051 | 0.055 |
| Order-of-the-group fixed effects | No | No | No | Yes | Yes |
| Provider fixed effects | No | No | No | No | Yes |

Table 7 (continued)

| | (1) | (2) | (3) | (4) | (5) |
|--------------|------|------|------|------|------|
| Observations | 2121 | 2057 | 2057 | 2057 | 2057 |

The specifications in this table are the same as those in Tables 3, 4, and 5 (except for the attributes, whose coefficients are reported in all specifications)

^aWe used 5000 replications

^bThe question was: “In a 1-to-5 scale, where 1 means ‘not important at all’ and 5 means ‘very important’, How important do you think the water service was to combat the contagion of COVID-19?” The variable used here is an indicator for ratings 4 and 5. Robust standard errors in parenthesis

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

OTASS in strengthening the *EPS* management and the effect of management on the quality of service.

We also analyze whether users from different providers (SEDAPAL, the largest provider in the country, the other *EPS*, and the municipal management units—*UGM* in charge of providing water service in small towns) have different average WTP for the same set of improvements in service. In principle, a higher WTP could be related to the users’ expectations about implementing the improvement, conditional on having achieved certain minimum level of satisfaction. However, on the other hand, users who are “moderately” satisfied with the current service, may not see the need to pay for additional improvements in the service. The results are reported in Appendix Table C8 (panel A, for improvements in water quality, and panel B, for improvements in water continuity/quantity) and Appendix Table C9 (for investments to secure water access for the poor through water trucks). Both tables report the WTP figures for the entire sample (in column 1), for reference. For the sake of space, we only report the WTP figures (full results are available from the authors).

We find that the mean WTP among SEDAPAL users is significantly smaller than those among users from other providers, for the three groups of improvements examined. In particular, the ratio of mean WTP among SEDAPAL users vis-à-vis that among users from the other providers goes between 0.56 and 0.77 in the case of water quality (Appendix Table C8, panel A, columns 2 to 7), between 0.34 and 0.59 for water continuity, no interruptions and adequate pressure (Appendix Table C9, panel B, columns 2 to 7). Considering that SEDAPAL has the highest report on users’ service satisfaction in our sample (as shown in Table 2), these results are likely driven by the relatively high valuation of SEDAPAL’s current service. In the case of water access via water trucks, the WTP for the first bid for SEDAPAL and small *EPS* from the logit and bivariate *Probit* regressions are imprecisely estimated (see Appendix Table C9, panels A and B); thus, considering the double-bound regression results (panel C), we see that, in general, there is no significant difference across WSS providers.

Second, we examine whether highly satisfied users (defined as those who reported the highest satisfactions levels, 4 and 5, on a Likert scale) are actually less willing to pay for additional improvements than the rest of not-highly satisfied users (reporting satisfaction levels of 1, 2, and 3). Looking at columns 8 and 9 from Appendix

Table C8, panels A (water quality) and B (water continuity/quantity), we do not see significant differences in WTP for these two groups of respondents. However, we do see higher WTP figures (first bid) for highly satisfied users for the case of contributing to provide water access to the poor, for all three models estimated (Appendix Table C9, columns 8 and 9, panels A to C). This result is consistent with highly satisfied users relying more on providers to get the related work done.

Finally, we split the sample by the degree of certainty with the answer to the WTP question. We compare those that reported levels 4 or 5 (“highly certain”) with those who reported levels 1 to 3. Again, for improvements in water quality and continuity (no interruption in service and adequate pressure), we do not see a clear pattern between the level of certainty in the responses and the WTP, as shown in columns 10 and 11 from panels A and B in Appendix Table C8. On the other hand, for securing water access for non-connected users, highly uncertain respondents to the WTP question have larger point estimates of WTP than highly certain respondents, but this difference is statistically significant only in the case of the double-bound regression, which has narrower confidence intervals (see columns 10 and 11, panel C in Appendix Table C9).

6 Conclusion

Access to safely managed drinking water service is still far from universal, especially in the developing world. We study the case of urban Peru, home to 81.5% of the population, where the official statistics show a relatively high access to tap water, as well as a significant heterogeneity in the characteristics of the water service and a fairly mediocre overall satisfaction with it. In particular, in our sample, a sizeable share of households perceives the tap water as unsafe and the typical user reports a modest to low satisfaction level with the service. In a context in which, as in other developing countries, most of the investments in water and sanitation aimed to improve the coverage and quality of the service, come from direct subsidies made at the national, regional, or local levels, we conduct a household-level water valuation exercise.

We find a positive willingness to pay (WTP) for three sets of improved water services (related to quality; continuity, no interruptions in the service, and adequate pressure; and to secure the supply for non-connected users in times of the COVID-19 pandemic), using a contingent valuation method. The cumulative income flow generated by the aggregate mean WTP over the next 25 years represents about 15% of the investment needed to close the country’s gap in access to quality water and sanitation infrastructure. This income flow may represent the households’ private contribution to a water fund that could crowd-in the public investment in the years to come.

In 2020, in the context of the COVID-19 pandemic, the Peruvian government passed an Emergency Decree (No. 036-2020), enabling water service providers to distribute drinking water through water trucks to those with no access to piped water. This water supply is financed through direct subsidies, which puts its sustainability at risk. Our WTP estimates show that a cross-subsidization policy, from the

users of water service to those with no access to piped water, could help ensure the financial sustainability of this particular type of water supply.

From a broader perspective, our results could further help guide policy interventions at the provider level. Once information on the marginal costs of the particular improvements in service examined becomes available, we could tell whether there are welfare gains from the investments in those improvements (if the marginal WTP exceeds the marginal cost) or we could estimate the extent of a subsidization program of the investment cost, net of the private contributions via increases in tariffs (if the marginal WTP falls short of the marginal cost). In either case, this analysis is worth pursuing in the future.

7 Potential limitations of the study

Although the results reported in the manuscript are suggestive of a non-trivial willingness to pay for several improvements in water service, our figures could be affected at least on three fronts: the survey mode, the contingent valuation (CV) method, and the inflation in stated WTP due to traumatic experience of the COVID-19 pandemic. First, while in-person interviews would be ideal, this was not feasible at the time of the survey, due to mandated restrictions on physical mobility. One could worry that phone surveys could yield different results than in-person surveys if the access to telephones were limited. However, this is not the case in our area of study (there is a widespread access to cellphones and even smartphones in Peru). Second, we could worry that the stated preferences elicited by the CV method would be higher than the true WTP, due to hypothetical bias (however, this would also affect in-person surveys). Third, our WTP estimates could be disproportionately high due to the traumatic experience of the COVID-19 that could have increased the stated WTP for access and improvements in actual service. We acknowledge that we cannot ensure this was not the case (since we do not have a proper before- and after-COVID-19 framework); however, we find evidence suggesting such inflation, if existed, should not significantly affect any of our results.

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