Neither Private nor Public: The Effects of Communal Provision of Water on Child Health in Peru

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Abstract

The literature on local services has focused on the effects of privatization and, if anything, has compared the effects of private and mixed public-private systems versus public provision. However, alternative forms of provision such as cooperatives, which can be very prevalent in many developing countries, have been completely ignored. In this paper, we investigate the effects of communal water provison (*Comités Vecinales* and *Juntas Administrativas de Servicios de Saneamiento*) on child health in Peru. Using detailed survey data at the household- and child-level for the years 2006-2010, we exploit the cross-section variability to assess the differential impact of this form of provision. Despite controlling for a wide range of household and local characteristics, the municipalities served by communal organizations are more likely to have poorer health indicators, what would result in a downward bias on the absolute magnitude of the effect of cooperatives. We rely on an instrumental variable strategy to deal with this potential endogeneity problem, and use the personnel resources and the administrative urban/rural classification of the municipalities as instruments for the provision type. The results show a negative and significant effect of comunal water provision on diarrhea among under-five year old children.

Keywords: water utilities, cooperatives, child health, regulation, Peru.

JEL Classification Numbers: L33; L50; L95

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1 Introduction

The objective of this paper is to assess the effect on child health of communal organizations that provide water and sewage services in Peru. An important percentage of the rural population of developing countries does not have access to clean water and sanitation and when it does, many times public water services are far from satisfactory in terms of coverage and quality. This is one factor that explains why in the last years several countries have introduced different types of private service participation (PSP) in the piped water sector. A number of papers have analyzed the effects of these reforms in different outcomes such as the expansion of piped water and the payment made by users. Most of these papers compare public and private provisions, and some of them advocate for the use of intermediate solutions such as public-private partnerships, which try to get the best of the two worlds, and are more popular than strict privatizations (Estache, 2001, Mckenzie and Mookherjee, 2003; Wallsten and Kosec, 2008; Clarke, Kosec, Wallsten, 2009).[1] In addition, some papers have analyzed the impact of PSP on population health.[2] Most studies focus on child health because children are more vulnerable to water-related diseases (Galiani et al., 2005; Barrera-Osorio et al., 2009; Kosec, 2011).[3]

However, an important limitation of these studies is the fact that a large number of rural localities with small and poor populations can't afford the subscription to private water operators. The benefits of privatization can emerge in dense cities but private concessionaires are usually not interested in rural localities, where the population has a lower willingness to pay and it is more costly to operate the service. In these instances, cooperatives, users and neighbor associations and other types of communal organizations can be an effective mechanism to pro-

[1] Privatization might expand the water supply and the sewage network, facilitating the access to the service to households that before were not connected to piped water and sewage. Private firms can also improve the quality of the service by reducing water spillage, introducing faster repair rates, fewer shortages, cleaner water, and better water pressure and sewage treatment. In spite of this, private firms may exclude low-income households from the network by raising prices. See Megginson and Netter (2000) for a review.

[2] Borooah (2004) explains that the vast majority of diarrheas are caused by infectious pathogens which reside in faeces. A pathogen may reach a new host by getting onto fingers and, thereby, into foods and fluids, or,without a human intermediary, for example, by flies carrying the pathogen to foods, or by excreta entering the water supply. Sanitation facilities contribute to stop transmission but in order to be effective they must be complemented with good domestic hygiene practices.

[3] According to WHO's 2005 World Health Report, diarrhea is the second biggest killer of children in developing countries. In Peru, each year diarrhea causes 8.4 millions cases of morbidity in children and 11.8 million cases in adults (Defensoria del Pueblo, 2007).

vide water services.[4] For one thing, the construction and management of communal networks require fewer resources, in part because they are operated through the voluntary work of their members. Moreover, the local management ensures a better suited system to the particular geographic and social needs.

Despite being an important form of provision in several countries, very little is known about these communal forms of water provision, their effectiveness and welfare implications.[5]The main contribution of this paper is to shed some light on the quality implications of communal water organizations in Peru, by comparing the effects on child health of this type of provision in relation to the public one.

Peru is one of the countries in AL with a larger rural population and with a lower access to water and sewage services, both in urban and rural municipalities (Table 1). Regional and local governments are responsible for providing water services in urban municipalities and in many rural villages. Only very recently PSP have been introduced in the region of Tumbes. On the other hand, more than 5 million people in rural and urban villages are served by a particular type of communal organization called *Juntas Administrativas de Servicios de Saneamiento* (JASS). Using a household- and child-level dataset for 2006-2010, we perform an instrumental variable approach that accounts for potential endogeneity and show that the episodes of diarrhea among under-five year old children are less likely when they have access to water through a communal organization than through a public system. This result may appear as surprising, since communal organizations in rural villages lack the resources and the personnel to efficiently manage a water network. However, the commitment of the workers in those organizations may compensate for those deficits and can have positive effects on the quality of water. Our analysis is to be extended to the assessment of communal organizations with respect to other outcomes such as network coverage, the payments made by consumers connected to the water systems and other aspects of quality of the service. However, the present draft of the paper doesn't contain these results yet.

The rest of the paper continues as follows. Section 2 shows the connection of our paper with the previous literature. Section 3 describes the recent developments in the regulatory

[4]This type of water provision is present in many developed countries such as the United States and Finland, and in less developed countries such as Argentina, Bolivia, Colombia, Chile, Ecuador and Peru (Dianderas, 2008).

[5]An exception is Estache et al. (2004) that reviews several experiences of infrastructure delivery in Latin America, and shows that these investments are less effective in poor regions, unless the governments take actions to improve local institutions. Differences in local institutions may also explain differences in the profitability of infrastructures.

policy of the water sector in Peru and details how the market is currently organized. Section 4 describes the data. Section 5 presents the empirical strategy and the main results. Finally, Section 6 concludes.

2 Literature Review

A number of papers have examined the relationship between child health and access to piped water. For example, Thomas and Strauss (1992) find that the availability of piped water, sewerage, and electricity has significantly affected child height in Brazil. Jalan and Martin (2003) estimate the impact of piped water on child health in rural India in terms of the incidence and severity of diarrhea. They find a lower incidence of diarrhea among children living in piped water households. Several papers consider the interaction of access to safer water and maternal characteristics. Borooah (2004) considers a data set of 13,000 mothers of children under 3 years old, living in rural households in India. He shows that children born to undernourished mothers may be more susceptible to infection than children whose mothers are well nourished, and that good hygienic practices within the home, such as washing hands with soap before feeding a child, can reduce the incidence of diarrhea. Chen and Li (2009) find that mother's education is an important determinant of the health of adopted children. The authors are able to separate the nature effect (more educated mothers are more likely to have better health, which genetically leads to better health for their children) and the nurturing effect (more educated mothers may have healthier children because they have better knowledge about health care and nutrition, have healthier behavior, and provide more sanitary and safer environments to their children).

Another group of papers has focussed on the form of water provision rather than on the source of water. Most of these studies compare private and public systems, or assess the impact of privatization on the expansion and affordability of the service, as well as on health. In this sense, and to the best of our knowledge, our paper is the first to examine the effects of communal forms of water provision on population health. Mckenzie and Mookherjee (2003) show that in Argentina, Bolivia, Mexico and Nicaragua privatization increased access to water at the bottom of the income distribution, but this effect was outweighed by its negative impact on prices. They offer complementary justifications for this result. One is that the water sector offers little opportunities for competition, what limits the benefits of privatization. Another is that private operators might fear government interference, for example, the regulation of prices. Clarke, Kosec and Wallsten (2009) use household-level data to examine the effects of privatization on water and sewerage coverage in Argentina, Bolivia and Brazil. Their results indicate that access to piped water and sewerage improved after privatization, but it also improved in cities that retained public ownership. Therefore, these improvements should not be attributed to Private Sector Participation. They also show that privatization increased water quality. Using a survey similar to the one we use, Barrera-Osorio et al. (2009) examine the effects of water privatization in Colombia. They obtain that privatization improved the quality of water and increased the frequency of the service in urban municipalities for the lower income quintiles. It also generated positive effects on health outcomes in both rural and urban areas. However, privatization had a negative effect on access to water in rural areas and on the prices paid by the lower income quintiles.[6]

Concerning the effects on health, Galiani et al. (2005) find that child mortality in Argentina fell significantly in regions that privatized the provision of water.[7] Using panel data at the local-level, they obtain the difference-in-differences estimate of the impact of privatization on the proportion of households who had access to the water system. They compare changes in health over time before and after changes in water accessibility and find that the effect of privatization on child mortality appeared from a reduction in the number of deaths caused by infectious and parasitic diseases related to water conditions, while privatization was uncorrelated with deaths due to other causes. They also obtain a null impact of water privatization on child mortality in municipalities with low levels of poverty (UBN lower than 25%). Galiani et al. (2009) examine the effects of a public program launched in 2002 by the private firm *Aguas Argentinas*, in collaboration with the local governments and the regulatory agency, to extend the water network in urban shantytowns. *Aguas Argentinas* was responsible for delivering the necessary materials and for training the labour force, whereas the beneficiary communities agreed to supply the labour force for the execution of the construction works in their neighborhoods. In retribution for this work, *Aguas de Argentina* did not charge water connection fees to the households in the neighborhood. Once connected, the households were incorporated as clients of *Aguas Argentinas* and had to pay a reduced bimonthly service fee. Galiani et al. found that, in comparison to the control group, the beneficiaries of the program had large reductions in the presence, severity and duration of diarrhea among children, as well as reductions in

[6] The authors explain that privatization in Colombia was undertaken simultaneously with the elimination of a cross-subsidy scheme. This situation complicates a causal explanation of the changes in prices.

[7] Municipalities could choose to privatize in response to local economic and health conditions. To account for this endogeneity problem, they analyze the determinants of whether and when a local government privatized, considering time varying factors that may be correlated with mortality. Their results show that privatization is explained by location specific fixed factors and political variables, and not time varying economic factors.

water-related expenses. They also showed that these health and water expenditure effects were important for households that previously had free clandestine self-connections to the network that provided low quality water.

Our paper is also related to another strand of literature that examines the role of collective action in improving the access of communities to public goods like water service. This literature usually analyzes the case of local infrastructures that are not locally financed, and examines how collective action influences the decisions of politicians and bureaucrats. In this sense, the characteristics of the local population that shape collective action and its influence on politicians are analyzed.[8] For example, Foster and Rosenzweig (2000) use data from a panel of 245 villages in India and find that between 1971 and 1982 investments in schooling were greater in areas with a high fraction of landed relative to landless households. The technological change and the corresponding rise in yields made education more valuable and the investments in schooling responded to an increase in demand. Alesina et al. (2003) show that fractionalization of society explains well long-run growth across countries and that the explanatory power of the fractionalization measures improves significantly when wide classifications of ethnic divisions are used. Miguel and Gugerty (2005) look at the effect of ethnic heterogeneity on school spending in western Kenya, where a significant part of school expenses are financed by parents through collective contributions. When they use the regional ethnic composition as an instrument for school-level heterogeneity, they obtain a negative effect of ethnic heterogeneity on school spending, maintenance and per pupil availability of desks and textbooks. Using data for an Indian parliamentary constituency, Barnerjee and Somanathan (2007) find that in the early 1970s, the population of Brahmans [elite priestly caste] in a constituency was positively correlated with access to primary, middle and secondary schools, to post offices and to piped water. They also find that the standard measure of ethno-linguistic fragmentation, applied to caste and religious divisions, was negatively related to access to several public goods. A paper that is particularly relevant to our work is Escobal and Ponce (2011). They explore the role of "institutional thickness" (a measure they construct that reflects, among others, economic and social fragmentation) on strengthening the effects of key infrastructure investments on growth in Peru. Two types of infrastructure are considered: improved sanitation facilities and electricity on the house. Their results show that the institutional environment affects the impact of public infrastructure on income growth, especially among the poorest segments of the

[8] Some relevant population characteristics are the share of the different groups in the community (which reflects differences in preferences), measures of social heterogeneity (to reflect social cohesion), and measures of income inequality that reflect the distribution of benefits from public goods. See Barnerjee et al. (2008).

population. We share with Escobal and Ponce (2011) the interest in identifying the relevance of collective action in the provision of public goods, although in our case the focus is on water provision.[9]

3 Water Provision in Peru

Peru has a very diverse geography which makes it very difficult to provide water with homogeneous standards to all the population. The country is divided in three clearly separated natural regions: the coast, the Andean region and the rainforest. The coast region has areas between 0 and 2000 meters above the sea level, and is characterized for the absence of rain during the year due to the interaction between the Pacific Ocean and the Peruvian Andes. This region represents only the 10% of the national territory but hosts 61% of the population –it includes the capital, Lima, which has 30% of the country's population. The population in this region uses water from a large number of rivers and underground waters. The Andean Region (Sierra) covers 31% of the territory and concentrates 29% of the population. It benefits from seasonal rains and the population and the agricultural sector use the water from the rain. Finally, there is the rainforest (Selva region) in the eastern part of Peru. It takes 59% of the territory and 10% of the population. It experiences intensive rains during all the year and water is abundant.

These geographical conditions as well as the existence of a large number of disperse and small villages favored that for many years central and regional governments focused in improving the water service in the urban municipalities while leaving unattended a vast number of rural villages. Calderón (2004) reports that at the beginning of the 2000s about 3.3 million people in rural villages (37% of the population) did not have access to clean water and 6.2 millions of people did not have sewage services (70% of the population). The situation has improved in the last years, but Peru is still one of the countries in Latin America with a lower coverage of water and sewage services. On top of this, many of the existing systems do not perform (shortages, low quality, large number of debtors) due to an inappropriate management and the absence of resources to operate them.

3.1 Regulatory reforms

[9] Escobal and Ponce (2011) use a different dataset as well: the ENAHO survey about Peruvian living standards for the years 2002 and 2006.

The organization of the water system in Peru has undergone important changes in the last two decades. In 1981, in an attempt to introduce new management principles in the provision of the service, the largest urban operators of the country were integrated in a national firm called *Servicio Nacional de Abastecimiento de Agua Potable y Alcantarillado* (SENAPA) – Bodero, 2003. However, in 1990 the market was reorganized again and all the operators integrated in SENAPA were transferred to the regional and local governments.[10] Moreover, in 1992 the Government created a national regulator (*Superintendencia Nacional de Sevicios de Saneameniento*, SUNASS), with the mission of supervising these operators and setting their tariffs.[11] Other institutions were also created with the objective of financing several investment projects.

These institutional reforms had little effect in rural villages, though. It was instead the cholera epidemic of 1991 that induced the government to make important investments to create new water and sewage systems in the rural areas. These interventions have been criticized though because the new water systems were not sustainable (Calderón, 2004): they were not coordinated with local communities and were very dependent on subsidies. Moreover, many of the infrastructures had to be operated by local communities (e.g. JASS) which did not receive any training to operate them. This situation favored the development of alternative projects promoted by local governments, communal organizations and international cooperation institutions. The new generation of projects took simultaneously into account the construction of the water systems, their management and the hygienic education of the population.

After the fall of the authoritarian regime of Alberto Fujimori in 2000, a process of decentralization was initiated across the country. The 2002 Regionalization Law divided the country into 25 regions, which in turn are subdivided into provinces, and these in districts (municipalities). In 2008 there were 195 provinces and 1833 districts. According to Escobal and Ponce (2011), fiscal decentralization is still on the making in Peru, and recent growth in the country has increased the funds available to regional and local governments. The share of expenditures executed at the sub-national level increased substantially from 10% in 1999 to about 34% in 2007. The decentralization process has had important consequences for the organization of the water sector. In 2002 the Ministry of Housing, Construction and Sewage (*Ministerio de Vivienda, Construcción y Saneamiento*, MVCS) was created. This Ministry is responsible for the regulation and supervision of the national policy on housing, urban planning and water

[10] Decreto Legislativo No 574 and 601.

[11] Decreto Ley No 25965.

provision.[12] The MVCS has created a special program to promote the development of the water sector in the rural regions (*Programa Nacional de Agua y Saneamiento Rural*, PRONASAR), which is managed and funded by FONCODES. Moreover, in 2005 it established that the communal organizations (JASS, users associations, etc.) are in charge of the provision of the water services in the rural regions.[13]

3.2 Market organization

Peruvian districts (municipalities) are divided in several urban and rural units (*centros poblados*). The MVCS considers as rural units the localities with less than 2.000 inhabitants and urban those with a larger number of inhabitants.[14] According to the National Plan for Water Services 2006-2015, in Peru there are 75.765 rural units that concentrate a population of 7,9 million inhabitants.[15] Among the urban units, the localities between 2.001 and 30.000 inhabitants are defined as small cities. Defensoria del Pueblo (2007) explains that there are 660 small cities, 82% of which have between 2001 and 10.000 inhabitants (see Table 2).

The organization and management of water systems is very different in urban and rural units. In urban units water can be supplied as follows:

(1) There are 54 public operators called *Empresas Proveedoras de Servicios* (EPS) that cover 62% of the population (around 300 municipalities). EPS are managed by regional or local governments (*municipalidades provinciales* and *municipalidades distritales*). The only exception is CEDEPAL, a public firm managed by the central government, which operates in Lima and Callao and covers 29% of the population. The prices of the EPS are regulated by SUNASS;

(2) Local governments (municipalities) provide the service in about 226 small cities that are not covered by EPS. This represents 9% of the country's population. In these municipalities the tariffs are approved by local authorities;

(3) A small number of municipalities in the Department of Tumbes are served by private

[12]Ley No 27779, Ley Orgànica de modifica la Organización y Funciones de los Ministerios y Ley No 27792 that aproves the Ley de Organización y Funciones del Ministerio de Vivienda, Construcción y Saneamiento.

[13]Decreto-Supremo No 023-2005-Vivienda.

[14]See the 1994 Water Act (*Ley General de Servicios de Saneamiento*), which was modified by the Decreto Sumpremo No 023-2005-Vivienda. At the same time, the Peruvian Statistical Institute (INEI) defines rural units as those that have less than 100 grouped houses (500 inhabitants on average) and are not the capital of the municipality. See the Directorio de Centros Poblados and Defensoria del Pueblo (2007).

[15]Plan Nacional de Saneamiento 2006-2015, aprobed by the Decreto Supremo No 007-2006-Vivienda.

operators. Private concessions where introduced in Peru in 2006;

(4) Communal organization (JASS, users associations, etc) covers the small cities that are not served by the EPS and the local governments. They define the type of service they want to receive, operate the water and/or the sewage system, and set a compensation mechanism to the users;

(5) Small scale local operators. There is a handful of private firms that supply water through tankers, barrels, small networks and other mechanisms. The price of these operators is not regulated and they usually don't have quality controls.

It is important to highlight that in the municipalities served by EPS and local governments there is a part of the population that access the water through alternative systems. In fact, around 20% of the population living in the areas attended by EPS obtain water from private tankers (25%), communal organizations such as JASS (22%) and other systems such as private wells (24%) (MVCS, 2007). This might occur because households are not connected to the water system, or because they can't afford the prices. MVCS (2007) explains that EPS have little incentive to expand their networks due to their financial fragility. For this reason, these alternative systems are the only option to access the service for the poorest segments of the population.

The provision of water and sewage in rural units (29% of the population) is attended by the municipalities and communal organizations such as the *Juntas Administrativas de los Servicios de Saneamiento* (JASS).[16] The regulation of the market establishes that all rural units should be served by the JASS. In spite of this, this happens only in around 12.000 out of 75.765 rural units. In the rest of cases, any local government or communal organization assumes the responsibility of providing the service with a minimum quality standard (Calderon, 2004). In the last years, several programs such as PROSANAR have been developed to finance the construction and rehabilitation of infrastructure in rural units and small cities, but their effectiveness has been criticized. The *Defensoría del Pueblo* (2007) considers that although the administrative division between urban and rural units determines the responsibilities in the management and financing of water systems, it doesn't reflect the real possibilities of local governments to satisfactorily operate and supervise the service.

JASS are civil associations that manage the water and/or the sewage services in rural units in collaboration with the municipalities. They must elaborate a plan of their activities, a budget, and must set the annual fees to be charged to households. In practice many users are not able to pay the fees, but JASS can survive thanks to the collective work of the population

[16] They are regulated by the Reglamento de la Ley General de Saneamiento 26338.

and the establishment of exceptional contributions. In many occasions, the members of the JASS don't receive any economic compensation or technical training to operate the system. This situation has favored the creation of other type of organizations like "users associations", which are managed following private principles.

4 The Data

We use the Endes Survey (*Encuesta Demográfica y de Salud Familiar*) which is a detailed survey at the household level conducted by the Statistical Institute in Peru (INEI). Since 2006 there is information on the key variable to this study: the type of water provision, that is, whether water is provided by a private operator, by a public agency, by other private means or by *Juntas Administradoras del Agua* (JASS) and other communal forms of provision. Table 3 shows the type of water provision as reported by the households. Notice that the public and communal forms of provision are clearly the important ones in Peru covering almost 50% and 44% of the households respectively, whereas the private systems only affect about 5.7% of the surveyed households.[17] For this reason the empirical analysis will focus on the differential impact on child health of the communal provision over the public one.

Every year Endes interviews more than 7,000 households that change year after year, with this number being increased up to 27,000 for 2009 and 2010. The survey provides a rich set of variables describing the living conditions, health and socio-demographic characteristics of the households. Among others, Endes contains health indicators for under-five year old children such as the incidence of diarrhea in the last weeks, their weigh and height, vaccination programs, etc. and basic information on their mothers such as their educational level, age, or number of children. The survey also offers information on household assets as for instance, the type of floor in the house, whether the household has electricity, radio, vehicles, etc. Several questions also refer to other relevant aspects to the water service, such as the source of water being consumed in the household, the monthly payments made to the water operator, the sewage system and the hygienic practices of the family. The information in Endes is complemented with the Peruvian municipalities survey (Renamu) from which we obtain additional controls at the municipality level, such as the population, and variables that we use as instruments as we will explain later.

For the purpose of our study, the relevant unit of analysis is a child under five who lives in

[17] The first privatization experiences in Peru took place in 2006 in the Department of Tumbes. We leave the analysis of privatization for a future version of the paper.

one of the interviewed households. This leaves us with a pooled cross-section of about 19,000 observations over the period 2006-2010. This sample size is somewhat reduced in the empirical analysis as the regressions are carried out on the common sample for all the variables. Table 4 provides descriptive statistics of the variables that will be used in the empirical analysis.[18]

5 Empirical Strategy and Results

We want to assess the differential impact on child health of the communal forms of water provision in Peru. Thus, we estimate the following empirical model

$$H_{ihrt} = \alpha.Comunal_{ht} + X_{iht}.\beta + \delta_r + \eta_t + \epsilon_{ihrt} \quad (1)$$

where i indexes children, h denotes household, r is region and t indexes year. H_{ihrt} is an indicator of child health susceptible of being affected by water quality. In particular, we use a dummy variable for diarrhea, which takes the value of 1 if the child has been affected by diarrhea recently and 0 otherwise; $Comunal_{ht}$ is a dummy variable that takes value 1 if the water used by the household is provided by a communal system (*Juntas Administradoras de Agua*, *Comités vecinales* or other forms of communal provision) and 0 if it is instead provided by a public system; X_{iht} is a vector of child's characteristics including age, gender and whether the child is breast-feeding or not, characteristics of the mother such as her age and education, and characteristics of the household as for instance, an income index, the number of members living there and household assets (whether there is electricity, radio, shared toilet, etc.). Region and year fixed effects, δ_r and η_t respectively, are included to control for unobserved heterogeneity across regions and years. Finally, ϵ_{ihrt} is the error term, assumed to be identically and independently distributed.

We start by estimating a linear model of (1) by OLS and also a probit model by maximum likelihood on the probability of the child experiencing diarrhea recently. Table 5 reports the estimation results. As observed, across all models we obtain a negative, although statistically insignificant, effect of the communal water provision on child diarrhea. However, these estimates might suffer from an endogeneity problem. In effect, the type of water provision is not randomly assigned across municipalities but there are reasons to believe that municipalities having communal water provision, just because public and private provisions have failed to be

[18] It is worth to point out that the statistics are calculated using the sample weights and thus larger municipalities might be over-represented as more individuals are sampled from those municipalities.

implemented, might tend to exhibit poorer health outcomes as well.[19] If this is the case, the OLS coefficient on communal provision is then likely to be biased towards zero, in which case we would conclude that communal provision has no efffect on child diarrhea or this effect is lower that it really is. The same can be said of the probit estimates.

In order to address this potential endogeneity problem we use an instrumental variable strategy. We need some variable (an instrument) that is correlated with the probability of having a communal water system while orthogonal to the child experiencing diarrhea. Using the available information on municipalities, we explored different variables. As we explain next, our best candidates for an instrument are the (per capita) professional personnel of the municipalities and the administrative classification of households on urban or rural units. We believe that the communal provision of water is related to the geographical and physical difficulties encountered by the public and private systems to provide the water service. One of those difficulties is the lack of technical and human resources of local governments to manage the service. Thus, we use the per capita number of professional personnel in the municipality as an instrument for communal water provision. One could argue that municipalities with less public resources would also tend to be poorer in other dimensions and would be more likely to have worse health outcomes, what would then invalidate the variable as an instrument. In order to avoid this problem, we do not consider all the personnel in the municipality (which would certainly mirror the economic capabilities of municipalities) but just the number of professional personnel, that is, classified as either "professional" or "technical" by Renamu. The other instrument we use is the administrative classification of the households as urban or rural. As we explained in Section 3, municipalities in Peru are divided into so-called *centros poblados* (population units), and based on the number of households in the unit and on whether they are the capital or not, units are classified as either urban or rural. In other words, the urban/rural classification responds to the notions of size (population mass) and population dispersion over the territory. While these factors clearly affect the economic viability of private and public forms of water provision, they do not necessarily correlate with health outcomes. Table 6 shows the partial correlation between the instruments and the communal provision dummy, the endogenous explanatory variable, and for comparison we also report the partial correlation between the instruments and the dependent variable. As observed in Table 6, the partial correlation (R-squared) between the 2 instruments and the communal provision dummy is 0,28, with the instruments being jointly significant and the F-statistic quite high (334) which

[19] In order to confirm the endogeneity of the comunal variable, we performed the Haussman test and the null hypothesis of exogeneity of the variable was rejected at the 1% significance level.

makes us confident about the instruments having sufficient explanatory power. On the other hand, the partial correlation of the instruments with the dependent variable is very low (R-squared equal to 0,0002) and the individual coefficients are only statistically significant in the case of professional personnel. This lends some initial support in favor of the validity of the instruments.

Table 7 presents the IV estimation results. Column (I) shows the first-stage estimation results where the endogenous explanatory variable, communal water provision, is regressed on the instruments and all the other exogenous variables. As already seen in Table 5, both instruments are negatively correlated to communal water provision, with the coefficients being statistically significant at the 1% significance level, and the F-statistic is quite high. Moreover, as we have more instruments than endogenous explanatory variable, we can perform the test of over-identifying restrictions that clearly confirms the validity of the instruments.[20] Columns II and III on Table 7 report the IV estimates for the lineal and the probit models respectively. According to both models, the communal provision of water has a clear negative differential impact on child diarrhea. Notice that the magnitude of the coefficient (in absolute value) is considerably higher than those obtained in the equivalent regressions of Table 5. More importantly, the coefficients are now statistically significant. This confirms our previous conjecture that the OLS and probit estimates of Table 5 were biased towards zero and under-estimated the true effect of the communal provision on the incidence of child diarrhea.

As a robustness check and in order to get sharper results on the effect of communal types of water provision, we also estimate the model in (1) restricting our attention to those households that access water through means of a network. We believe that in the case of piped water, the provision of the service is technically more demanding. Thus we leave out all the households reporting as their source of water public fountains, wells, rivers, tankers, barrels, and others sources, and consider only those connected to a water network either into their homes or outside the house. The IV estimation results of the linear model are reported in Table 8. The negative and significant effect on child diarrhea of the communal provision of water is confirmed, with the point estimate of the coefficient being only slightly lower, in absolute value, than that of Table 7, column II.

[20] The test statistic is well below the critical value for a chi-squared with 1 degree of freedom at 0.5% significance level.

6 Conclusions

Although the literature on public services has put the emphasis on private and/or mixed private-public provision systems, communal provision of water such as cooperatives and user associations play an important role in countries where a large percentage of the population has a low willigness to pay and lives in rural areas. Peru is a good example of this situation. The main two types of water provision are the public and communal systems, with the private sector being introduced only recently and covering a very small percentage of the population. In this paper we assess the effect of communal forms of water provision on child health in Peru. To the best of our knowledge this is the first attempt to examine communal forms of provision.

Using detailed survey data at the household- and child-level for the years 2006-2010, we exploit the cross-section variability to identify the differential impact of the communal provision over the public one. We show how the OLS estimates, that do not account for potential endogeneity, might under-estimate the true effect of communal provision and, instead, rely on an instrumental variable approach that clearly confirms the negative and statistically significant effect of communal water provision on child diarrhea. The study is to be extended to explore the effect of this provision system to other aspects of the service such as coverage, quality, and payments.

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Tables

Table 1. Access to water and sewage services in Latin America (in %)

Country	Water			Sewage			Rural Population (2000)
	Urban	Rural	Total	Urban	Rural	Total	
Bolivia (2003)	89	37	70	59	22	31	60
Chile (2003)	99	43	91	92	49	80	17
Colombia (2005)	94	47	83	90	18	73	35
Ecuador (2004)	88	59	75	64	15	44	52
El Salvador (2005)	83	59	73	79	64	73	n.a
Guatemala (2002)	73	46	63	86	60	72	n.a.
Perú (2004)	81	62	76	68	30	57	37

Source: Defensoria del Pueblo (2007) and Dianderas (2008)

Table 2. Water Provision in Peru, 2004

	Population (millions)	Clean Water		Sewage	
		Population served	%	Population served	%
EPS (226 urban units)					
-SEDEPAL					
-Large EPS (9 operators)	8.0	7.1	89	6.7	84
-Average EPS (20 operators)	5.4	4.5	82	3.7	48
- Small EPS (16 operators)	3.0	2.4	79	1.8	61
	0.7	0.4	71	0.3	51
Local governments and JASS					
	2.5	1.5	60	0.8	33
Rural units (75.765 units)	7.9	4.9	62	2.4	30
Total	27.6	20.8	76	15.8	57

Source: MVCS (2007).

Table 3. Type of water provision (% of sampled households)

Comunal provision	44,4%
Private provision	3,6%
Other private provision	2,2%
Public provision	49,8%

Table 4. Descriptive Statistics

Variable	Mean	St. Deviation	Min	Max
Dummy -- child experienced diarrea recently	0,15	0,36	0	1
Dummy- child is a girl	0,49	0,50	0	1
Child age (years)	2,45	1,44	0	5
Dummy -- child is breastfeeding	0,36	0,48	0	1
Mother's age	29,55	6,95	15	49
Dummy -- mother has no education	0,03	0,16	0	1
Dummy -- mother has primary education	0,28	0,45	0	1
Dummy -- mother has secondary education	0,44	0,50	0	1
Dummy -- mother has higher education	0,25	0,43	0	1
Dummy -- very low income	0,12	0,33	0	1
Dummy -- low income	0,27	0,44	0	1
Dummy -- middle income	0,29	0,45	0	1
Dummy -- high income	0,20	0,40	0	1
Dummy -- very high income	0,12	0,33	0	1
Dummy -- mother tongue Spanish	0,09	0,29	0	1
Household members	5,59	2,02	2	11
Dummy -- HH has natural floor	0,47	0,50	0	1
Dummy -- HH has a fridge	0,34	0,47	0	1
Dummy -- HH has a radio	0,85	0,36	0	1
Dummy -- HH has a TV	0,81	0,39	0	1
Dummy -- HH has electricity	0,88	0,33	0	1
Dummy -- HH has a bike	0,23	0,42	0	1
Dummy -- HH has a vehicle	0,08	0,27	0	1
Dummy -- HH has a telephone	0,20	0,40	0	1
Dummy -- toilet shared with another HH	0,13	0,33	0	1
Altitude	12.905	1.415	0	4.660
Population of municipality	83.302	124.247	204	812.656

Table 5. OLS and ML estimation results

Dependent variable: child experienced diarrhea recently	Linear regression (I)	Linear regression (II)	Linear regression (III)	Probit (IV)
Comunal provision	-0,0083	-0,0083	-0,0023	-0,0078
	0,0076	0,0077	0,0078	0,0336
Child age	-0,0250***	-0,0255***	-0,0250***	-0,1231***
	0,0029	0,0030	0,0030	0,0142
Dummy -- child is breastfeeding	0,0089	0,0077	0,0112	0,0336
	0,0099	.0099638	0,0099	0,0422
Mother's age	-0,0018***	-0,0017***	-0,0017***	-0,0077***
	0,0005	0,0005	0,0005	0,0021
Dummy -- mother has primary education	0,0382**	0,0387**	0,0359**	0,2123**
	0,0165	0,0165	0,0165	0,1008
Dummy -- mother has secondary education	0,0284	0,0288*	0,0232	0,1488
	0,0176	0,0177	0,0177	0,1041
Dummy -- mother has higher education	0,0120	0,0125	0,0025	0,0519
	0,0185	0,0185	0,0186	0,1080
Dummy -- mother tongue Spanish	-0,0133	-0,0137	-0,0039	-0,0267
	0,0123	0,0123	0,0138	0,0661
Dummy -- low income	0,0208	0,0215	0,0215	0,1008
	0,0132	0,0136	0,0137	0,0642
Dummy -- middle income	0,0165	0,0170	0,0267	0,1305
	0,0163	0,0173	0,0176	0,0796
Dummy -- high income	-0,0194	-0,0189	0,0050	0,0332
	0,0187	0,0200	0,0205	0,0934
Dummy -- very high income	-0,0429**	-0,0418*	-0,0041	-0,0408
	0,0215	0,0230	0,0238	0,1102
Household members	-0,0005	-0,0005	-0,0023	-0,0122*
	0,0016	0,0016	0,0016	0,0071
Dummy -- toilet shared with another HH	0,0238**	0,0244***	0,0132	0,0487
	0,0098	0,0098	0,0100	0,0408
Dummy -- HH has natural floor	0,0141	0,0141	0,0135	0,0573
	0,0094	0,0095	0,0096	0,0403
Dummy -- HH has a fridge	0,0112	0,0109	0,0074	0,0375
	0,0087	0,0087	0,0088	0,0387
Dummy -- HH has a radio	-0,0351***	-0,0346***	-0,0331***	-0,1313***
	0,0099	0,0099	0,0099	0,0394
Dummy -- HH has a TV	0,0153	0,0146	0,0172	0,0794
	0,0112	0,0113	0,0113	0,0501
Dummy -- HH has electricity	-0,0103	-0,0112	-0,0051	-0,0251
	0,0130	0,0130	0,0132	0,0593
Dummy -- HH has a bike	0,0017	0,0018	0,0085	0,0362
	0,0071	0,0071	0,0073	0,0334
Dummy -- HH has a vehicle	0,0035	0,0034	0,0055	0,0274
	0,0104	0,0104	0,0104	0,0522
Dummy -- HH has a telephone	0,0109	0,0109	0,0030	0,0175
	0,0089	0,0089	0,0091	0,0421
Altitude	-0,0000***	-0,0000***	-0,0000	-0,0000
	0,0000	0,0000	0,0000	0,0000
Population	0,0000	0,0000	0,0000***	0,0000***
	0,0000	0,0000	0,0000	0,0000
Year fixed effects	NO	YES	YES	YES
Region fixed effects	NO	NO	YES	YES
R-squared/ Pseudo R-squared	0,026	0,027	0,038	0,047
No observations	13.779	13.779	13.779	13.779

Notes: Standard errors underneath coefficient point estimates; (*), (**) and (***) denotes 10%, 5% and 1% significance level respectively.

Table 6. Partial correlations between the IVs and the endogenous explanatory variable and the dependent variable

	OLS regression. Dep var.: comunal provision
Urban unit	-0,5862***
	0,0234
Per capita professional personnel	-19,2477***
	6,0493
R-squared	0,2793
F-statistic	333,86

	OLS regression. Dep var.: child experienced diarrea recently
Urban unit	0,0063
	0,0081
Per capita professional personnel	-1,5034**
	0,7393
R-squared	0,0002
F-statistic	2,99

Notes: Standard errors underneath coefficient point estimates; (*), (**) and (***) denote 10%, 5% and 1% significance level respectively.

Table 7. IV Estimation Results

	1st stage regression	Linear IV regression	Probit IV regression
Dependent variable:	Comunal provision	Child experienced diarrhea recently	Child experienced diarrhea recently
Comunal provision		-0,0862***	-0,3578***
		0,0292	0,1249
Urban unit	-0,3271***		
	0,0400		
Per capita professional personnel	-17,5414***		
	6,9346		
Child age	-0,0020**	-0,0255***	-0,1236***
	0,0008	0,0032	0,0135
Dummy -- child is breastfeeding	-0,0088	0,0103	0,0298
	0,0066	0,0104	0,0429
Mother's age	-0,0010**	-0,0017***	-0,0078***
	0,0005	0,0005	0,0021
Dummy -- mother has primary education	0,0108	0,0351**	0,2065**
	0,0303	0,0161	0,0973
Dummy -- mother has secondary education	-0,0132	0,0197	0,1319
	0,0336	0,0164	0,0972
Dummy -- mother has higher education	-0,0350	-0,0040	0,0239
	0,0334	0,0169	0,0991
Dummy -- mother tongue Spanish	0,1417***	0,0127	0,0437
	0,0312	0,0148	0,0701
Dummy -- low income	-0,0362*	0,0141	0,0697
	0,0195	0,0131	0,0620
Dummy -- middle income	-0,2182***	-0,0022	0,0103
	0,0286	0,0191	0,0849
Dummy -- high income	-0,3807***	-0,0407*	-0,1549
	0,0388	0,0245	0,1082
Dummy -- very high income	-0,3884***	-0,0522**	-0,2372*
	0,0420	0,0280	0,1270
Household members	-0,0201***	-0,0043***	-0,0206***
	0,0026	0,0017	0,0077
Dummy -- toilet shared with another HH	0,1077***	0,0198**	0,0765**
	0,0240	0,0096	0,0393
Dummy -- HH has natural floor	-0,0488***	0,0101	0,0422
	0,0197	0,0095	0,0396
Dummy -- HH has a fridge	-0,0086	0,0087	0,0420
	0,0144	0,0085	0,0375
Dummy -- HH has a radio	-0,0075	-0,0319***	-0,1239***
	0,0152	0,0098	0,0384
Dummy -- HH has a TV	-0,0092	0,0148	0,0688
	0,0161	0,0110	0,0492
Dummy -- HH has electricity	-0,1276***	-0,0179	-0,0802
	0,0309	0,0153	0,0673
Dummy -- HH has a bike	-0,0020	0,0081	0,0340
	0,0110	0,0081	0,0362
Dummy -- HH has a vehicle	0,0190	0,0085	0,0408
	0,0139	0,0099	0,0485
Dummy -- HH has a telephone	-0,0504***	-0,0018	-0,0022
	0,0127	0,0103	0,0477
Altitude	-0,0000	-0,0000	0,0000
	0,0000	0,0000	0,0000
Population	-0,0000***	0,0000**	0,0000**
	0,0000	0,0000	0,0000
Year fixed effects	YES	YES	YES
Region fixed effects	YES	YES	YES
R-squared	0,412		
F-statistic	107,95		
No observations	18.993	13.763	13.763

Notes: Standard errors underneath coefficient point estimates; (*), (**) and (***) denotes 10%, 5% and 1% significance level respectively.

Table 8. IV Estimation Results

	1st stage regression	Linear IV regression
Dependent variable:	Comunal provision	Child experienced diarrhea recently
Comunal provision		-0,0589**
		0,0247
Urban unit	-0,4307**	
	0,0416	
Per capita professional personnel	-12,4618*	
	7,3631	
Child age	-0,0017**	-0,0228***
	0,0008	0,0034
Dummy -- child is breastfeeding	-0,0076	0,0169
	0,0066	0,0108
Mother's age	-0,0012**	-0,0016***
	0,0005	0,0005
Dummy -- mother has primary educa	0,0105	0,0384**
	0,0276	0,0163
Dummy -- mother has secondary ed	-0,0161	0,0229
	0,0301	0,0164
Dummy -- mother has higher educat	-0,0285	0,0021
	0,0305	0,0174
Dummy -- mother tongue Spanish	0,1553***	0,0072
	0,0332	0,0146
Dummy -- low income	-0,0355*	0,0077
	0,0201	0,0135
Dummy -- middle income	-0,1679***	0,0080
	0,0295	0,0182
Dummy -- high income	-0,2263***	-0,0221
	0,0354	0,0219
Dummy -- very high income	-0,2068***	-0,0402*
	0,0377	0,0245
Household members	-0,0191***	-0,0028
	0,0025	0,0018
Dummy -- toilet shared with another	0,1566***	0,0196*
	0,0238	0,0106
Dummy -- HH has natural floor	-0,0437**	0,0050
	0,0181	0,0099
Dummy -- HH has a fridge	-0,0200	0,0117
	0,0123	0,0088
Dummy -- HH has a radio	-0,0126	-0,0364***
	0,0153	0,0107
Dummy -- HH has a TV	-0,0054	0,0208*
	0,0158	0,0108
Dummy -- HH has electricity	-0,1332***	-0,0118
	0,0330	0,0157
Dummy -- HH has a bike	-0,0065	0,0069
	0,0110	0,0084
Dummy -- HH has a vehicle	0,0142	0,0075
	0,0132	0,0105
Dummy -- HH has a telephone	-0,0482***	0,0016
	0,0124	0,0105
Altitude	0,0000	0,0000
	0,0000	0,0000
Population	-0,0000***	0,0000*
	0,0000	0,0000
Year fixed effects	YES	YES
Region fixed effects	YES	YES
R-squared	0,472	0,0348
F-statistic	105,78	
No observations	16.990	12.264

Notes: Standard errors underneath coefficient point estimates; (*), (**) and (***) denotes 10%, 5% and 1% significance level respectively.