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

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December 2014

Abstract

The literature on water provision has compared the effects of private and public systems, but has completely ignored communal organizations, which are very prevalent in developing countries. Using detailed survey data at the household level for the years 2006-2010, we investigate the effects of communal water provision on child health in Peru. As the households served by communal organizations are more likely to have poorer health indicators, we rely on an instrumental variable strategy to deal with the endogeneity problem. Exploiting the legislative changes that affected the provision of water across the sub-units in which the Peruvian municipalities are divided, we use the administrative rural/urban classification of those sub-units as instrument for the type of water provision. We offer indirect and direct evidence based on a recently developed test for instrument validity that this variable meets the exclusion restriction condition. Our results show a negative and significant effect of communal water provision on diarrhea and acute malnutrition among children under five, and the findings are robust to a number of checks and placebo tests. We also find that communal provision is not associated with higher rates of access to piped water. Rather, the channel through which communal organisations benefit child health seems to be better management and service quality.

Keywords: water, communal organizations, child health, regulation, Peru.

JEL Classification Numbers: L33, L50, L95.

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1 Introduction

Water-related diseases are one of the most common causes of morbidity and mortality in developing countries, especially among children under the age of five. According to the WHO World Health Report 2005, diarrhea is the second biggest killer of children in developing countries. In Peru, each year diarrhea causes 8.4 million cases of morbidity in children and 11.8 million cases among adults (Defensoria del Pueblo, 2007). This constitutes an important concern of public health that is not easy to solve. Contaminated water supplies and inadequate sanitation are generally responsible for this problem and thus, improving public health requires improving water infrastructures and water provision, something that is often beyond the economic means of public authorities in many developing countries.

The objective of this paper is to assess whether alternative water systems based on user associations, the so-called *communal organizations*, can offer children in developing countries greater protection against water-related diseases than conventional public water systems. Communal water organizations have an important presence in Andean countries including Argentina, Bolivia, Colombia, Chile, Ecuador, Peru and Venezuela,[1] as well as in some developed countries such as the U.S. and Finland. According to the Avina Foundation, there are more than 80,000 communal organizations in Latin America providing access to water and sewage services to more than 40 million people. In some countries the percentage of the population covered by this type of provision can be higher than 30%. Despite the importance of communal organizations very little is known about their effectiveness and welfare implications. By contrast, there are several papers analyzing the effects of privatization of the water service in developing countries. Most works compare private to public provision in terms of coverage of piped water, payments and quality, and some advocate for the use of mixed public-private partnerships that can offer the best of both worlds (Estache et al., 2001, McKenzie and Mookherjee, 2003; Wallsten and Kosec, 2008; Gassner et al, 2008; Clarke et al, 2009).[2] A number of papers have also analyzed the impact of private service participation on health (Galiani et al., 2005;

[1]These organizations can be found under various names: *Juntas de Administración de Agua* in Ecuador, *Juntas Administradoras* or *Juntas de Acción Comunal* in Colombia, *Mesas Técnicas de Agua* in Venezuela, *Juntas Administrativas de Servicios de Saneamiento* in Peru, and *Comités de Agua Potable y Saneamiento* in Bolivia. Some of them are part of the international association *Confereración Latino Americana de Organizaciones Comunitarias de Servicios de Agua y Saneamiento* (CLOCSAS).

[2]Generally these studies find that privatization tends to expand water and sewage networks and improves the quality of the service, but it might also exclude low-income households by raising prices. See Megginson and Netter (2001) for a review.

Barrera-Osorio et al., 2009; Kosec, 2011). However, in order to correctly orientate public policies, it is important to note that privatization is infrequent in small and remote municipalities where the service is expected to be unprofitable. Moreover, local governments might be too poor to construct and maintain water systems. In these instances, user associations and other communal organizations may be the only effective option to set up, maintain and run the water service. On the one hand, they require fewer resources because they are heavily reliant on the voluntary work of its members. On the other hand, decentralization improves project selection, fosters community involvement and meets user demands better.

Peru is a good example to illustrate the importance that communal organizations can have in the provision of public goods. Although in the last years the country has made an important effort to meet the Millennium Development Goals, the coverage of the water service is still one of the lowest in the region. According to the World Bank, in 2012 87% of the Peruvian population (only 72% in the rural areas) had access to improved water, while the average coverage in Latin America and the Caribbean was 94% (82,5% in rural areas). Regional and local governments tend to provide the water service in cities while in villages and rural areas the service has been delegated to communal organizations called *Juntas Administrativas de Servicios de Saneamiento* (JASS). All in all the JASS supply water to more than five million people. The members of the JASS contribute with their work to construct the water infrastructure and operate the system. Moreover, as users of the service they have clear incentives to supervise the quality of the water. On the negative side, it needs to be said that most JASS face important difficulties: they lack the resources to expand and maintain the water networks; often their members lack adequate training and many users may not afford the price of the service. All this raises the question of whether communal organizations can be an effective way to organize water provision.

Our paper contributes to the literature on the provision of basic public services by examining the effects of communal water organizations on child health in Peru. To the best of our knowledge this is the first attempt to empirically assess this type of provision. Using data at the household- and child-level for the period 2006-2010, we estimate the differential impact that communal water organizations have on child health with respect to the public provision. An instrumental variable approach is used to deal with the potential endogeneity of the provision system. Our findings show that diarrhea and acute malnutrition among children under the age of five are less likely when these children have access to water through a communal organization than through a public system. This result may appear surprising given the economic difficulties and lack of resources faced by JASS. However, decentralized management and the greater involvement of communal workers in the provision of the service may compensate for those deficits. The paper also analyses the channels through which communal organizations can help improve child health. We argue that, although communal provision does not mean greater access to piped water, this type of provision is associated with higher quality of the service.

The rest of the paper continues as follows. Section 2 links the paper to the existing literature. Section 3 explains the main legislative changes of the last decades that affected the water sector in Peru and the current organization of the service. Section 4 describes the data. Section 5 discusses the empirical strategy, paying particular attention to the validity of the instrument, and presents the results and some robustness checks. Section 6 analyzes the channels through which communal organizations seem to benefit child health. Finally, Section 7 concludes.

2 Related Literature

The connection between water conditions and human health has long been established in the epidemiological literature. Unsafe water, poor sanitation and lack of hygiene are major causes of morbidity and mortality among the poor in developing countries (Esrey et al., 1991; Fewtrell et al., 2005; Hubbard et al., 2005).[3] Children are more vulnerable to water-related diseases; around 80% of the people affected with diarrheal diseases are children under five. Moreover, the effects of diarrhea go beyond the immediate problems of dehydration and potential death. High diarrheal morbidity can have long-term effects on physical growth (Checkley et al., 2008), physical fitness and cognitive functions (Guerrant et al., 1999; Niehaus et al., 2002).

An important strand of the economics literature has analyzed the effects of water service privatization on child health and other outcomes such as network coverage, quality and affordability of the service. For instance, Galiani et al. (2005) find that child mortality in Argentina fell significantly in regions that privatized the provision of water. Using panel data at the local level and a difference-in-difference estimation strategy, they find that privatization was associated with a reduction in the number of deaths caused by infectious diseases related to water conditions, although they obtained a null impact of privatization in municipalities with

[3] A number of papers have examined the relationship between water and sewage services and child health especifically for Peru. For example, Checkley et al. (2004) examine the effects of water and sanitation on health for a cohort of children in a periurban community in Lima and find that at 24 months of age, children with the worst conditions for water source, water storage and sanitation had more diarrheal episodes (54% more) and grew less in height than those with the best conditions. In a large cross-sectional multicountry study including Peru, Esrey (1996) shows that improvements in sanitation resulted in less diarrhea and in taller and heavier children, especially in urban municipalities.

low levels of poverty. Galiani et al. (2009) examine the effects of a 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 labor force, whereas the beneficiary communities agreed to supply the labor force for the construction of the network. The results show 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. They also show that these effects were important for households that previously had free clandestine connections to the network that provided low quality water.

Using household surveys similar to the one used in this paper, Barrera-Osorio et al. (2009) and Kosec (2014) examine the effects of water privatization on child health in Colombia and Africa, respectively. Barrera-Osorio et al. (2009) find that privatization improved the quality of water and increased the frequency of the service in urban municipalities for the lower income quintiles, while it had a negative effect on access to water in rural areas. Their results also suggest that privatization generated positive effects on health outcomes (diarrhea and weight for height of children) in both rural and urban municipalities. For a group of 39 African countries, Kosec (2014) finds that the introduction of Private Sector Participation (PSP) was associated with a lower incidence of diarrhea among children, especially those from the poorest households. With regard to other outcomes, McKenzie and Mookherjee (2003) show that in Argentina, Bolivia, Mexico and Nicaragua privatization increased access to piped water at the bottom of the income distribution, but that this effect was outweighed by its negative impact on prices. Clarke et al (2009) find that privatization in Argentina, Bolivia and Brazil improved water quality and increased access to piped water and sewerage, although access also improved in cities that retained public ownership. Thus, the improvements could not be completely attributed to PSP. We contribute to this literature by departing from the public-private dichotomy to analyze instead the effect of communal water organizations on child health. As far as we know, the performance of this type of organizations has not been empirically assessed before.[4]

This paper is also related to the literature on community-driven projects and on collective action. As we explain in the next section, Peru is a large and very diverse country geographically and also in terms of socio-demographics, which makes it very difficult to guarantee a uniform, minimum-quality water service. Up to recent years, the country was highly central-

[4]Whittington et al (2009) analyze 400 communal projects in Bolivia, Peru and Ghana, but they mainly examine the sustainability of the projects.

ized with most of the decisions being taken at the capital by government officials who were usually unaware of the actual needs of many communities throughout the country. Moreover, many Peruvian municipalities do not have networks of piped water and when these exist, they are often the result of one-off investments financed externally at some point and serving only a small proportion of the population. In these instances, water systems can be more effectively maintained and managed by communal associations where the members have a direct interest in the success of the service. This is also the underlying idea of the literature on community-driven development (CDD) projects that emphasizes the need to involve the community in the operation of public infrastructures –see for instance Besley and Coate (2003), Mansuri and Rao (2004), Estache (2004) or Bardhan and Mookherjee (2005). Most public services such as schools, drinking water services, sanitation and roads serve a well-defined local group: a village, a neighborhood or a municipality. When these groups are in small and remote areas, it is very costly for distant administration centers to acquire information about the preferences of the population and to supply the local public good effectively. It is believed that decentralization can then lead to better and more cost-effective projects, timely delivery results and higher quality program implementation.[5] For example, Newman et al. (2002) show that water projects that include community-level training improve quality and accessibility. Galiani et al. (2009) argue that the success of the public program launched in Argentina by the private firm *Aguas Argentinas* was largely due to the involvement of the beneficiary communities in the extension of the water network. Analyzing water systems across several countries, Katz and Sara (1997) also find that these perform better when people can participate in the design and management of the projects. Moreover, community members are more willing to meet investment costs when they have control over the funds.

The literature on collective action suggests that the creation and viability of communal organizations depend on the characteristics of the population. Communities that have similar preferences, open systems of decision-making and clear rules for determining the beneficiaries of the projects are more likely to create such organizations (Alesina and La Ferrara, 2000 and Bandiera et al. 2005). Empirically several papers have shown that the ability of local communities to provide public goods depends on group characteristics like the shares of different ethnic groups in the community as well as social and economic heterogeneity (Miguel and Gugerty, 2005; Barnerjee and Somanathan, 2007; Barnerjee et al. 2008; Alesina et al., 2012; Glennerster et al, 2013). A paper that has analyzed collective action in Peru is Escobal and

[5] On the other hand, a common criticism on decentralized projects is that, in practice, they are controlled by local elites and opportunistic entrepreneurs, and might never reach the intended recipients.

Ponce (2011). The authors explore the role of "institutional thickness" (a measure they construct based on the degree of economic and social fragmentation) in strengthening the effects of improved sanitation and access to electricity on growth. They show that the institutional setting determines the impact of these infrastructures on income growth, especially among the poorest segments of the population. We acknowledge that collective action plays a role in the provision of water in Peru and, in particular, that the existence of communal organizations is linked to the ethnic composition of communities. However, the objective of this paper is not to explain the emergence of this type of organizations but rather the effect that they have on health outcomes.[6]

3 Water Provision in Peru

Peru has a very diverse geography that coupled with the existence of a large number of small and dispersed villages hinders the homogenous provision of water to all the population. The country can be divided in three clearly separated natural regions that differ greatly in terms of their water resources: the coast, the Andean region and the rainforest. The coast occupies areas between 0 and 2000 meters above sea level, and is characterized by the scarcity of rain throughout the year. This region represents only 10% of the national territory but hosts 61% of the population –it includes the capital, Lima, which has 30% of the country's population. Access to water in this region is gained via a large number of rivers and underground waters. The Andean region (the *Sierra*) covers 31% of the territory and concentrates 29% of the population. It benefits from seasonal rains and the population and the agricultural sector obtain water primarily from natural springs and rainwater. Finally, there is the rainforest (the *Selva*) in the eastern part of Peru, which accounts for 59% of the territory and is home to only 10% of the population. It experiences intense rainfall throughout the year and water is abundant.

Administratively Peruvian municipalities (*distritos*) are divided into smaller units called population units (*centros poblados*) and these sub-units are classified as either urban or rural. The precise definition of rural and urban units varies slightly depending on the government agency. The definition used in the Peruvian water legislation considers a population unit to be rural if it has less than 2,000 inhabitants and does not serve as the capital of the municipality.[7]

[6] The role that collective action and ethnic composition play as determinants of communal water organizations in Peru is analyzed in Calzada, Iranzo and Saenz (2014).

[7] In our empirical analysis, though, we use the definition given by the Peruvian Statistical Institute (INIE)

Currently, Peru has 734 urban population units that concentrate approximately 19 million inhabitants (around 70% of the population) and 85,138 rural population units that group over 8 million inhabitants. This classification is important because, as we will explain, the Peruvian law establishes a markedly different regulation of the water service for rural and urban population units.

In what follows we summarize the main regulatory changes Peru underwent the last decades and the current organization of the water service.

3.1 Regulatory Reforms

The major regulatory reforms regarding the Peruvian water service were initiated in the early 1990s when the largest water operators, until then integrated in a unique national firm, were transferred to the regional and local governments, and converted into public firms called *Entidades Prestadoras de Servicios* (EPS).[8] At that time, the government also created a national water regulator called SUNASS (*Superintendencia Nacional de Servicios de Saneameniento*) with the mission of supervising the market and setting the fees. These institutional reforms, however, were to have little effect in small and remote villages. Rather, it was the cholera epidemic of 1991 that urged the government to undertake major investments in water and sewage systems through institutions like the *Fondo Nacional de Cooperación para el Desarrollo (FONCODES)*[9] and the 1994 Law for Municipalities (*Ley Organica de Municipalidades)* that introduced significant changes in the regulatory framework affecting the provision of water in municipalities. For instance, this was the first law that established that rural population units had to be served by communal organizations called *Juntas Administrativas de los Servicios de Saneamiento* (JASS), even though this was not implemented until years later, in 2005, when further reforms were undertaken.

After the fall of the authoritarian regime of Alberto Fujimori in 2000 a decentralization process was initiated in Peru[10] (Escobal and Ponce 2011) and the regulation of the water sec-

where our data comes from. According to INIE a population unit is classified as rural if it has less than 100 grouped houses (500 inhabitants in average) and does not serve as capital of the municipality.

[8] Only SEDAPAL, the public operator in Lima, remains under the control of the central government.

[9] The projects made in this period came in for severe criticism though, because most of the new water systems were not sustainable. They were not coordinated with local communities and they were highly dependent on subsidies. Many infrastructures were never used because nobody in the community had the necessary training to operate them, and some were soon deteriorated due to lack of economic resources to maintain them (Calderon, 2004).

[10] The 2002 Regionalization Law divided the country into 25 regions (*departamentos*) which in turn were

tor was to be further modified. In 2002, the Ministry of Housing, Construction and Sewage (*Ministerio de Vivienda, Construcción y Saneamiento* or MVCS), which is at present responsible for establishing the water policy in the country, was created. The MVCS implemented the PRONASAR program (*Programa Nacional de Agua y Saneamiento*), which helps communities with the construction and rehabilitation of water systems. The 2003 Law for Municipalities (*Ley Organica de Municipalidades)* set the provincial governments responsible for managing, regulating and supervising the provision of water and sewerage services and in 2005 the MVCS regulated the role and obligations of the JASS. Among others, it made the JASS responsible for running, supervising and setting the fees for the water service in rural population units.

In sum, in the last decades the water regulation in Peru has undergone an important decentralization process that has given regional and local municipalities, as well as communal organization like the JASS, more responsibilities in the management and supervision of the service. These reforms are in line with the guidelines from several international institutions and scholars that advocate for "demand-driven" water supply programs involving the community (Sara and Katz, 1997, and Whittington et al. 2009) and have shaped in an important way the current organization of the water service.

3.2 Current Organization of the Service

As said above, the Peruvian law establishes a markedly different regulation of the water service for rural and urban population units. Since the legislative reforms of the early 2000s, rural units are to be served by communal organizations, in particular by JASS, and are supervised by the municipalities while urban units are to be served by public firms or local governments. However, in practice both types of provision, communal and public, are still present in rural and urban population units.

In particular, in urban units water is supplied by the following organizations:

(1) The public operators called *Empresas Proveedoras de Servicios* (EPS). There are 54 public operators supplying water to about 60% of the total population. The EPS are managed by regional or local governments, with the sole exception of SEDAPAL, the public firm operating in Lima and Callao which offers the service to 29% of the population and is managed by the central government. The prices of the EPS are regulated by the national regulator

divided into provinces, and these in municipalities (*distritos*). In 2008 there were 195 provinces and 1,833 municipalities. On the other hand, the share of expenditure dedicated to the sub-national level increased from 10% in 1999 to 34% in 2007.

SUNASS.

(2) Local governments. They provide the service in 226 small cities not covered by EPS, representing 9% of the country's population. Water fees are approved by local authorities.

(3) Private firms. Since 2006 a small number of municipalities in the region of Tumbes have been served by private operators. The uncertainty about the evolution of this system and the opposition of many local governments have prevented its extension to other regions.

(4) Communal organizations such as the *Juntas Administrativas de los Servicios de Saneamiento* (JASS), *Comites Vecinales* (neighbor associations) and other user associations. They operate in areas of small cities that are not served by the EPS or by local governments.

(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 do not implement any quality controls.

It should be pointed out that even in the localities served by EPS and local governments around 20% of the population has access to water via alternative systems, including private tankers, communal organizations such as the JASS or private wells –MVCS, 2007. Such a situation might arise because the EPS networks do not cover a part of the municipality.

In rural population units, water and sewage is provided by JASS in around 12,000 of a total of 85,138 rural units. In the rest of cases, the local governments might assume the responsibility to provide the service, but often the provision of the service is not organized.

The JASS are civil associations that manage the water and/or the sewage services in many rural and peri-urban units. Since 2005 they have to be registered and are regulated by the central government. This regulation focuses on the procedures for electing and renewing the board, and for guaranteeing their transparency and accountability. The board has to plan the activities of the JASS, organize the construction works, provide the service and set the fees to be charged to households. However, the law is not precise in defining the technical and financial mechanisms that the JASS should use in order to collect, treat, distribute and bill the water.

The JASS find their historical roots in the pre-Columbian tradition of communal work called *Minka.* During the Inca Empire the *Minka* was a system for organizing communal projects, including the construction of public buildings and roads, and a mechanism for organizing agricultural activities. The *Minka* has survived in Andean communities with a large presence of Quechuas and can be related to the presence of communal organizations. Nowadays, the JASS still rely on the volunteer work of their members, although some of them might receive technical support from public programs or non governmental organizations.[11] In recent years, several public programs, such as PROSANAR, have financed the construction and rehabilitation of water infrastructures in rural population units and the resulting systems are usually managed by JASS. Although the JASS face important challenges that have led some communities to create alternative organizations, they still remain the main type of communal water organizations in Peru.

4 The Data

We use the ENDES Survey (*Encuesta Demográfica y de Salud Familiar*) for the years between 2006 and 2010. ENDES is a nationally representative, health and demographic survey at the household level conducted by the Peruvian Statistical Institute (INEI). It interviews a different panel of households every year; in 2006, just over 7,000 households were surveyed and the sample size was progressively increased in subsequent years up to 27,000 households.

The survey contains detailed information on the health status of families as well as on important aspects of their living conditions, and on the key variable in this study: the type of agency to which the household pays for the water service. In the pooled sample for 2006-2010, almost 50% of the households reported obtaining this service from a public operator, 44% from a communal organization (a JASS or another user association) and less than 6% got access to water through a private operator –see Table 2. As the private provision accounts for a very small percentage of households and it is geographically concentrated in just one region (Tumbes), we drop households using this type of provision and simply focus on households served by either communal or public water systems. More precisely, our treatment variable is constructed as a dummy variable that takes the value of 1 if the water used by the household is provided by a communal organization and 0 if it is provided by a public system.

The survey also includes a rich set of characteristics of the households, mothers and children. Among others, it provides health indicators for children, including the incidence of diarrhea and other diseases, weight, height, vaccination programs, etc. and basic information regarding the mothers such as the age, educational level, ethnicity and number of children. There is information on household income and household assets, including the type of floor in the house, whether the household has electricity, any vehicles, fridge, TV and other appliances.

[11] Some JASS in Peru form part of national and international associations that coordinate their actions and provide training. See for example the national association called *Red Agua Segura* (www.gestoresdeaguasegura.org).

Several questions refer to other relevant aspects of the water service such as the source of water being consumed in the household or the monthly payments made to the water operator. We complete the information provided by ENDES with data from the National Register of Municipalities (RENAMU), from which we obtain additional controls at the municipality level such as population and municipality resources.

For the purpose of our study, the relevant unit of analysis is a child under the age of five that lives in one of the interviewed households. After data cleaning we are left with a pooled cross-section of about 18,000 observations over the period 2006-2010. This sample size is somewhat reduced in the empirical analysis as the regressions are carried out on the sample for which information is available on all variables. The top panel of Table 3 provides descriptive statistics of the variables used in our study for the full sample of children, while the bottom panel shows the variable means for children living in households served by communal water organizations (our treatment group) and for those served by public provision (the control group). As observed, the treatment and control groups differ importantly along several dimensions. First, there are more indigenous mothers in the treatment group and they tend to have lower educational levels. Second, the households served by communal water provision are also poorer, have less assets and tend to be in municipalities with fewer resources as proxied by the per capita municipality personnel. Clearly these statistics already question the exogeneity of the treatment. As they have worse socioeconomic characteristics, we can also expect households being served by communal water systems to have poorer health outcomes, and indeed the raw data confirms that. The incidence of diarrhea and acute malnutrition (our two health indicators of interest) is higher among children living in households served by communal organizations than those that get access to water through public systems. Consequently, in addition to controlling for as many characteristics as possible, we will follow an identification strategy that accounts for the endogeneity of the type of water provision.

5 Empirical Strategy and Results

Our goal is to identify the differential impact on child health of communal versus public water provision. More precisely, we want to know if children under five living in a household served by communal water providers (a JASS, *Comites Vecinales* and other user associations) are better protected against water-related diseases than children in households served by public providers (EPS and local governments). To answer this question we estimate the following model:

$$H_{ihrt} = \alpha.Communal_{hrt} + X_{ihrt}.\beta + \delta_r + \eta_t + \epsilon_{ihrt}, \quad (1)$$

where i indexes the child, h the household, r the region, and t the year. H_{ihrt} is an indicator of child health susceptible to water conditions; $Communal_{hrt}$ is our treatment variable which is binary and takes value 1 if the water used by the household is provided by a communal organization and 0 if it is provided by a public system; X_{ihrt} is a vector of child's characteristics including age, gender and whether the child is breast-feeding or not, mother's characteristics such as her age, education and ethnicity, and household's characteristics, including an income index, the number of persons living in the household and household assets (see Table 3 for a complete list of assets). The set of controls also contains the altitude where the home is located. This is an important variable since water tends to be purer at higher altitudes, especially in the case of surface water coming from streams, rivers or lakes. Likewise, we include controls at the municipality level such as the population and the per capita public personnel which is a proxy for the economic resources of the municipality. 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 disturbance term.

We consider two health indicators that are commonly used in studies of water-related diseases: a dummy variable for whether the child experienced diarrhea in the two-week period prior to the interview, and another dummy for whether the child suffers from acute malnutrition. Information for diarrhea is obtained directly from a question in the survey, while the variable for acute malnutrition is created according to the weight-for-height z-score. A child is considered to suffer acute malnutrition if his/her weight is less than one standard deviation from the median weight for his/her height.[12] Unlike other anthropometrics that reflect the long-term nutritional status of the child, such as the weight-for-age or the height-for-age, acute malnutrition is directly linked to water quality because it is often the consequence of repeated diarrhea episodes. Thus, this variable is especially useful for assessing the impact of communal organizations as children affected by poor water quality might suffer from acute malnutrition even though in the two-week period prior to the interview they did not experience diarrhea.

[12] We use the World Health Organization (WHO) tables for median weights and standard deviations for any given height, for boys and girls under five. Available at www.ops.org.bo/textocompleto/naiepi_patrones_crecimiento.pdf.

5.1 Identification Strategy

We start by estimating a linear model by OLS and a probit model by maximum likelihood on the probability of the child having experienced diarrhea recently, as laid out in equation (1). We then use the same methods to estimate the probability of the child suffering acute malnutrition. Estimation results are reported in Tables 4 and 5 respectively. As observed in Table 4, across all the models we obtain a negative, although statistically insignificant, coefficient on communal water provision. Hence, based on these estimates we would conclude that communal water provision does not have a differential impact on child health compared to public provision. In the case of acute malnutrition, communal provision has a negative and significant effect in the models with time and region fixed effects –see Table 5 columns III and IV. Communal provision is shown to reduce acute malnutrition by 1 percentage point according to the linear model and by about 0.9 percentage points according to the probit model. Nonetheless, the estimates of both the diarrhea and acute malnutrition models might suffer from a potential endogeneity problem. The type of water provision is not randomly assigned across households but, as Table 3 made it evident, communal provision is more prevalent among households with worse socioeconomic characteristics and in poorer municipalities. In this case we would expect households supplied by a communal system to also exhibit poorer health outcomes and thus the estimated coefficients on communal provision reported in Tables 4 and 5 are likely to be biased upwards, and even biased towards zero.

One way to address this potential endogeneity problem is to use an instrumental variable strategy. To do this, we need some variable (instrument) that is correlated with the probability of having a communal water system (the treatment) but has no effect on the outcome of interest other than indirectly through its impact on the treatment. This is the so-called exclusion restriction condition.

The existence of communal water systems is related to a number of factors. However, finding good instruments is not easy as many of those variables might not be orthogonal to the error term in (1). For instance, as explained above, the JASS and other communal water organizations in Peru are greatly influenced by the *Minka* tradition of the Inca civilization. As descendants of the Incas, the ethnic group of Quechuas has maintained this tradition of communal work and indeed basic regressions (not reported here) show that communal water provision is positively, and statistically significantly, associated to the share of Quechuas in the municipality.[13] However, the concentration of Quechuas is also likely to be correlated to cul-

[13] Calzada, Iranzo and Sanz (2014) show that communal water organizations are not only correlated to the current concentration of Quechuas across municipalities but also to the historical settlments of Incas in

tural aspects and habits (such as hygienic habits) that might affect health outcomes. Thus we do not pursue sociocultural determinants of communal organizations as instruments. Instead, we exploit the legislative changes introduced in the early 2000s that established a markedly different water provision across the sub-units (population units) within the municipality. According to the legislation passed in 2003 and 2005, population units classified as rural are to be served by JASS and have a soft regulation whereas urban units are to be served by EPS or local governments and are regulated by the national regulator SUNASS.[14] Therefore we use as instrument for communal water provision the administrative classification of population units into rural or urban, as defined by the Peruvian Statistical Institute (INEI). In particular, the instrument is a binary variable that takes value 1 if the population unit where the household lies is classified as rural and value 0 if it is classified as urban. As this classification is defined at the level of the population unit, it is better suited to track the variability in water provision across households than most variables defined at the municipality level. In terms of explanatory power, it is highly correlated with the treatment variable. The administrative rural/urban classification of population units alone can explain up to 26% of the variability in the type of water provision across households. Thus, a priory this variable seems a relevant instrument and as the instrumental variable first-stage regressions will show, even after controlling for all other exogenous covariates the instrument holds considerable explanatory power. In the next subsection we provide some evidence that this variable also meets the exclusion restriction condition and thus constitutes a valid instrument.

5.1.1 Validity of the instrument: the exclusion restriction condition

There is a number of reasons why we believe the rural/urban classification of the sub-units in which Peruvian municipalities are divided constitute a good instrument for the existence of communal water systems. First, it is mainly an administrative classification that does not respond to standard conventions defining cities and villages. Irrespective of whether a population unit belongs to a large municipality (city) or to a small one (town or village), according to the INEI a population unit is classified as rural if it has fewer than 100 grouped houses (that is, less than 500 inhabitants on average) and does not serve as the capital of the municipality. Consequently, we can find rural population units in large municipalities and conversely, we can also find urban population units in relatively small municipalities. Just to

pre-Columbian Peru.

[14] Although public systems are more common in urban units and communal provision is more prevalent in rural units, both public and communal systems can still be found in rural and urban population units.

give a few examples, according to the 2007 Census, the municipality of Carabayllo,[15] in the province of Lima, hosted over 200,000 inhabitants and about 3% of them lived in population units classified as rural. In Cajamarca (in the province of Cajamarca) 20% of its 188,000 inhabitants lived in rural population units, whereas in the municipality of Tambo Grande (in the province of Piura) as many as 64% of its 96,000 inhabitants lived in rural population units. As an example of the opposite case, in the Amazonas region one can find a number of small municipalities with a significant percentage of their inhabitants living in population units classified as urban. Furthermore, there are no municipalities with only rural population units and just a few with only urban population units.[16] For instance, in 2007 just 70 out of a total of 1833 Peruvian municipalities had all their inhabitants living in population units classified as urban.

Second, to the extend that the assignment of water provision systems across population units is dictated by law, it should be exogenous to the water-related health indicators of interest. In this sense it would only be endogenous if the legislation itself responded to the average health outcomes of the two types of sub-units or if the classification of population units into rural and urban could be altered as to change the type of water provision of households. Both sources of endogeneity are unlikely. On the one hand, the legislative changes introduced in the early 2000s were partly motivated by the difficulties to set up public water systems in small and disperse communities as the low population density compromises the extend to which economies of scale in the water service can be exploited. However, while the notions of population mass and geographical dispersion of households clearly affect the economic viability of public water systems, they are not necessarily linked to health outcomes. On the other hand, the classification of population units as rural or urban is done at the level of the central government and thus it is unlikely to respond to the health status of households within each municipality.

Notwithstanding the previous arguments, the validity of the instrument depends ultimately on whether the administrative rural/urban classification of population units is correlated to income and other factors that might also affect health outcomes. For example, the instrument would not be exogenous if the indigenous population was concentrated in rural population units and these ethnic groups also had distinct habits that could affect the incidence of diarrhea and acute malnutrition. Likewise, the instrument would not be valid if families moved from rural to

[15] This muncipality is also part of the so-called Metropolitan Lima Municipal Council.

[16] As the population unit that serves as the capital of the municipality is classified are urban, there is always at least one urban population unit in each municipality,

urban population units (or viceversa) in order to choose their water provider. We address these problems in a number of ways. First, we include controls for the household income level and for the mother's ethnicity and we eliminate the observations of households that changed place of residence at some point after a year prior to the birth of the child.[17] Moreover, in order to obtain cleaner estimates we also estimate the model for the restricted sample of non-indigenous households with income above the "very poor" level.

Second, we perform explicit checks to ensure that our instrument meets the exclusion restriction condition. In order to understand the problem at hand, let us re-write the model in (1) as follows:

$$H_{ihrt} = \alpha.Communal_{hrt} + \lambda.Z_{hrt} + X_{ihrt}.\beta + \delta_r + \eta_t + \epsilon_{ihrt} \tag{2}$$

$$Communal_{hrt} = \pi_1.Z_{hrt} + X_{ihrt}.\pi_2 + \upsilon_{hrt} \tag{3}$$

Equation (2) is essentially the same as in (1) with the only difference that it includes the instrument Z_{ht} (in our case, the administrative rural/urban classification of the population unit to which household h belongs) and equation (3) is the auxiliary regression for the endogenous treatment variable, communal water provision. If the exclusion restriction condition is met then $\lambda = 0$ and the instrumental variable estimator is consistent. However, in order to analyze the implications of the exclusion restriction condition, at this point we allow for $\lambda \neq 0$. The reduced-form equation associated to the model above is:

$$H_{ihrt} = \phi.Z_{ht} + X_{iht}.\varphi + \delta_r + \eta_t + \mu_{ihrt} \tag{4}$$

where $\phi = \alpha\pi_1 + \lambda$, $\varphi = \alpha\pi_2 + \beta$, and $\mu_{ihrt} = \alpha\upsilon_{hrt} + \epsilon_{ihrt}$. Notice that parameter ϕ captures the total effect of the instrument on the health outcome of interest. It includes the indirect effect through the endogenous treatment variable but also the direct effect given by λ. If the instrument Z_{ht} satisfies the exclusion restriction ($\lambda = 0$) the parameter in the reduced-form equation reduces then to $\alpha\pi_1$, which will be significantly different from zero if the instrument is relevant. By contrast, if the exclusion restriction condition does not hold, the parameter on the reduced-form regression includes both the indirect and direct effect of the instrument on the health outcome and it is not possible to disentangle one from the other. In this case the instrument is not "valid".

We use two approaches to assess if the instrument has a direct impact on the dependent variable (i.e. whether $\lambda \neq 0$). First, we offer indirect evidence based on the following falsification tests. If the administrative rural/urban classification of population units has a direct

[17] We eliminate those observations because we do not know where they were previously living.

impact on the health conditions of interest, then we would also expect it to have an impact on other health outcomes. Thus, we estimate reduced-form regressions as in (4) where different health outcomes are regressed on the instrument and the full set of exogenous covariates. In addition to our two health indicators of interest, diarrhea and acute malnutrition, we consider the following non-water related health problems: whether the child had cough recently, whether she had fever recently and whether she suffers from chronic malnutrition.[18] Cough (and, more generally, respiratory problems) and fever are not necessarily related to the conditions of drinkable water. Respiratory problems in developing countries are often associated with the use of biomass for cooking and heating while fever can be related to a variety of diseases and infections generated by sources other than water. Unlike acute malnutrition, chronic malnutrition can not be directly linked to water conditions, but rather other factors like the long-term nutritional status of the child are more important causes. If the coefficient on the administrative rural/urban classification in any of these reduced-form regressions is significantly different from zero, this implies that the instrument has an impact (direct or indirect, or both) on that particular health outcome. By contrast, if the coefficient is not significantly different from zero, this would mean that both the direct and indirect effects are zero or, in the very unlikely case, that the direct and indirect effects are of the same magnitude but opposite signs.

Table 6 shows the reduced-form regressions for diarrhea (column I), acute malnutrition (column II), cough (column III), fever (column IV) and chronic malnutrition (column V). As observed, while we obtain positive and significant coefficients on the instrument for diarrhea and acute malnutrition, the coefficients in the regressions for the other health outcomes are clearly not statistically different from zero. This implies that the administrative rural/urban classification of population units has no direct impact on the probability of the child experiencing fever, cough and chronic malnutrition.[19] Therefore there is no reason to expect it should have a direct impact on water-related health problems either. In other words, the positive coefficient on the instrument found in the reduced-form regressions for diarrhea and acute malnutrition must then be entirely attributed to the indirect effect through the type of water provision.

Our second strategy to verify that the instrument satisfies the exclusion restriction condi-

[18] A child is said to suffer chronic malnutrition if his/her height is less than one standard deviation below the median height for his/her age.

[19] As said above, if the reduced-form coefficient on the instrument is zero, in principle, it could also be the case that the direct and indirect effects are different from zero but of opposite signs. However, the placebo tests reported in Table 13 rule this possibility out as they evidence that the instrument has no indirect effect on the non-water related health outcomes considered here.

tion consists of performing the formal test proposed by Huber and Mellace (2014) for valid instruments in just identified heterogeneous treatment effect models with endogeneity. Huber and Mellace (2014) establishes necessary, albeit not sufficient, conditions for both the exclusion restriction and the monotonicity assumptions assumed in local average treatment effect (LATE) models. In the case of a binary instrument, the intuition of the test goes as follows. If the instrument is valid, then the mean potential outcome under treatment of the always takers (those always treated irrespective of the instrument) is point identified; it just corresponds to the observed mean outcome of the treated subpopulation that does not receive the instrument. Moreover, they derive upper and lower bounds based on the treated subpopulation receiving the instrument within which the point identified mean outcome of the always takers must lie. If those constraints are violated, either the instrument has a direct effect on the mean potential outcome of the always takers, or the treatment is not monotonic in the instrument, or both. A similar result applies to the never takers (those that never take the treatment irrespective of the instrument). The mean potential outcome of the never takers under non-treatment is point identified and is equal to the observed mean outcome of the non-treated subpopulation in the presence of the instrument. For the instrument to be valid, the mean potential outcome must lie within the lower and upper bounds that can be obtained from the non-treated subpopulation that does not receive the instrument. Hence, Huber and Mellace (2014) test for instrument validity comes down to jointly testing 4 inequality constraints. It is important to note that the power of the test depends importantly on the share of compliers –those that take the treatment when they receive the instrument and do not take the treatment in the absence of the instrument. The test is more powerful the lower the share of compliers is because the bounds for the inequalities become then tighter. In fact, testing power is maximized when equality of mean potential outcomes is assumed because then the bounds collapse to a point and the inequality constraints turn into equality constraints. Therefore a stronger version of the test consists of 2 simple equality of means tests: 1) that the mean outcome of the treated subpopulation receiving the instrument is equal to the mean outcome of the treated subpopulation not receiving the instrument and 2) that the mean potential outcome of the non-treated subpopulation in the absence of the instrument is equal to the mean outcome of the non-treated receiving the instrument. Failure to reject the null hypothesis of equal means indicates valid instrument and homogeneity of the mean potential outcomes of always takers and compliers under treatment, and of never takers and compliers under non-treatment.

Table 7 shows the results of Huber and Mellace (2014) test based on the moment inequality constraints for our two outcomes of interest: diarrhea (top panel) and acute malnutrition (bottom panel). The first row in each panel presents the results for the full sample of children without conditioning on any covariates, while in the following rows we condition for covariates that are potentially correlated with both the instrument and the outcomes of interest. In particular, rows 2 to 9 show the results of the instrument validity test for 8 subsamples consisting of non-indigenous households with the different combinations of below and above the "poor" level of income, below and above primary education level of the mother and below and above the mean altitude of households. The first column in each panel reports the estimated share of compliers which is in all cases very high –above 50% for the full sample and above 22% in any subsample. Columns II through V report the p-values for the test of instrument validity, according to the different methods used to jointly test the inequalities.[20] Based on the p-values (well above 0.10), we clearly fail to reject the null hypothesis of instrument validity for the full sample and for all the subsamples, for both diarrhea (top panel of Table 7) and acute malnutrition (bottom panel). Given the high share of compliers, and thus relatively low power of the test, it is not surprising that the test fails to detect violations of instrument validity.

Hence, next we perform the stricter test of equality of mean outcomes under treatment and non-treatment. Table 8 reports the results. Columns I and II show respectively the mean health outcomes for the treated subpopulation (children in households served by communal water provision) in the presence of the instrument (living in population units classified as rural) and in the absence of the instrument (living in urban population units); column III reports the difference of those means, while column IV shows the p-value of the test of equality of means. Columns V through VIII on Table 8 show the same information for the non-treated subpopulation of children. In the case of diarrhea (top panel) the t-test yields a very low p-value for the treated subpopulation in the full sample, leading us to reject the hypothesis that the mean incidence of diarrhea is the same for children served by communal water provision living in population units classified as rural and those living in urban population units. By contrast, the equality of means across rural and urban population units is accepted for the non-treated subpopulation (children served by public systems). The equality of means test is also generally passed at conventional significance levels for the treated and non-treated subpopulations when we restrict attention to non-indigenous mothers and condition on the covariates of household income, mother's education and altitude –see rows 2 through 9 on the top panel of Table 8. The same can be said in the case of acute malnutrition. Although

[20] Refer to Huber and Mellace (2014) for an explanation of the different methods used: boostrap test with Bonferroni adjustment, the minium p-value of Bennet (200) with partial and full recentering and the smoothed inidcator-based method of Chen and Szroeter (2012).

the equality of means is not accepted in the full sample for the treated subpopulation, it is accepted at reasonable significance levels in all the subsamples for the treated children and in all cases for the non-treated subpopulation. Thus, all in all, the results of Huber and Mellace (2014) test suggests that even though the instrument might not unconditionally exogenous (as it is potentially correlated with other factors that might also affect diarrhea and acute malnutrition) instrument validity conditional on covariates can not be refuted.

5.1.2 Instrumental Variable Estimation Results

Conventional instrumental variable techniques can be applied when the outcome variable and the endogenous regressor are continuos variables. However, in our model both the health indicators and the treatment are dichotomous variables. In this case, the literature does not offer a clear and unique strategy to deal with the endogeneity issue. One possibility suggested by Angrist (2001) is to apply two-stage least squares (2SLS) to linear probability models of dichotomous variables.[21] We take this approach and perform instrumental variable estimation by two-stage least squares on two samples: 1) the full sample of children under five that have not changed place of residence for at least a year prior to the birth of the child and 2) the subsample of children from non-indigenous mothers and households with income level above "very low" that have not changed place of residence for at least a year prior to the birth of the child.

Table 9 presents the results for diarrhea for the full sample (columns I and II) and for the subsample of children (columns III and IV). Columns I and III show the first-stage regression results. As observed, conditional on all the other exogenous covariates, living in a population unit classified as rural is positively correlated with the household being served by a communal water organization, and the coefficient is highly significant. This is consistent with the legislative changes introduced in the early 2000s that established that in rural population units the water service had to be provided by a JASS. The overall R-squared of the first-stage regressions is 0.411 and 0.304 for the full sample and for the subsample respectively. More importantly, after partialling out the effect of all other exogenous covariates, the instrument still accounts for considerable variation in the type of water provision across households. The partial R-squared is 0.058 for the full sample and 0.050 for the subsample, and the F-statistic of significance of

[21] Angrist and Pischke (2009) also argue in favor of OLS in the first and second stages as OLS always gives a minimum mean square error (MMSE) linear approximation to the conditional expectation function without compromising to any particular functional form and distributional assumptions, which usually one can not be sure about.

the excluded instruments is 115.45 and 92.03 respectively, well above the recommended values to rule out the problem of weak instruments. Therefore we can confidently conclude that the administrative rural/urban classification of population units is a relevant instrument.

Columns II and IV on Table 9 show the instrumental variable estimates of the effect of communal water provision on diarrhea for the full sample and for the subsample respectively. The estimated coefficient for the full sample of children (our baseline estimation) is statistically significant and considerably larger in magnitude (that is, more negative) than that obtained in the OLS regressions (-0.0783 versus -0.0026). The Haussman test for endogeneity, based on the comparison of the OLS and instrumental variable estimators, was also performed and the null hypothesis of exogeneity of the communal provision variable was clearly rejected. This confirms the need to instrument for communal water provision. The point estimate for the subsample, also negative and significant, is fairly similar in magnitude to that obtained for the entire sample. In fact, they are not statistically different from each other. Thus, the instrumental variable estimations show that the null impact of communal provision on diarrhea obtained in the OLS (and probit) estimations of Table 4 was due to an upward bias in the estimated coefficients. More broadly, these results also suggest that, with respect to public provision, the communal provision of water reduces the incidence of diarrhea in children by about 8 percentage points . Given that the average incidence of diarrhea among children in Peru for the period considered is 15%, this effect is quite important.

The instrumental variable regression results for acute malnutrition are reported in Table 10.[22] The point estimates for the full sample of children and for the subsample are similar (-0.0303 and -0.0394) and they are about three times larger in magnitude than the OLS coefficients reported in Table 5. However, due to the large standard errors, in this case we cannot reject the hypothesis that the instrumental variable coefficients are equal to the OLS estimates. In other words, in the case of acute malnutrition we cannot unambiguously conclude that the OLS estimates underestimated the true effect of communal provision.[23]

Taken together, our results indicate that communal water provision in Peru has a positive and significant impact on child health outcomes by reducing the incidence of diarrhea and acute malnutrition, and at least in the case of diarrhea this effect is significantly larger than what OLS estimations would suggest.

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[22] In the case of acute malnutrition the sample size is somewhat reduced because the information on children's weight and height was not available for the year 2006.

[23] We draw the same conclusion from the Haussman test. In the case of acute malnutrition we can not reject the null hypothesis that the OLS and instrumental variable estimates are the same at the 1% significance level.

5.2 Robustness Checks

We check the robustness of our results in several ways. First, we re-estimate the models for children between one and five years of age, since children under one could be exclusively breast-feeding, and are consequently better protected against water-related diseases.[24] Second, despite our best efforts to control for characteristics at the municipality level, there is still expected to be considerable unobserved heterogeneity across municipalities. Estimating a model with municipality fixed effects is difficult as our data does not have many observations per municipality for the model to be identified. An alternative way to deal with at least some of the unobserved heterogeneity is to eliminate the observations from those municipalities that only have communal or public water systems. By doing that the sample size is not dramatically reduced and the model can still be easily estimated. Third, as the instrument is based on the administrative classification of population units as rural or urban, we check the robustness of our results to the elimination of observations from municipalities with only urban population units.[25]

Tables 11 and 12 show the instrumental variable results for diarrhea and acute malnutrition respectively when the above robustness checks are performed. The first thing to notice is that, with the exception of the regressions for municipalities with both types of provision (column II in Tables 11 and 12), the point estimates are not too different from the baseline instrumental variable estimates reported in column II of Tables 9 and 10.[26] For both diarrhea and acute malnutrition, the estimated coefficients are slightly larger in magnitude (i.e., more negative) when only children over 1 year old are considered (-0.0874 versus -0.0783 in the case of diarrhea, and -0.0350 versus -0.0308 for acute malnutrition). This is consistent with our earlier point that children under one are less susceptible to be affected by water conditions (as they are more likely to be exclusively breast-feeding) and so including them in the sample results in a less important effect of communal water provision. The point estimates are considerably

[24]Note that notwithstanding the "breastfeeding" control included in the regressions, the fact that a child is reported to be breastfeeding does not imply that this is her only feeding source. In 2010, the average period of breastfeeding in Peru was 21.3 months and the average period of exclusive breastfeeding was 4.2 months. Thus by focusing on children above one we ensure the sample does not include children that are exclusively breastfeeding.

[25]Recall there are no municipalities with only rural population units because there is at least always one urban population unit in each municipality classified as urban: the unit serving as capital of the muncipality.

[26]Morevoer, given the relatively large standard errors for both diarrhea and acute malnutrition, the estimated coefficient in each one of the robustness checks are never statistically different from the baseline instrumental variable estimates.

larger in magnitude when we restrict the attention to the municipalities with both provision types (see columns II of Tables 11 and 12). The estimated coefficient on communal provision is then -0.135 for diarrhea (almost twice as large in magnitude as in the baseline instrumental variable regressions) and -0.048 for acute malnutrition (as opposed to the baseline estimate of -0.031). This indicates that unobserved heterogeneity at the municipality level might be important and tends to underestimate the effect of communal water organizations. Thus, if anything, the baseline instrumental variable estimates on Tables 9 and 10 should be taken as an upper bound of the effect of communal water provision on child health. Finally, when we eliminate the observations from municipalities with only urban population units (see columns III on Tables 11 and 12), we obtain coefficients on communal provision that are fairly close to the baseline estimates (only slightly less negative). The only important difference is that in the case of acute malnutrition, due to the large standard errors, the coefficient fails to be significant. All in all, though, these robustness checks confirm the negative and significant effect of communal water provision on diarrhea and acute malnutrition.

Finally, we conduct some placebo tests to further check the robustness of our results. If communal water provision genuinely has an impact on child health, it should do so by affecting the incidence of water-related diseases such as diarrhea and acute malnutrition, but not other diseases unrelated to water conditions. Therefore, we estimate the model in (1) for the non water-related health outcomes considered earlier: i) whether the child had cough in the two weeks prior to the interview, ii) whether the child had fever in the previous two weeks and iii) whether the child suffers chronic malnutrition. As explained above, cough and fever are not related to water conditions, and chronic malnutrition can not be directly attributed to water conditions either as other factors such as the long-term nutritional status of the child are more important causes of it. Taking this into account, we expect communal water provision to have no effect on the probability of a child experiencing any of these health problems. Table 13 presents the OLS results of regressing these health outcomes on communal water provision and the same set of controls used before (see columns I, III and V) and also the instrumental variable estimations using the same instrument for communal water provision as before (columns II, IV and VI). The estimated coefficients of both the OLS and instrumental variable models clearly indicate that communal provision has no impact on the probability of the child experiencing cough or fever as they are never statistically different from zero (see columns I through IV on Table 13). Interestingly, in the case of chronic malnutrition the OLS estimated coefficient is positive and significant (see column V on Table 13) what points to a positive relation between this condition and communal water provision. However, the communal provision variable must be picking up the effect of unaccounted factors correlated to chronic malnutrition, because when we deal with the endogeneity of communal provision, the instrumental variable estimate gets smaller and, what is more important, is no longer statistically different from zero (see column VI on Table 13). Thus, we can confidently conclude that communal water provision has no effect on these non water-related health conditions and this confirms the genuine effect on diarrhea and acute malnutrition.

6 Why Does Communal Water Provision Positively Affect Child Health?

The result that communal water provision results in better child health outcomes than public provision is quite robust, and nevertheless surprising given that the JASS lack many of the financial and technical resources, including training, necessary to run the service. That said, it is also true that the JASS have the advantage that their members are users of the service and, as such, they are more aware of the problems of the service. They also have higher incentives to use treatment methods to ensure clean and safe supplies. Still, the natural questions that emerge are: why does communal water provision have a positive impact on child health? And via which channels does communal provision achieve so?

In recent privatization experiences documented in the literature the reason why health indicators improved was because private operators increase access to piped water which is presumably safer because it is generally subject to water treatments.[27] For instance, Galiani et al. (2005) explain that privatized firms in Argentina expanded their network and significantly increased the connections of low income households. Similarly, Kosec (2014) finds that private provision in Africa was associated with improved access to piped water. We try to assess whether this is also the reason why communal provision improves child health in Peru. That is, we ask the question: do the JASS and other communal organizations use cleaner and safer water sources or is it rather that they can manage the service more effectively? Simple descriptive statistics provide a partial answer to the first part of the question. Table 14 shows the different sources of drinkable water used by public and communal systems in our sample. As observed, about 95% of the children living in households served by public systems have

[27] The positive relation between piped water and health has been documented in several papers. Just to mention some, Thomas and Strauss (1992) find that the availability of piped water (as well as sewerage, and electricity) significantly affected child height in Brazil, and Jalan and Martin (2003) find a lower incidence of diarrhea among children living in piped water households in rural India.

access to piped water (whether this is inside or outside their homes) while only 76% of those served by JASS and other communal organizations have such access. Even when we control for municipality, household and individual characteristics (including income), communal water provision is negatively and significantly correlated with the coverage of piped water.[28] This should not be surprising if we take into account the lack of economies of scale in the water service in small communities and the limited resources that the JASS have to construct and maintain piped water networks.[29] Moreover, our data shows that piped water is associated to higher fees while households served by the JASS pay on average lower fees than households served by public systems. This might partly reflect the compensation that the members of the JASS receive for their volunteer work but it is also due to their lower willingness to pay and the lower financial capabilities of the JASS. Altogether, these facts confirm that in general the JASS lack the resources to expand their water networks and, thus, their better performance in terms of health outcomes cannot be attributed to larger coverage of piped water.

We turn then to the next possibility. Do communal organizations manage the service more efficiently than public systems? In order to answer this question we need to compare public and communal systems that share similar conditions in all other dimensions that could matter for our health outcomes of interest, including water sources. One crude way to do this without compromising sample size is to simply include controls for the source of water. Another way is to restrict our attention to households using the same water source. Given that the number of observations for sources other than piped water is small as to make statistically significant comparisons, we just consider households that have access to piped water, either inside or outside their homes. Finally, to further ensure comparability of public and communal systems, we focus on households in municipalities with both communal and public systems as we did previously. All these approaches are taken in Table 15 (for diarrhea) and Table 16 (for acute malnutrition). Column I in Tables 15 and 16 report the instrumental variable estimates as in Table 9 (for diarrhea) and Table 10 (for acute malnutrition) except that we now include dummies for the source of water as additional controls. Compared to the baseline instrumental variable estimates, the estimated coefficient for communal provision for diarrhea is somehow smaller in magnitude (-0.0597 versus -0.0783), which would indicate that part of the positive health impact of communal systems might be due to better water sources, whereas the point

[28] Regression results not reported here but available upon request.

[29] In this sense, Keener, Luengo and Banerjee (2010) explain that a frequent problem of community-based management is that communities try to minimize expenses by limiting the extension of the system. By contrast, in the public system the expansion of the water infrastructure has been used to win votes by many Peruvian local governments.

estimate for acute malnutrition is almost of the same magnitude than that reported in Table 10 (-0.0322 versus -0.0308). When we restrict the attention to households served only by piped water, the magnitude of the point estimates falls even further. In the case of diarrhea it is now -0.0471 and statistically significant (see Table 15 column II) while for acute malnutrition it is -0.0180 (see Table 16 column II) and this fails to be statistically significant. If we then restrict the sample further to municipalities with both communal and public systems, the coefficient in the case of diarrhea is -0.0969 and significant (see Table 15 column III) and lies in between the baseline instrumental variable estimate and the estimate reported in Table 11 column III when only municipalities with both systems were considered. In the case of acute malnutrition the instrumental variable coefficient is close to the baseline instrumental variable estimate although it is quite imprecise and fails to be significant. Hence, these results indicate that part of the beneficial effects on health of communal provision could be due to better water sources (not to higher access to piped water but perhaps purer water), but most of the effect seems to be due to better management.

Finally, we explore some of the possible channels through which communal systems might improve child health. In particular, in Table 17 we examine the relation between communal water provision and some indicators of service quality such as continuous water availability, water storage and time to collect water. Column I in Table 17 shows that households served by the JASS have on average more uninterrupted access to water than those served by public systems. Having a continuous supply of water is not only more convenient to users, but it also encourages a higher use of water and reduces storage, which is a potential risk for health because the pathogens of some diseases originate in stored water.[30] Consistent with this, column II indicates that people served by communal organizations tend to store water less, although the coefficient is not significant. Finally, Column III shows that users of communal organizations spend more time (travel longer distances) to collect water, which can easily be explained by the fact that communal water provision is associated with lower rates of access to piped water. Although these are only indirect indicators of quality, the regressions in Table 17 suggest that communal water provision in Peru seem to improve child health thanks to a better quality service. In this sense, the superior knowledge of user needs and the greater involvement of workers in communal organizations appear to make up for the lack of financial and technical resources in the provision of water.

[30]Storing water is also potentially problematic because often many of the containers used to store water, especially small ones, are not disinfected. The impact that water storage can have on child health is analyzed, for instance, in Checkley et al. (2004).

7 Conclusions

The literature on public services has devoted considerable effort to analyze the effects of private and mixed public-private systems, but it has largely neglected communal forms of provision such as user associations. Yet, communal provision plays a very important role in many developing countries, including the remote areas of the Andes region where local governments are too poor to set up and maintain water systems. In these instances when public and private organizations fail to offer the service, community members can still organize themselves and provide a service that meets minimum quality levels, as long as they have the right training. In this paper we have analyzed the effects that communal water provision systems such as the *Juntas Administrativas de Servicios de Saneamiento* (JASS) and other user associations have on child health in Peru. To the best of our knowledge this is the first attempt to examine the impact of this type of provision.

Using detailed survey data at the household- and child-level for the years 2006-2010, we exploit cross-sectional variation to identify the differential impact of communal versus public water provision. As communal organizations are more prevalent in small and remote areas with worse socioeconomic characteristics they are also more likely to have poorer health outcomes, and hence OLS estimates are expected to be biased. In order to correctly identify the effect of communal provision on child health, we adopt an instrumental variable approach. Exploiting the legislative changes introduced in the early 2000s that established a markedly different water provision for areas within municipalities, we use the administrative rural/urban classification of the sub-units in which Peruvian municipalities are divided as instrument for the likelihood of a household to be served by communal water provision. We provide compelling indirect evidence that this instrument meets the exclusion restriction condition and we also test explicitly for instrument validity using a recently developed test for heterogenous treatment models with endogeneity. Our findings show that communal provision is more effective than public provision in preventing water-related diseases such as diarrhea and acute malnutrition in children under five and this result is robust to a number of checks and placebo tests. At first sight this finding may appear surprising since the JASS lack the financial and technical resources to operate the service. In fact, our results also show that communal organizations are less likely than public systems to expand piped networks. However, decentralized management and the greater level of involvement of communal workers may account for the positive impact of the JASS on health outcomes. Insofar as the members of the JASS are also users of the service, they possess a better understanding of the community's needs and have higher incentives to provide clean and safe water. Indeed, we find that communal water provision is positively correlated to some indirect measures of service quality, which seems to be the channel through which this type of provision improves health outcomes.

Our results have important policy implications. They suggest that communal organizations can be a practical and cost-effective means to provide the water service in many areas of developing countries where the establishment of public (and private) systems is difficult. This does not mean that the governments can shirk responsibility on the provision of the service. On the contrary, public authorities can contribute to the effectiveness of communal organizations by providing a sensible regulatory framework and, more importantly, by lending the necessary support and training to community members in order to ensure the viability and quality of the service.

8 Acknowledgements

We thank Taryn Dinkelman, Mario Fiorini, Martin Huber, Fernando Laca, Jessica Oliva and Katrien Stevens for useful comments and suggestions. We also thank seminar participants at La Trobe University, Macquire University, Monash University, Pontificia Universidad Católica de Perú, University of Barcelona, University of Sydney and EARIE. This research has received financial support from the Spanish Ministry of Economics and Competitiveness (ECO2012-33392) and the Catalan Government (SGR2009-1066).

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Tables

Table 1. Water Provision in Peru, 2004

	Population (millions)	Clean Water		Sewage	
		Population served (millions)	(%)	Population served (millions)	(%)
Urban units:					
EPS (226 units)					
- SEDEPAL	8.0	7.1	89	6.7	84
- Large EPS (9 operators)	5.4	4.5	82	3.7	48
- Average EPS (20 operators)	3.0	2.4	79	1.8	61
- Small EPS (16 operators)	0.7	0.4	71	0.3	51
Local governments and JASS (490 units)	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 2. Types of water provision (% of sampled households)

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

Table 3. Descriptive Statistics

Variable	Mean	St. Deviation	Min	Max
Dummy -- child had diarrhea recently	0.15	0.36	0	1
Dummy -- child suffers acute malnutrition	0.05	0.21	0	1
Dummy -- child is a girl	0.50	0.50	0	1
Child's age (years)	2.51	1.47	0	5
Dummy -- child is breastfeeding	0.35	0.47	0	1
Weight at birth (kg.)	3.24	0.55	0.66	6
Mother's age	29.66	6.98	15	49
Dummy -- mother has no education	0.03	0.17	0	1
Dummy -- mother has primary education	0.28	0.45	0	1
Dummy -- mother has secondary education	0.44	0.49	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	0.28	0.45	0	1
Dummy --high income	0.20	0.40	0	1
Dummy --very high income	0.13	0.33	0	1
Dummy -- indigenous	0.10	0.30	0	1
Household members	5.56	2.01	1	11
Dummy --HH has natural floor	0.48	0.50	0	1
Dummy --HH has fridge	0.33	0.47	0	1
Dummy --HH has radio	0.85	0.36	0	1
Dummy --HH has TV	0.81	0.39	0	1
Dummy --HH has electricity	0.87	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 telephone	0.20	0.40	0	1
Altitude	1,346	1,423	0	4,660
Population	82,208	128,486	518	898,443
Per capital local personnel	0.003	0.002	0	0.083

Variable	Public Provision Mean	Communal Provision Mean
Dummy -- child had diarrhea recently	0.14	0.15
Dummy -- child suffers acute malnutrition	0.04	0.05
Dummy -- child is a girl	0.49	0.50
Child's age (years)	2.49	2.52
Dummy -- child is breastfeeding	0.34	0.35
Weight at birth (kg.)	3.29	3.19
Mother's age	29.99	29.29
Dummy -- mother has no education	0.01	0.05
Dummy -- mother has primary education	0.16	0.42
Dummy -- mother has secondary education	0.45	0.41
Dummy -- mother has higher education	0.37	0.12
Dummy --very low income	0.02	0.24
Dummy --low income	0.14	0.41
Dummy --middle income	0.31	0.25
Dummy --high income	0.31	0.07
Dummy --very high income	0.21	0.03
Dummy -- indigenous	0.02	0.19
Household members	5.68	5.44
Dummy --HH has natural floor	0.29	0.68
Dummy --HH has fridge	0.48	0.16
Dummy --HH has radio	0.89	0.81
Dummy --HH has TV	0.94	0.66
Dummy --HH has electricity	0.97	0.76
Dummy --HH has a bike	0.25	0.20
Dummy --HH has a vehicle	0.12	0.04
Dummy --HH has telephone	0.32	0.07
Altitude	1,050	1,680
Population	107,642	53,411
Per capital local personnel	0.003	0.002

Table 4. OLS and ML estimation results. Dependent variable: Child experienced diarrea recently

	OLS (I)	OLS (II)	OLS (III)	Probit (IV)
Communal provision	**-0.0098**	**-0.0102**	**-0.0026**	**-0.0020**
	(0.0074)	**(0.0074)**	**(0.0073)**	**(0.0069)**
Child's age	-0.0265***	-0.0269***	-0.0266***	-0.0283***
	(0.0030)	(0.0030)	(0.0029)	(0.0028)
Child's gender	-0.0124**	-0.0125**	-0.0121**	-0.0122**
	(0.0052)	(0.0052)	(0.0052)	(0.0051)
Dummy -- child is breastfeeding	0.0072	0.0062	0.0086	0.0044
	(0.0095)	(0.0094)	(0.0090)	(0.0083)
Mother's age	-0.0018***	-0.0017***	-0.0017***	-0.0016***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Dummy -- mother has primary education	0.0243	0.0242	0.0224	0.0278
	(0.0153)	(0.0154)	(0.0150)	(0.0185)
Dummy -- mother has secondary education	0.0126	0.0130	0.0082	0.0118
	(0.0154)	(0.0154)	(0.0153)	(0.0177)
Dummy -- mother has higher education	0.0014	0.0019	-0.0056	-0.0024
	(0.0159)	(0.0160)	(0.0159)	(0.0181)
Dummy -- indigenous	-0.0194*	-0.0194*	-0.0103	-0.0106
	(0.0107)	(0.0107)	(0.0116)	(0.0113)
Dummy --low income	0.0142	0.0131	0.0120	0.0122
	(0.0108)	(0.0110)	(0.0110)	(0.0112)
Dummy --middle income	0.0114	0.0091	0.0144	0.0161
	(0.0149)	(0.0145)	(0.0145)	(0.0145)
Dummy --high income	-0.0322*	-0.0351**	-0.0167	-0.0142
	(0.0170)	(0.0170)	(0.0169)	(0.0161)
Dummy --very high income	-0.0580***	-0.0611***	-0.0296	-0.0317*
	(0.0201)	(0.0202)	(0.0206)	(0.0190)
Household members	-0.0006	-0.0006	-0.0021	-0.0024*
	(0.0016)	(0.0016)	(0.0014)	(0.0014)
Dummy --HH has natural floor	0.0136*	0.0126	0.0124	0.0112
	(0.0079)	(0.0080)	(0.0081)	(0.0074)
Dummy --HH has fridge	0.0159**	0.0159**	0.0152**	0.0154**
	(0.0075)	(0.0075)	(0.0075)	(0.0075)
Dummy --HH has radio	-0.0363***	-0.0357***	-0.0353***	-0.0326***
	(0.0086)	(0.0086)	(0.0085)	(0.0081)
Dummy --HH has TV	0.0072	0.0072	0.0105	0.0103
	(0.0089)	(0.0090)	(0.0088)	(0.0082)
Dummy --HH has electricity	0.0000	0.0001	0.0036	0.0031
	(0.0115)	(0.0113)	(0.0111)	(0.0107)
Dummy --HH has a bike	0.0016	0.0017	0.0071	0.0068
	(0.0065)	(0.0064)	(0.0070)	(0.0070)
Dummy --HH has a vehicle	0.0016	0.0017	0.0018	0.0016
	(0.0095)	(0.0095)	(0.0095)	(0.0105)
Dummy --HH has telephone	0.0090	0.0095	0.0025	0.0032
	(0.0087)	(0.0087)	(0.0096)	(0.0099)
Altitude	-0.0066**	-0.0066**	-0.0108***	-0.0106***
	(0.0033)	(0.0033)	(0.0041)	(0.0041)
Population	0.0000	0.0000	0.0001***	0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Per capital local personnel	-1.7883	-2.2841	-1.4979	-1.7791
	(1.3696)	(1.3969)	(1.2363)	(1.5153)
Year fixed effects	NO	YES	YES	YES
Region fixed effects	NO	NO	YES	YES
R-squared/Pseudo R-squared	0.026	0.026	0.038	0.045
Observations	17,587	17,587	17,587	17,587

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1

Table 5. OLS and ML estimation results. Dependent variable: Child suffers acute malnutrition

	OLS (I)	OLS (II)	OLS (III)	Probit (IV)
Communal provision	**-0.0087**	**-0.0088**	**-0.0111****	**-0.0091****
	(0.0054)	**(0.0054)**	**(0.0050)**	**(0.0038)**
Child's age	-0.0008	-0.0009	-0.0004	-0.0004
	(0.0016)	(0.0016)	(0.0016)	(0.0014)
Child's gender	-0.0014	-0.0016	-0.0014	-0.0002
	(0.0034)	(0.0034)	(0.0034)	(0.0029)
Dummy -- child is breastfeeding	0.0146**	0.0143**	0.0169***	0.0146***
	(0.0062)	(0.0062)	(0.0061)	(0.0056)
Weight at birth	-0.0431***	-0.0430***	-0.0419***	-0.0341***
	(0.0040)	(0.0040)	(0.0039)	(0.0024)
Mother's age	0.0003	0.0003	0.0003	0.0002
	(0.0003)	(0.0003)	(0.0003)	(0.0002)
Dummy -- mother has primary education	0.0087	0.0082	0.0052	0.0026
	(0.0126)	(0.0125)	(0.0124)	(0.0105)
Dummy -- mother has secondary education	0.0107	0.0105	0.0077	0.0060
	(0.0129)	(0.0129)	(0.0130)	(0.0109)
Dummy -- mother has higher education	0.0081	0.0083	0.0031	0.0012
	(0.0131)	(0.0131)	(0.0131)	(0.0111)
Dummy -- indigenous	0.0123	0.0119	0.0182*	0.0166*
	(0.0099)	(0.0099)	(0.0098)	(0.0096)
Dummy --low income	-0.0006	-0.0014	-0.0020	-0.0037
	(0.0084)	(0.0087)	(0.0090)	(0.0064)
Dummy --middle income	-0.0113	-0.0131	-0.0095	-0.0075
	(0.0094)	(0.0101)	(0.0106)	(0.0076)
Dummy --high income	-0.0231**	-0.0254**	-0.0149	-0.0128
	(0.0109)	(0.0121)	(0.0130)	(0.0085)
Dummy --very high income	-0.0231*	-0.0258*	-0.0079	-0.0072
	(0.0127)	(0.0138)	(0.0146)	(0.0103)
Household members	-0.0008	-0.0008	-0.0020*	-0.0015*
	(0.0010)	(0.0010)	(0.0011)	(0.0009)
Dummy --HH has natural floor	0.0004	-0.0003	-0.0028	-0.0015
	(0.0056)	(0.0057)	(0.0059)	(0.0047)
Dummy --HH has fridge	-0.0038	-0.0037	-0.0042	-0.0034
	(0.0054)	(0.0056)	(0.0054)	(0.0046)
Dummy --HH has radio	-0.0023	-0.0021	0.0013	0.0006
	(0.0052)	(0.0052)	(0.0053)	(0.0039)
Dummy --HH has TV	-0.0104	-0.0103	-0.0071	-0.0049
	(0.0071)	(0.0072)	(0.0073)	(0.0054)
Dummy --HH has electricity	0.0097	0.0102	0.0049	0.0047
	(0.0080)	(0.0080)	(0.0078)	(0.0056)
Dummy --HH has a bike	0.0119**	0.0118**	0.0134***	0.0107**
	(0.0050)	(0.0050)	(0.0049)	(0.0043)
Dummy --HH has a vehicle	-0.0008	-0.0008	0.0007	0.0015
	(0.0052)	(0.0053)	(0.0051)	(0.0055)
Dummy --HH has telephone	0.0011	0.0017	-0.0046	-0.0036
	(0.0058)	(0.0057)	(0.0054)	(0.0047)
Altitude	-0.0105***	-0.0107***	-0.0150***	-0.0137***
	(0.0017)	(0.0017)	(0.0031)	(0.0024)
Population	-0.0000***	-0.0000***	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Per capital local personnel	-0.1719	-0.6260	-0.3837	-0.3287
	(0.7697)	(0.8079)	(0.7255)	(0.7679)
Year fixed effects	NO	YES	YES	YES
Region fixed effects	NO	NO	YES	YES
R-squared/Pseudo R-squared	0.019	0.020	0.032	0.082
No observations	14,110	14,110	14,110	14,110

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1

Table 6. Check for exclusion restriction condition – Reduced-form regressions

Dependent variable:	Diarrhea (I)	Acute Malnutrition (II)	Cough (III)	Fever (IV)	Cronic Malnutrition (V)
Rural population unit	**-0.0240****	**-0.0097***	**-0.0020**	**0.0099**	**0.0041**
	(0.0099)	**(0.0059)**	**(0.0146)**	**(0.0121)**	**(0.0147)**
Child's age	-0.0257***	-0.0008	-0.0002	-0.0085***	0.0232***
	(0.0030)	(0.0018)	(0.0039)	(0.0031)	(0.0040)
Child's gender	-0.0129**	-0.0015	-0.0170**	0.0018	-0.0382***
	(0.0057)	(0.0036)	(0.0078)	(0.0070)	(0.0085)
Dummy -- child is breastfeeding	0.0076	0.0147**	0.0051	0.0195**	0.0039
	(0.0093)	(0.0068)	(0.0112)	(0.0094)	(0.0120)
Weight at birth		-0.0427***			-0.1559***
		(0.0040)			(0.0082)
Mother's age	-0.0015***	0.0004	-0.0028***	0.0002	-0.0012**
	(0.0004)	(0.0003)	(0.0006)	(0.0005)	(0.0006)
Dummy -- mother has primary education	0.0207	0.0039	0.0547**	0.0588***	-0.0198
	(0.0158)	(0.0128)	(0.0239)	(0.0215)	(0.0248)
Dummy -- mother has secondary education	0.0067	0.0072	0.0572**	0.0524**	-0.0830***
	(0.0160)	(0.0136)	(0.0236)	(0.0223)	(0.0259)
Dummy -- mother has higher education	-0.0101	0.0052	0.0562**	0.0624***	-0.1614***
	(0.0170)	(0.0137)	(0.0253)	(0.0231)	(0.0272)
Dummy -- indigenous	-0.0144	0.0192*	-0.0150	-0.0120	0.0297*
	(0.0127)	(0.0103)	(0.0179)	(0.0170)	(0.0179)
Dummy --low income	0.0103	0.0008	0.0005	-0.0036	-0.0655***
	(0.0122)	(0.0096)	(0.0189)	(0.0178)	(0.0165)
Dummy --middle income	0.0102	-0.0100	-0.0039	-0.0209	-0.1481***
	(0.0165)	(0.0116)	(0.0250)	(0.0225)	(0.0207)
Dummy --high income	-0.0234	-0.0125	-0.0280	-0.0616**	-0.2054***
	(0.0190)	(0.0142)	(0.0289)	(0.0247)	(0.0266)
Dummy --very high income	-0.0388*	-0.0081	-0.0211	-0.0811***	-0.2579***
	(0.0231)	(0.0160)	(0.0339)	(0.0286)	(0.0325)
Household members	-0.0029*	-0.0012	0.0024	-0.0012	0.0124***
	(0.0015)	(0.0011)	(0.0021)	(0.0020)	(0.0022)
Dummy --HH has natural floor	0.0153*	-0.0031	-0.0136	-0.0068	0.0159
	(0.0085)	(0.0066)	(0.0123)	(0.0103)	(0.0123)
Dummy --HH has fridge	0.0135	-0.0054	0.0163	0.0099	-0.0183
	(0.0082)	(0.0058)	(0.0123)	(0.0107)	(0.0151)
Dummy --HH has radio	-0.0280***	0.0009	-0.0300**	-0.0018	0.0011
	(0.0089)	(0.0058)	(0.0122)	(0.0108)	(0.0123)
Dummy --HH has TV	0.0112	-0.0094	-0.0068	-0.0158	0.0206
	(0.0094)	(0.0079)	(0.0138)	(0.0132)	(0.0140)
Dummy --HH has electricity	-0.0026	0.0043	-0.0023	-0.0001	0.0134
	(0.0118)	(0.0085)	(0.0170)	(0.0159)	(0.0163)
Dummy --HH has a bike	0.0074	0.0110**	-0.0033	-0.0106	0.0014
	(0.0074)	(0.0051)	(0.0098)	(0.0092)	(0.0111)
Dummy --HH has a vehicle	0.0052	-0.0010	-0.0034	-0.0043	-0.0061
	(0.0103)	(0.0053)	(0.0158)	(0.0120)	(0.0167)
Dummy --HH has telephone	0.0048	-0.0021	0.0122	0.0238**	-0.0064
	(0.0100)	(0.0057)	(0.0125)	(0.0114)	(0.0133)
Altitude	-0.0056	-0.0155***	-0.0039	0.0036	0.0578***
	(0.0045)	(0.0033)	(0.0062)	(0.0059)	(0.0058)
Population	0.0001***	-0.0000	-0.0000	0.0001*	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Per capital local personnel	-1.4588	-0.6557	1.3358	-0.9674	-0.3096
	(1.4334)	(0.7056)	(1.7747)	(1.8835)	(1.9594)
Year fixed effects	YES	YES	YES	YES	YES
Region fixed effects	YES	YES	YES	YES	YES
R-squared	0.037	0.033	0.024	0.019	0.207
Observations	15,404	12,331	15,405	15,408	12,365

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1
Observations of households that changed place of residence since a year prior to the birth of the child were eliminated.

Table 7. Huber&Mellace (2014) instrument validity test based on inequality moment constraints

Results for Diarrhea

	Share of compliers	p-values: Bonferroni adjustment	Benett(2009) - partial recentering	Benett(2009) - full recentering	Chen and Szroeter (2012)
	(I)	(II)	(III)	(IV)	(V)
Full sample	56.86%	1.0000	1.0000	1.0000	1.0000
Subsample 1	29.24%	1.0000	0.7569	1.0000	1.0000
Subsample 2	42.02%	1.0000	0.5598	1.0000	1.0000
Subsample 3	44.29%	1.0000	0.7779	1.0000	1.0000
Subsample 4	35.31%	1.0000	0.5803	1.0000	1.0000
Subsample 5	26.96%	1.0000	0.6253	1.0000	1.0000
Subsample 6	47.21%	1.0000	0.6243	1.0000	1.0000
Subsample 7	22.32%	1.0000	0.6253	1.0000	1.0000
Subsample 8	39.79%	1.0000	0.5358	1.0000	0.9950

Results for Acute Desnutrition

	Share of compliers	p-values: Bonferroni adjustment	Benett(2009) - partial recentering	Benett(2009) - full recentering	Chen and Szroeter (2012)
	(I)	(II)	(III)	(IV)	(V)
Full sample	57.51%	1.0000	1.0000	1.0000	1.0000
Subsample 1	36.32%	N/A	1.0000	1.0000	0.4370
Subsample 2	44.71%	1.0000	0.7639	1.0000	0.9999
Subsample 3	50.76%	1.0000	0.8369	1.0000	0.9996
Subsample 4	36.09%	1.0000	0.7704	1.0000	1.0000
Subsample 5	28.84%	1.0000	0.5608	1.0000	0.9995
Subsample 6	46.85%	1.0000	0.6648	0.9990	0.9993
Subsample 7	24.76%	1.0000	0.7009	0.9965	0.9789
Subsample 8	40.66%	1.0000	0.8214	1.0000	1.0000

Notes: p-value > 0.10 indicates failure to reject the null hypothesis of valid IV.

Treated population= children in households served by communal water provision;

non-treated population= children in households served by public provision.

Subsample 1= non-indigenous, income level > poor, mother edu <= primary, altitude > 1350m

Subsample 2= non-indigenous, income level > poor, mother edu > primary, altitude <= 1350m

Subsample 3=non-indigenous, income level > poor, mother edu <= primary, altitude <= 1350m

Subsample 4=non-indigenous, income level > poor, mother edu > primary, altitude > 1350m

Subsample 5=non-indigenous, income level <= poor, mother edu <= primary, altitude <= 1350m

Subsample 6=non-indigenous, income level <= poor, mother edu <= primary, altitude > 1350m

Subsample 7=non-indigenous, income level <= poor, mother edu > primary, altitude <= 1350m

Subsample 8=non-indigenous, income level <= poor, mother edu > primary, altitude > 1350m

Table 8. Huber&Mellace (2014) instrument validity test based on equality of means

Health outcome: Diarrhea	$Mean(H)_{C=1,Z=1}$ (I)	$Mean(H)_{C=1,Z=0}$ (II)	Diff (III)	p-value (IV)	$Mean(H)_{C=0,Z=0}$ (V)	$Mean(H)_{C=0,Z=1}$ (VI)	Diff (VII)	p-value (VIII)
Full sample	0.1372	0.1705	-0.0330	0.0001	0.1460	0.1448	0.0012	0.9346
Subsample 1	0.1509	0.1333	0.0176	0.7798	0.1517	0.1081	0.0436	0.4946
Subsample 2	0.1281	0.1532	-0.0252	0.3514	0.1294	0.1842	-0.0548	0.0864
Subsample 3	0.1591	0.2146	-0.0555	0.2718	0.1806	0.1000	0.0806	0.2612
Subsample 4	0.1231	0.1870	-0.0638	0.0888	0.1382	0.1197	0.0185	0.5738
Subsample 5	0.2227	0.1935	0.0292	0.3233	0.1852	0.2162	-0.0310	0.5547
Subsample 6	0.1375	0.1296	0.0079	0.8207	0.1481	0.0795	0.0686	0.1259
Subsample 7	0.2024	0.1912	0.0112	0.7108	0.2695	0.1915	0.0780	0.2549
Subsample 8	0.0998	0.1382	-0.0384	0.1827	0.2228	0.1667	0.0562	0.2806

Health outcome: Acute Malnutrition	$Mean(H)_{C=1,Z=1}$ (I)	$Mean(H)_{C=1,Z=0}$ (II)	Diff (III)	p-value (IV)	$Mean(H)_{C=0,Z=0}$ (V)	$Mean(H)_{C=0,Z=1}$ (VI)	Diff (VII)	p-value (VIII)
Full sample	0.0467	0.0559	-0.0092	0.0993	0.0417	0.0515	-0.0097	0.2953
Subsample 1	0.0000	0.0536	-0.0536	0.1214	0.0135	0,0000	0.0135	0.5615
Subsample 2	0.0391	0.0494	-0.0103	0.5511	0.0393	0.0588	-0.0195	0.3637
Subsample 3	0.0370	0.0471	-0.0101	0.7124	0.0590	0.0556	0.0034	0.9522
Subsample 4	0.0354	0.0222	0.0132	0.4457	0.0305	0.0109	0.0197	0.2795
Subsample 5	0.0646	0.0752	-0.0106	0.5872	0.0938	0.0667	0.0271	0.5125
Subsample 6	0.0394	0.0333	0.0061	0.7763	0.0093	0.0405	-0.0313	0.1591
Subsample 7	0.0670	0.0858	-0.0189	0.3877	0.0762	0.0278	0.0484	0.2860
Subsample 8	0.0413	0.0476	-0.0063	0.7565	0.0526	0.0400	0.0126	0.6784

Notes: C denotes the treatment, whether the child lives in a household served by a communal water organization (C = 1) or by a public system (C = 0).
Z denotes the instrument, ie, whether the household belongs to a population unit classified as rural (Z = 1) or urban (Z = 0).
Subsample 1= non-indigenous, income level > poor, mother edu <= primary, altitude > 1350m
Subsample 2= non-indigenous, income level > poor, mother edu > primary, altitude <= 1350m
Subsample 3=non-indigenous, income level > poor, mother edu <= primary, altitude <= 1350m
Subsample 4=non-indigenous, income level > poor, mother edu > primary, altitude > 1350m
Subsample 5=non-indigenous, income level <= poor, mother edu <= primary, altitude <= 1350m
Subsample 6=non-indigenous, income level <= poor, mother edu <= primary, altitude > 1350m
Subsample 7=non-indigenous, income level <= poor, mother edu > primary, altitude <= 1350m
Subsample 8=non-indigenous, income level <= poor, mother edu > primary, altitude > 1350m.

Table 9. Instrumental Variable Estimation Results – Diarrhea

	Full Sample		Subsample	
	First-stage Reg.	IV Regression	First-stage Reg.	IV Regression
	(I)	(II)	(III)	(IV)
Communal provision		**-0.0783****		**-0.0835****
		(0.0333)		**(0.0370)**
Rural population unit	0.3061***		0.2957***	
	(0.0285)		(0.0308)	
Child's age	-0.0060*	-0.0261***	-0.0077**	-0.0259***
	(0.0032)	(0.0031)	(0.0036)	(0.0034)
Child's gender	0.0027	-0.0127**	0.0036	-0.0080
	(0.0062)	(0.0057)	(0.0073)	(0.0064)
Dummy -- child is breastfeeding	-0.0068	0.0071	-0.0111	0.0086
	(0.0090)	(0.0093)	(0.0103)	(0.0100)
Mother's age	-0.0011**	-0.0015***	-0.0014***	-0.0016***
	(0.0005)	(0.0004)	(0.0005)	(0.0005)
Dummy -- mother has primary education	-0.0144	0.0195	0.0053	-0.0077
	(0.0196)	(0.0158)	(0.0373)	(0.0269)
Dummy -- mother has secondary education	-0.0327	0.0041	-0.0188	-0.0229
	(0.0225)	(0.0159)	(0.0389)	(0.0257)
Dummy -- mother has higher education	-0.0579**	-0.0146	-0.0455	-0.0417
	(0.0248)	(0.0170)	(0.0399)	(0.0267)
Dummy -- indigenous	0.0944***	-0.0070		
	(0.0209)	(0.0135)		
Dummy --low income	-0.0478***	0.0066	0.4180***	0.0754***
	(0.0184)	(0.0124)	(0.0337)	(0.0277)
Dummy --middle income	-0.2475***	-0.0091	0.2227***	0.0635***
	(0.0282)	(0.0196)	(0.0246)	(0.0184)
Dummy --high income	-0.4417***	-0.0580**	0.0272*	0.0166
	(0.0360)	(0.0270)	(0.0144)	(0.0115)
Dummy --very high income	-0.4696***	-0.0756**		
	(0.0412)	(0.0308)		
Household members	-0.0236***	-0.0047***	-0.0280***	-0.0049***
	(0.0026)	(0.0016)	(0.0028)	(0.0018)
Dummy --HH has natural floor	-0.0352**	0.0126	-0.0414**	0.0135
	(0.0171)	(0.0087)	(0.0174)	(0.0090)
Dummy --HH has fridge	0.0013	0.0136*	0.0060	0.0129
	(0.0126)	(0.0082)	(0.0130)	(0.0085)
Dummy --HH has radio	-0.0001	-0.0280***	-0.0042	-0.0272**
	(0.0130)	(0.0090)	(0.0163)	(0.0109)
Dummy --HH has TV	-0.0086	0.0105	-0.0149	0.0057
	(0.0152)	(0.0095)	(0.0202)	(0.0127)
Dummy --HH has electricity	-0.0661***	-0.0078	-0.1058***	-0.0162
	(0.0197)	(0.0126)	(0.0297)	(0.0177)
Dummy --HH has a bike	0.0005	0.0074	-0.0011	0.0058
	(0.0110)	(0.0075)	(0.0119)	(0.0082)
Dummy --HH has a vehicle	0.0317**	0.0077	0.0332**	0.0084
	(0.0149)	(0.0102)	(0.0153)	(0.0103)
Dummy --HH has telephone	-0.0450***	0.0013	-0.0426***	-0.0011
	(0.0122)	(0.0100)	(0.0126)	(0.0103)
Altitude	-0.0093	-0.0063	-0.0157	-0.0038
	(0.0104)	(0.0046)	(0.0119)	(0.0046)
Population	-0.0002***	0.0000**	-0.0002***	0.0000*
	(0.0001)	(0.0000)	(0.0001)	(0.0000)
Per capital local personnel	-5.8901*	-1.9199	-7.5307*	-2.3318
	(3.4237)	(1.4440)	(3.9132)	(1.4553)
Year fixed effects	YES	YES	YES	YES
Region fixed effects	YES	YES	YES	YES
Partial R-squared	0.058		0.050	
F-test of excluded instruments	115.45		92.03	
(p-value)	(0.000)		(0.000)	
R-squared	0.411	0.030	0.304	0.028
Observations	15,404	15,404	12,729	12,729

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1.
Observations of households that changed place of residence since a year prior to the birth of the child were eliminated.
The subsample consists of children in non-indigenous households with income level above "very low" and that have not changed place of residence since at least a year prior to the birth of the child.
The reference income level category for the full sample is "very low income" while for the restricted sample is "very high income".

Table 10. Instrumental Variable Estimation Results – Acute Malnutrition

	Full Sample		Subsample	
	First-stage Reg.	IV Regression	First-stage Reg.	IV Regression
	(I)	(II)	(III)	(IV)
Communal provision		**-0.0308***		**-0.0394***
		(0.0188)		**(0.0213)**
Rural population unit	0.3164***		0.3104***	
	(0.0301)		(0.0325)	
Child's age	-0.0038	-0.0009	-0.0067*	-0.0004
	(0.0036)	(0.0018)	(0.0041)	(0.0019)
Child's gender	0.0016	-0.0014	0.0013	-0.0015
	(0.0067)	(0.0036)	(0.0077)	(0.0038)
Dummy -- child is breastfeeding	-0.0000	0.0147**	-0.0066	0.0159**
	(0.0103)	(0.0069)	(0.0116)	(0.0073)
Weight at birth	-0.0106	-0.0430***	-0.0140*	-0.0450***
	(0.0069)	(0.0040)	(0.0078)	(0.0044)
Mother's age	-0.0008	0.0003	-0.0011	0.0005*
	(0.0006)	(0.0003)	(0.0007)	(0.0003)
Dummy -- mother has primary education	0.0005	0.0039	0.0152	0.0104
	(0.0238)	(0.0129)	(0.0422)	(0.0191)
Dummy -- mother has secondary education	-0.0178	0.0066	-0.0069	0.0135
	(0.0265)	(0.0136)	(0.0440)	(0.0199)
Dummy -- mother has higher education	-0.0370	0.0040	-0.0274	0.0096
	(0.0287)	(0.0138)	(0.0446)	(0.0198)
Dummy -- indigenous	0.0879***	0.0219**		
	(0.0222)	(0.0106)		
Dummy --low income	-0.0532***	-0.0008	0.4222***	0.0263
	(0.0193)	(0.0097)	(0.0372)	(0.0169)
Dummy --middle income	-0.2502***	-0.0178	0.2284***	0.0085
	(0.0307)	(0.0137)	(0.0270)	(0.0100)
Dummy --high income	-0.4422***	-0.0261	0.0355**	-0.0025
	(0.0389)	(0.0183)	(0.0164)	(0.0054)
Dummy --very high income	-0.4779***	-0.0228		
	(0.0454)	(0.0203)		
Household members	-0.0255***	-0.0019*	-0.0298***	-0.0013
	(0.0028)	(0.0012)	(0.0030)	(0.0012)
Dummy --HH has natural floor	-0.0327*	-0.0041	-0.0378**	-0.0054
	(0.0179)	(0.0067)	(0.0185)	(0.0071)
Dummy --HH has fridge	0.0055	-0.0052	0.0092	-0.0034
	(0.0138)	(0.0058)	(0.0143)	(0.0060)
Dummy --HH has radio	0.0034	0.0010	0.0035	0.0006
	(0.0141)	(0.0059)	(0.0169)	(0.0062)
Dummy --HH has TV	-0.0106	-0.0098	-0.0120	-0.0201**
	(0.0153)	(0.0079)	(0.0218)	(0.0096)
Dummy --HH has electricity	-0.0606***	0.0024	-0.1084***	-0.0030
	(0.0210)	(0.0086)	(0.0308)	(0.0123)
Dummy --HH has a bike	-0.0022	0.0109**	-0.0050	0.0100*
	(0.0120)	(0.0050)	(0.0128)	(0.0053)
Dummy --HH has a vehicle	0.0271	-0.0002	0.0279	0.0004
	(0.0167)	(0.0054)	(0.0172)	(0.0056)
Dummy --HH has telephone	-0.0428***	-0.0034	-0.0401***	-0.0040
	(0.0130)	(0.0058)	(0.0134)	(0.0058)
Altitude	-0.0105	-0.0158***	-0.0168	-0.0160***
	(0.0108)	(0.0032)	(0.0124)	(0.0039)
Population	-0.0002***	-0.0000	-0.0002***	-0.0000
	(0.0001)	(0.0000)	(0.0001)	(0.0000)
Per capital local personnel	-6.5358*	-0.8571	-7.8146**	-1.3142*
	(3.3703)	(0.7089)	(3.7628)	(0.7471)
Year fixed effects	YES	YES	YES	YES
Region fixed effects	YES	YES	YES	YES
Partial R-squared	0.061		0.054	
F-test of excluded instruments	110.35		91.45	
(p-value)	(0.000)		(0.000)	
R-squared	0.402	0.031	0.305	0.031
Observations	12,331	12,331	10,395	10,395

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1.
Observations of households that changed place of residence since a year prior to the birth of the child were eliminated.
The subsample consists of children in non-indigenous households with income level above "very low" and that have not changed place of residence since at least a year prior to the birth of the child.
The reference income level category for the full sample is "very low income" while for the restricted sample is "very high income".

Table 11. Robustness checks - Instrumental Variable Results for Diarrhea

	Children older than 1yr (I)	Only municipalities with both water provision systems (II)	Only municipalities with both rural and urban population units (III)
Communal provision	**-0.0874****	**-0.1355****	**-0.0696****
	(0.0349)	**(0.0544)**	**(0.0331)**
Child controls	YES	YES	YES
Mother controls	YES	YES	YES
Household controls	YES	YES	YES
Year fixed effects	YES	YES	YES
Region fixed effects	YES	YES	YES
R-squared	0.043	0.018	0.035
Observations	11,767	12,023	13,334

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1
Observations of households that changed place of residence since a year prior to the birth of the child were eliminated.

Table 12. Robustness checks - Instrumental Variable Results for Acute Malnutrition

	Children older than 1yr (I)	Only municipalities with both water provision systems (II)	Only municipalities with both rural and urban population units (III)
Communal provision	**-0.0350***	**-0.0483***	**-0.0303**
	(0.0199)	**(0.0284)**	**(0.0190)**
Child controls	YES	YES	YES
Mother controls	YES	YES	YES
Household controls	YES	YES	YES
Year fixed effects	YES	YES	YES
Region fixed effects	YES	YES	YES
R-squared	0.032	0.029	0.031
Observations	9,622	9,790	10,678

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1
Observations of households that changed place of residence since a year prior to the birth of the child were eliminated.

Table 13. Placebo tests - Relation between Communal Provision and non-water related health indicators

Dependent variable:	Child had cough recently		Child had fever recently		Child suffers cronic malnutrition	
	OLS	IV Linear Regression	OLS	IV Linear Regression	OLS	IV Linear Regression
	(I)	(II)	(III)	(IV)	(V)	(VI)
Communal provision	**0.0104**	**-0.0064**	**0.0089**	**0.0323**	**0.0217****	**0.0128**
	(0.0110)	**(0.0476)**	**(0.0099)**	**(0.0392)**	**(0.0096)**	**(0.0461)**
Child's age	-0.0003	-0.0002	-0.0070**	-0.0083***	0.0237***	0.0232***
	(0.0035)	(0.0039)	(0.0030)	(0.0031)	(0.0039)	(0.0040)
Child's gender	-0.0175**	-0.0170**	0.0002	0.0017	-0.0411***	-0.0382***
	(0.0072)	(0.0078)	(0.0067)	(0.0070)	(0.0081)	(0.0085)
Dummy -- child is breastfeeding	0.0070	0.0051	0.0264***	0.0197**	-0.0001	0.0039
	(0.0107)	(0.0111)	(0.0091)	(0.0094)	(0.0120)	(0.0119)
Weight at birth					-0.1598***	-0.1558***
					(0.0074)	(0.0082)
Mother's age	-0.0027***	-0.0028***	0.0001	0.0002	-0.0014***	-0.0012**
	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0006)
Dummy -- mother has primary education	0.0433*	0.0546**	0.0517**	0.0592***	-0.0336	-0.0198
	(0.0230)	(0.0239)	(0.0204)	(0.0215)	(0.0233)	(0.0247)
Dummy -- mother has secondary education	0.0529**	0.0570**	0.0501**	0.0534**	-0.1003***	-0.0828***
	(0.0228)	(0.0238)	(0.0207)	(0.0222)	(0.0242)	(0.0258)
Dummy -- mother has higher education	0.0513**	0.0558**	0.0549**	0.0643***	-0.1724***	-0.1610***
	(0.0246)	(0.0256)	(0.0216)	(0.0232)	(0.0250)	(0.0272)
Dummy -- indigenous	-0.0126	-0.0144	-0.0091	-0.0151	0.0348**	0.0285
	(0.0173)	(0.0192)	(0.0158)	(0.0181)	(0.0169)	(0.0191)
Dummy --low income	-0.0041	0.0002	-0.0073	-0.0021	-0.0556***	-0.0649***
	(0.0168)	(0.0194)	(0.0158)	(0.0180)	(0.0157)	(0.0171)
Dummy --middle income	-0.0068	-0.0054	-0.0214	-0.0129	-0.1301***	-0.1449***
	(0.0218)	(0.0295)	(0.0196)	(0.0264)	(0.0193)	(0.0264)
Dummy --high income	-0.0287	-0.0308	-0.0572**	-0.0473	-0.1855***	-0.1997***
	(0.0256)	(0.0394)	(0.0227)	(0.0326)	(0.0251)	(0.0381)
Dummy --very high income	-0.0234	-0.0241	-0.0738***	-0.0660*	-0.2368***	-0.2517***
	(0.0299)	(0.0444)	(0.0261)	(0.0370)	(0.0305)	(0.0436)
Household members	0.0017	0.0022	-0.0010	-0.0004	0.0134***	0.0127***
	(0.0020)	(0.0023)	(0.0019)	(0.0022)	(0.0020)	(0.0025)
Dummy --HH has natural floor	-0.0140	-0.0138	-0.0078	-0.0057	0.0134	0.0163
	(0.0113)	(0.0124)	(0.0103)	(0.0103)	(0.0114)	(0.0122)
Dummy --HH has fridge	0.0184	0.0163	0.0126	0.0098	-0.0186	-0.0184
	(0.0118)	(0.0122)	(0.0103)	(0.0107)	(0.0128)	(0.0151)
Dummy --HH has radio	-0.0265**	-0.0300**	-0.0025	-0.0018	-0.0030	0.0011
	(0.0110)	(0.0121)	(0.0101)	(0.0109)	(0.0108)	(0.0122)
Dummy --HH has TV	-0.0032	-0.0069	-0.0125	-0.0155	0.0171	0.0208
	(0.0126)	(0.0138)	(0.0120)	(0.0132)	(0.0128)	(0.0140)
Dummy --HH has electricity	-0.0053	-0.0027	-0.0051	0.0020	0.0072	0.0142
	(0.0158)	(0.0177)	(0.0150)	(0.0164)	(0.0156)	(0.0167)
Dummy --HH has a bike	-0.0039	-0.0033	-0.0104	-0.0106	0.0052	0.0014
	(0.0093)	(0.0098)	(0.0089)	(0.0092)	(0.0109)	(0.0111)
Dummy --HH has a vehicle	0.0038	-0.0032	-0.0105	-0.0054	-0.0128	-0.0064
	(0.0148)	(0.0159)	(0.0114)	(0.0122)	(0.0162)	(0.0166)
Dummy --HH has telephone	0.0073	0.0119	0.0176	0.0252**	-0.0064	-0.0058
	(0.0120)	(0.0126)	(0.0113)	(0.0115)	(0.0124)	(0.0134)
Altitude	-0.0049	-0.0040	0.0023	0.0039	0.0574***	0.0579***
	(0.0059)	(0.0062)	(0.0053)	(0.0059)	(0.0054)	(0.0058)
Population	-0.0000	-0.0000	0.0001	0.0001*	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Per capital local personnel	1.3056	1.2979	1.0219	-0.7776	0.0266	-0.2279
	(1.6108)	(1,8089)	(1.7445)	(1,9045)	(1.8390)	(1.9446)
Year fixed effects	YES	YES	YES	YES	YES	YES
Region fixed effects	YES	YES	YES	YES	YES	YES
R-squared	0.024	0.024	0.019	0.019	0.202	0.208
Observations	17,590	15,405	17,593	15,408	14,148	12,365

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1.
In IV linear regression observations of households that changed place of residence since a year prior to the birth of the child were eliminated.

Table 14. Source of drinkable water by provision type (% of sampled households)

	Public Provision	Communal Provision
Pipeline inside house	89.42	63.68
Pipeline outside house	5.52	12.60
Public tap	1.21	8.22
Well inside house	0.03	0.00
Public well	0.12	0.69
Water spring	0.06	0.18
River, lake or dam	0.07	0.19
Rain	0.02	0.00
Water trunk	0.56	1.61
Bottled water	2.57	1.27
Other	0.42	11.57
Total	100	100

Table 15. Instrumental Variable Estimation Results Controlling for Water Source – Diarrhea

	Full Sample (I)	Only piped water (II)	Only piped water & municipalities with both communal and public systems (III)
Communal provision	**-0.0597****	**-0.0471***	**-0.0969****
	(0.0277)	**(0.0261)**	**(0.0385)**
Dummy --Water source: pipeline outside house	0.0192		
	(0.0128)		
Dummy --Water source: public tap	0.0673***		
	(0.0213)		
Dummy --Water source: well inside house	-0.0660***		
	(0.0184)		
Dummy --Water source: public well	0.0219		
	(0.0468)		
Dummy --Water source: water spring	0.0081		
	(0.0791)		
Dummy --Water source: river, lake or dam	0.0077		
	(0.0659)		
Dummy --Water source: water trunk	0.0257		
	(0.0320)		
Dummy --Water source: bottled water	0.0140		
	(0.0287)		
Dummy --Water source: other	0.0276*		
	(0.0160)		
Child controls	YES	YES	YES
Mother controls	YES	YES	YES
Household controls	YES	YES	YES
Year fixed effects	YES	YES	YES
Region fixed effects	YES	YES	YES
R-squared	0.035	0.035	0.031
Observations	15,402	13,345	10,337

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1
The full sample is that of Table 9 Column II for which information exists for all variables. All regressions include the child, mother and household controls used in Table 9, as well as the controls for altitude, population and per capita public personnel in the municipality.
The reference category for water source dummies is "Pipeline inside the house". Piped water defined as having access to pipeline water either inside or outside the house.

Table 16. Instrumental Variable Estimation Results Controlling for Water Source – Acute Malnutrition

	Full Sample (I)	Only piped water (II)	Only piped water & municipalities with both communal and public systems (III)
Communal provision	**-0.0322****	**-0.0180**	**-0.0287**
	(0.0155)	**(0.0158)**	**(0.0228)**
Dummy --Water source: pipeline outside house	-0.0120*		
	(0.0064)		
Dummy --Water source: public tap	0.0034		
	(0.0136)		
Dummy --Water source: public well	-0.0374		
	(0.0289)		
Dummy --Water source: water spring	0.0224		
	(0.0687)		
Dummy --Water source: river, lake or dam	0.0068		
	(0.0524)		
Dummy --Water source: water trunk	-0.0004		
	(0.0191)		
Dummy --Water source: bottled water	0.0052		
	(0.0205)		
Dummy --Water source: other	0.0048		
	(0.0129)		
Child controls	YES	YES	YES
Mother controls	YES	YES	YES
Household controls	YES	YES	YES
Year fixed effects	YES	YES	YES
Region fixed effects	YES	YES	YES
R-squared	0.031	0.033	0.037
Observations	12,330	10,674	8,422

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1
The full sample is that of Table 10 Column II for which information exists for all variables. All regressions include the child, mother and household controls used in Table 10, as well as the controls for altitude, population and per capita public personnel in the municipality.
The reference category for water source dummies is "Pipeline inside the house". Piped water defined as having access to pipeline water either inside or outside the house.

Table 17. Relation between Communal Provision and Water Quality Indicators

Dependent variable:	Water available 24h (I)	Store water (II)	Time to collect water (III)
Communal provision	**0.0774*****	**-0.0128**	**0.6107*****
	(0.0247)	**(0.0128)**	**(0.2043)**
Dummy --Water source: network outside house	-0.0522**	0.0451**	6.7603***
	(0.0263)	(0.0201)	(0.2703)
Dummy --Water source: public tap	-0.2202***	0.1221***	22.3719***
	(0.0546)	(0.0239)	(1.7384)
Dummy --Water source: well inside house	0.6935***	-0.1860	-1.3556*
	(0.0607)	(0.1326)	(0.7703)
Dummy --Water source: public well	0.1236	0.1780***	21.1787***
	(0.2594)	(0.0353)	(2.9822)
Dummy --Water source: water spring		0.2113***	15.8942***
		(0.0752)	(1.4677)
Dummy --Water source: river, lake or dam	0.3212***	0.1330***	12.0169***
	(0.0821)	(0.0495)	(3.8356)
Dummy --Water source: water trunk	-0.2496	0.1061***	14.1686***
	(0.2133)	(0.0258)	(1.8393)
Dummy --Water source: bottled water	-0.0386	-0.7635***	13.3927***
	(0.0272)	(0.0238)	(3.3229)
Dummy --Water source: other	-0.0969	0.1311***	17.8985***
	(0.0857)	(0.0195)	(1.5165)
Mother controls	YES	YES	YES
Household controls	YES	YES	YES
Year fixed effects	YES	YES	YES
Region fixed effects	YES	YES	YES
R-squared	0.164	0.202	0.406
Observations	54,884	56,916	79,046

Notes: Robust standard errors in parentheses, clustered by municipality. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include the mother and household controls included in Tables 9 and 10, as well as the controls for altitude, population and per capita public personnel in the municipality.
The reference category for water source dummies is "Pipeline inside the house".
Piped water defined as having access to pipeline water either inside or outside the house.