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Can Communal Systems Work? The Effects of Communal Water Provision on Child Health in Peru

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Abstract

Communal water organizations are widespread in many areas of developing countries, where local governments lack the resources to offer a minimum quality water service. However, these organizations have their own resource limitations and they additionally face the well-known problems associated with collective action. It is therefore unclear how effectively they can provide safe water, and the evidence available thus far is mixed. This paper analyzes the communal water organizations in Peru known as *Juntas Administrativas de Servicios de Saneamiento* (JASS). Using detailed household survey data, we empirically assess the differential impact of the JASS vis-a vis public systems on two water-related child health outcomes: diarrhea and low birth weight. Our identification strategy exploits the legislative changes introduced in the 2000s and the arbitrary cut-off to classify the administrative sub-units of Peruvian municipalities (districts) in order to achieve exogenous variation in the type of water provision. We find that child diarrhea and low birth weight are significantly lower for households served by JASS in the districts located in the first Inca settlements where the pre-Columbian tradition of communal work, called Minka, has survived over centuries. We also show that in those districts the JASS have better governance (existence of their own rules, higher participation and accountability and a greater ability to obtain external support). These findings confirm the hypothesis that social capital and traditions foster cooperation among community members and are in line with recent works showing the importance of historically developed institutions in building social capital. More generally, our results suggest that communal organizations are not a one-fits-all solution, but rather their success depends crucially on the existence of mechanisms for overcoming the problems associated with collective action and the active involvement of the community.

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

*Highlights (WITHOUT author details)

Highlights

1- We assess the impact of communal versus public water provision on child health in Peru

2- Identification strategy based on the discontinuity in the type of provision across district sub-units

3- Communal organizations result in better health outcomes in historical Inca settlements

4- Long-standing effects of the Minka tradition of collective work

5- Social norms and traditions are important for the success of communal projects

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1. Introduction

Communal water organizations are a supply system that is widespread in many areas of less developed countries. Partly due to the disappointing results of centralized water projects, the 1990s witnessed the expansion of demand-driven, community-managed systems that sought to engage local communities in the operation and maintenance of water systems (Agrawal and Gibson 1999, Hutching et al 2015). The goal of these projects was to increase the coverage to areas beyond the governments' operational and financial reach (Isham, Narayan, & Pritchett, 1995; Joint Monitoring Programme, 2000; World Bank, 2003; Badrul Hasan et al. 2020). Today participatory projects are widespread, and in many countries they are considered a viable alternative to public and private systems (Isham and Kähkönen, 2002 Agrawal et al. 2008; Propoky, 2009; Whittington et al., 2009). In Latin America and the Caribbean (LAC) it is estimated that more than 80,000 communal organizations supply water services to more than 40 million people, with coverage rates in some countries being as high as 30% of the population (CLOCSAS, 2016).[1]

A key aspect of the performance of communal water systems is their ability to provide safe water and their effects on public health.[2] A number of case studies have analyzed aspects of communal water systems such as sustainability (Whittington et al 2009, Sara and Katz 1997, Hutching et al 2015). Other works have compared the performance of

[1] Although there is no precise information on how these organizations have contributed to the universalization of water access, according to the Joint Monitoring Programme (2016) improved rural water coverage in LAC increased from 37% to 68% between 1990 and 2015. Moreover, Joint Program Monitoring (2019) shows that between 2000 and 2017 the number of Latin Americans without access to basic drinking water decreased from 52 to 21 million people (7 million people rely on surface water), and the number without basic sanitation decreased from 139 to 83 million people.

[2] It is well established that 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).

communal and public water systems with regard to access to quality water (e.g. Newman et al, 2002 for Bolivia; Sun et al, 2010 for rural villages in Ghana) or piped water (e.g. Barde, 2017 for Brazil). However, the literature examining the effects of different provision systems on health is scarce. Most of the efforts have focused on the impact of privatization on child health (Galiani et al, 2009; Barrera-Osorio et al., 2009; Kosec, 2014) but in the case of communal organizations the effect on health remains relatively understudied.[3]

We add to the debate on the effectiveness of communal systems by analyzing the impact of communal water provision on child health in Peru. Peru constitutes an interesting case to examine due to the role that communal water organizations have played in the transformations that the sector has undergone in recent decades. In the 1990s Peru initiated a decentralization process that, in the water sector, involved handing over the responsibility of providing the service to regional and local governments and to communal organizations called *Juntas Administrativas de Servicios de Saneamiento* (JASS). A dual provision system was then established by which public companies and local governments were to serve larger municipality sub-units while the JASS were encouraged to offer the water service in small sub-units. As users of the service, the members of the JASS know the actual needs of the service well and have clear incentives to supervise the quality of the water. On the downside, many JASS lack the financial resources and the technical training to maintain the water systems. Moreover, they face the typical problems associated with the provision of collective goods, namely

[3] One of the few examples is Isham and Kähkönen (2002), which analyzes 50 water committees' projects in Sri Lanka and India in the 1990s. They found that the new water services improved the health of families and decreased the incidence of diarrhea.

the incentives for members to under-contribute to the finance and maintenance of the systems and to free ride on the contributions and work of others (Olson 1965, Harding 1968).

This paper attempts to shed some light on whether these communal organizations can be an effective way of providing the population with safe water. More precisely, the main contributions of the paper are twofold. First, we use a sound identification strategy to econometrically isolate the effects of communal water provision compared to public systems on water-related health outcomes, child diarrhea and low birth weight. In particular, we use an instrumental variable approach that exploits the legislative changes introduced in the 2000s and the arbitrary population cut-off to classify municipality sub-units in order to obtain exogenous variation on the type of water provision. Second, we test some of the factors that the theory on collective action has identified as conducive to successful communal projects. In this sense, we find that the presence of a pre-Columbian tradition of communal work, called *Minka*, in the Andean region of the country is associated with better governance practices of the JASS and results in better child health outcomes.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework and the hypothesis that will be explored, as well as the related existing evidence. Section 3 describes the current organization of the water sector in Peru, with an emphasis on the characteristics of the JASS. Section 4 presents the data and the estimation strategy, while Section 5 reports the results. Section 6 tests the explanations for the heterogeneous effects of the JASS found throughout Peru. Lastly, Section 7 concludes.

2. Theoretical framework and related literature

Several collective theorists and researchers across disciplines have attempted to characterize the principles and factors that help communal organizations deal successfully with collective action.[4] Below we discuss the theoretical predictions with regard to three groups of factors and discuss some of the related empirical studies available, with an emphasis on water provision. The factors we examine refer to i) the capacity of communities to participate effectively in the design and operation of water systems, ii) characteristics of the community that affect their ability to act collectively, and iii) the role of traditions and social norms in facilitating cooperation.

Community participation and governance

A central aspect for analyzing communal organizations is to understand how community participation (in the design, operation and maintenance of water systems) can improve their performance. According to Prokopy (2005), participation implies attending meetings, speaking out at meetings, being involved in decisions such as the location of key facilities and the timing of water supply, and supervising construction.

Early analysis by Isham, Narayan, and Pritchett (1995), Katz and Sara (1997) and Manikutty (1997) compared rural water systems in several countries and found that

[4] See Ostrom (1990), Wade (1988), Baland and Platteu (1996), and the early studies on irrigation systems by Tang (1992) or Lam (1998). Agrawal (2001) provides an excellent review of the factors facilitating collective action.

participation creates a sense of ownership among community members that increases project sustainability. More recently, Whittington et al. (2009) and Marks and Davis (2012) have confirmed that participation in the planning and construction of water systems contributes to the communities' sense of ownership and the maintenance of the systems. Examining water supply projects in India, Prokopy (2005) found that both capital cost contributions and households' participation in decision-making positively affect household satisfaction, equal access, and time-savings in carrying out repairs.

Some authors have also identified limitations in the governance of communal organizations that might affect participation. Mansuri and Rao (2004) and Hutchings et al. (2015) argue that the lack of technical expertise and training in the organizations prevents the creation of adequate infrastructures and the provision of reliable water services. Prokopy (2005) argues that people are sometimes forced to participate in the projects against their will or are not involved in higher level decision-making. Other studies highlight the need to establish mechanisms of accountability to prevent the arbitrary exercise of power (Agrawal and Gibson, 1999) or the control of the projects by local elites (Bardhan, 2002; Bardhan and Mookherjee, 2005; Dasgupta and Beard, 2007).

Community size and homogeneity

The research on common-property resources has examined how the size of the communities affects the ability of their members to act collective. Baland and Platteau (1996) shows the potential for collective action in small rural communities in which users interact frequently, but also in larger communities in which an effective authority offers leadership and trust.[5] The empirical analysis conducted by Aggarwal (2000) finds a non-linear relationship between community size and performance, which is related to the lower efficacy of peer monitoring when the number of users increases. Other studies have found that the effect of community size can be influenced by other relevant aspects such as capacity and local enforcement (Ostrom, 2005; Chhatre and Agrawal, 2008). Indeed, more users contributing in the community means more resources that can be engaged in maintenance and monitoring activities. However, a large number of users can generate collective action problems that makes enforcement more challenging to resolve.

The ethnic, socio-cultural and economic composition of the community may also play an important role in the likelihood of its members to self-organize and in the provision of collective goods. Heterogeneous groups tend to have differing interests and thus a differing willingness to contribute to a public good or agree on a common set of rules (Dayton-Johnson and Bardhan, 2002; Ostrom, 2005, Barnerjee et al., 2008).The likelihood of self-organizing may also be lower in a heterogeneous group due to a lack of trust and mutual understanding (Ostrom and Varughese, 2001). Empirically, Alesina et al. (2014) find a negative association between ethnic inequality and the provision of public goods such as access to clean piped water and sewerage in African countries. Glennerster et al (2013) do not find a relationship between ethnic diversity and local provision of public goods in Sierra Leone. Barnerjee and Somanathan (2007) show that the population of Brahmans (an elite priestly caste) in Indian parliamentary constituencies is positively correlated with access to piped water in the 1970s and that ethno-linguistic fragmentation is negatively related to access to public goods. Escobal

[5] The studies carried out by Tang (1992) and Lam (1998) on irrigation systems did not find a clear association between the number of famers and their performance.

and Ponce (2011) explore the role that "institutional thickness" (a measurement based on economic and social fragmentation) has in the provision of sanitation services in Peru. Prokopy (2009) explores community water projects in rural India and finds that social cohesion increases community participation.

Norms, social capital and traditions

Social capital, understood as norms, trust and networks that enable collective action, lowers the transaction costs of working together, such as monitoring and enforcing costs, and thus fosters cooperation (Putnam et al, 1993, Lam and Ostrom, 2009; Bluffstone et al, 2020). Isham and Kähkönen (2002) confirm these predictions in their study of water projects in Sri Lanka and India. They find that communities with higher levels of social capital (active community groups and associations) participate more in the construction of water systems, develop more monitoring mechanisms and exercise less free-riding. Similarly, for rural water organizations in Costa Rica, Madrigal and Alpizar (2011) find that high performance is the result of the existence of working rules that are properly defined and enforced by the local communities.

Past experience and historically developed institutions are important determinants of social capital - Ostrom (1990) and Ostrom and Gardner (1993). Several empirical studies have documented the historical roots of social capital. For instance, in a study on Chinese students Talheim et al (2014) show that the "rice culture" that promotes cooperative behavior can persist and shape people's attitudes long after such farming activity has been abandoned. Similarly, Fujiie, Hayami and Kikuchi (2005) and Lam and Ostrom (2010) show that irrigation systems in Nepal and the Philippines are better managed when farmers rely on long-established social norms and monitoring mechanisms. In contrast, Amirova et al. (2019) find no evidence that historical irrigation traditions determine local water cooperation today in Kazakhstan and Uzbekistan.

3. Water Provision in Peru

Peru has a very diverse geography that hinders the homogenous provision of water across the country. There are three natural regions that differ greatly, not only in terms of geography and water resources but also in terms of economic and institutional development: the Coast, the Andean (or *Sierra*) region and the Rainforest (or *Selva*) region. The Coast occupies areas between 0 and 2,000 meters above sea level and is characterized by scarcity of rain throughout the year. Access to water is gained via rivers and underground waters. The Coast is the region in Peru with the highest level of urban development; it represents only 10% of the national territory but hosts 61% of the population. It includes the capital, Lima, which is home to 30% of the country's population. The Sierra covers 31% of the territory and concentrates 29% of the population. It sits on the "Altiplano" plateau, whose average height is over 3,500 meters above sea level. It benefits from seasonal rains and the population and the agricultural sector obtain water primarily from natural springs and rainwater. The historic settlements of the pre-Columbian Inca Empire are mostly found in this region, and as such the Sierra is home to a large Quechua population - the ethnic group that are the descendants of the Incas. Lastly, the Selva region, in the eastern part of Peru, is a vast area of flat terrain that 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.

The current organization of water provision in Peru is the result of the country's geographical characteristics as well as of several laws introduced at different points in time. Administratively Peruvian municipalities (called districts) are divided into smaller units called population units (*centros poblados*) and these sub-units are classified as either urban or rural, depending primarily on size. For water regulation purposes, a population unit is considered to be rural if it has fewer than 2,000 inhabitants and does not act as the capital of the district.[6] The 1994 Municipalities Law was the first regulation to establish that the districts' rural population units could be supplied by a JASS. However, this provision model was not fully implemented until the 2000s. In 2005 a government order reaffirmed that the JASS were responsible of providing the water services in the rural population units, and established their autonomy to operate the service, set the fees, and supervise the water systems.[7] Hence, since the mid-2000s Peruvian districts have a dual model of water provision regulated by the national agency SUNASS: urban population units tend to be supplied by public firms or local governments while rural population units are to be supplied by a JASS. In practice though, both types of provision, communal and public, still coexist in rural and urban population units, as we explain in greater detail below.

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[6] Other government departments use different classification criteria. For instance, the Peruvian Statistical Institute (INEI), where our data comes from, works with statistical units called clusters which are classified as rural if they have fewer than 100 grouped houses (500 inhabitants on average).

[7] *Decreto Supremo Nº 023-2005-Vivienda*. Other important regulatory changes during the 2000s included the creation in 2002 of the PRONASAR program (*Programa Nacional de Agua y Saneamiento*) to assist the JASS in designing and constructing water infrastructures, and the 2003 Municipalities Law that established the ultimate responsibility for supervising the provision of water and sewerage services in rural population units with local governments. In many districts this implied the creation of Technical Offices (*Unidades Técnicas Municipales*) that offer assistance to the JASS.

3.1 Public Provision

Provincial governments are responsible for providing water services in urban areas through *Empresas Prestadoras* (EP). There are currently 50 EPs in Peru: 48 municipal firms, SEDAPAL (owned by the national government), and one private company in the region of Tumbes. Altogether, the EPs offer the service to 17.9 million people, 57% of the national population and 73% of the urban population. As for the sewerage service, the coverage is 16.7 million people, of which about 50% are served by SEDAPAL. In addition to these large firms, local governments provide water services in more than 250 small cities representing 9% of the country's population (Calderón, 2004; Felgendreher & Lehmann, 2016).[8] Lastly, in many urban population units where public networks do not cover all the households JASS are the default water provision systems (with this affecting around 20% of the people living in urban population units).

One of the main challenges the public water sector in Peru faces is the difficulty in increasing the service's coverage. This is partly due to the delicate financial and operational situation of public firms, especially EPs, and the policy on water fees (OTASS, 2017). Local governments tend to set low fees for political reasons, which further reduces the resources available. Additionally, many administrative barriers are often encountered during construction of the water systems that altogether hinder the expansion of the systems (MVCS, 2017).

3.2 The JASS

[8] Since 2017, in small cities the government has been promoting the integration of the EPs with firms run by local governments and nearby JASSs in order to increase their scale of operation.

The *Juntas Administrativas de Servicios de Saneamiento* (JASS) are civil associations of users that provide water and sewerage services in many communities in Peru. They date back to the 1960s when international organizations and donors developed several programs to construct water infrastructure in rural areas. Many of these organizations were modernized in the 1990s, but the main impulse for the JASS took place in the 2000s with the consolidation of the dual model of water provision described above.

The organizational design of the JASS consists of a general delegate assembly, a management board and a supervisory board, with the latter having power of veto over the management board. The assembly comprises all the members of the JASS and is responsible for appointing the management board and approving the rules of the organization as well as the work plan, annual budget, and household fees. The management board consists of a president, a secretary, a treasurer and two additional members, and is in charge of managing the water system. The JASS's users are members of the assembly and are eligible to sit on the management and supervisory boards.

An essential aspect of the JASS is the commitment of their members to contribute towards the maintenance and construction of the water systems with their work. Besides paying fees, each household needs to contribute with a number of hours of work per year. This type of collective work finds its historical roots in a pre-Columbian tradition called Minka. During the Inca Empire that prevailed in the Andean region before the arrival of the Spaniards, the Minka was a system of communal work used to construct public buildings, irrigation canals, bridges and roads, to perform agricultural activities and to help the disabled and elderly (Espinoza 1997, Pease 1991, Altamirano and Bueno

2011). This tradition has survived in the Andean region and in some other areas where there is a strong Inca influence.

Except for the labor costs, the water infrastructure systems operated by the JASS are generally financed by the government by way of national programs.[9] Once the construction of the infrastructure is completed, it is transferred through a Transfer Act to the JASS, which then becomes responsible for the maintenance and running operation costs. As water meters to track consumption are usually not available, the JASS charge a uniform flat rate per household. Only in special circumstances (e.g. elderly or sick users) is this rate subsidized. The fees are often not enough to finance all the costs, and so, unless the JASS manage to increase the fees or get help from other institutions, maintenance of the infrastructures and water treatment can be compromised.

With regard to the operation of the systems, the members of the JASS are trained by experts in how to treat the water and deal with incidents. For example, they are given guidelines on how to maintain the reservoirs, disinfect the pipelines and carry out water chlorination. The JASS also tend to be assisted by Technical Offices, managed by local governments, which provide legal and technical advice and training.

4. Methodology and Identification

We assess the performance of the JASS vis-à-vis public provision with regard to their

[9] In 2012 the PNSR program (Programa Nacional de Saneamiento Rural) replaced the PROSANAR program in financing the water infrastructure systems operated by the JASS. The PNSR's goal is to increase access to water and sewerage services for the population living in rural areas, giving priority to communities of more than 500 inhabitants with greater needs (Calzada et al, 2017). Some projects receive the support of international institutions like the World Bank, NGOs and national cooperation agencies.

impact on child health, as this is an important aspect of the performance of water systems. We thus aim to estimate the following model:

$$H_{ihdt} = \alpha . Communal_{hdt} + X_{ihdt} . \beta + \delta_d + \eta_m + \tau_t + \varepsilon_{ihdt}$$

(1)

where H_{ihdt} is a water-related health outcome of child *i*, living in household *h*, in district (municipality) d at year *t*; $Communal_{hdt}$ is our variable of interest and indicates whether the household is supplied by a JASS or a public system; X_{ihdt} is a matrix of controls at the child, mother, household and district levels. District fixed effects (δ_d) are included, so that the estimates are identified out of within-district variation, and we also include year (τ_t) and month (η_m) fixed effects. Lastly, ε_{ihdt} is the disturbance term. Below we describe all the variables used and where we obtain them.

4.1. Data sources

Our primary data source is the Demographic and Health Survey (DHS) or *ENDES* in Spanish (*Encuesta Demográfica y de Salud Familiar*). ENDES is a nationally representative household survey conducted by the Peruvian Statistical Institute (INEI) following the methodological design used by the DHS worldwide. Every year since 2004 it has interviewed a different pool of households from which it collects detailed information on children and women's reproductive health, as well as on several aspects of the living conditions of the households. For the purpose of our study, the relevant unit of analysis is a child under the age of five born to a woman who lives in one of the households interviewed. We use the years 2010-2014 for which the variable of interest -

communal water provision - was available, and for which it was possible to retrieve the district sub-unit, the population unit where the household is located. As we will explain below, this geographical information is key to construct the instrument on which our identification strategy relies.[10]

The explanatory variable of interest, the outcome variables and the vast majority of controls are drawn from ENDES. The variable *Communal* (explained further below) is based on the survey question: “To which type of agency does the household pay for water?” Answers could be: i) a public company or agency, ii) a JASS, iii) a private company or agency, iv) another private water provider and v) a remaining category labeled "Others". Overall private provision accounts for a very small percentage of the observations (about 6%), and it is geographically concentrated in one region (Tumbes) that underwent privatization of the service in some districts in 2006. We eliminated those observations, since private provision is not the focus of this paper. The "Others" category represents 12% of the observations and groups together a wide range of answers with the only common feature of payment for water being made via a third party –e.g. payment to a neighbor, landlord, etc.[11] As it was impossible to infer the type of water provider for these households, we were forced to drop those observations. We also eliminated the observations of respondents who were visitors in the household at the time of the interview. All in all, after data cleaning we are left with a pooled cross-section of over 84,600 households and about 26,200 children under five. The sample size is further reduced in the empirical analysis, since the models are estimated based on

[10] Population units were not initially available in the dataset published by INEI. We were able to map practically all households to the population units where they are located thanks to the bridging files provided by ENDES upon request. These files link the smallest geographical unit ENDES uses, the cluster, to population units. Only about 3% of the observations could not be linked to any population unit since they were missing from the bridging files.

[11] We thank ENDES for providing us with the raw answers for this category.

the sample for which information on all variables is available.

We complemented ENDES with data from the Census (*Censo de Población y Vivienda* or CPV) from which we drew the population of the districts, as well as information on the population units (name, size and whether or not they are the capital of the district), and the ethno-linguistic information we exploit in Section 6.1.

Our third important data source is a survey from SIASAR on around 9,600 rural water organizations, carried out in 2015. As most of the organizations are JASS (less than 8% are small-scale public water systems) we were unable to use it in conjunction with ENDES to analyze the differential impact of communal versus public provision. Notwithstanding this limitation, the rich set of variables provided by this survey conveys a very detailed picture of the governance and other important operational aspects of JASS across Peru. We use this information in Section 6 in order to reveal differences between the JASS that work well in terms of child health and those that do not.

4.2. Variable Description

In line with most studies on water-related diseases (Kosec, 2014, or Barrera-Osorio et al., 2009), the main health outcome we look at is diarrhea in children under five. Diarrhea is directly related to water conditions, and children are more vulnerable to it, with its effects going beyond the immediate problems of dehydration and potential death (Checkley et al., 2008, Niehaus et al., 2002). The *Diarrhea* variable is taken directly from ENDES and is a dummy variable that takes value 1 if the child experienced diarrhea in the two weeks prior to the interview, and 0 otherwise.

The second health outcome we examine is low birth weight (LBW). Although not as directly related as diarrhea, LBW has also been documented as being affected by water conditions (Currie et al, 2013, Padhie et al 2015, Campbell et al 2015), and the improvement of water systems and sanitation is one of the recommended interventions for developing countries in order to prevent LBW (WHO 2014). *LBW* is another dummy variable based on the child's weight at birth. According to the WHO a child has LBW if its birth weight is less than 2.5kg.

The explanatory variable of interest, *Communal*, is constructed as a dummy variable that takes value 1 if the water used by the household is provided by a JASS, and 0 if it is provided by a public system (see description of the ENDES question above). About 40% of the observations used in the empirical analysis are supplied by a JASS.

As for the set of controls - matrix *X* in model (1) - the wealth of information available at ENDES allows us to include a comprehensive list of variables. The primary controls include variables related to sanitation, personal hygiene habits and household crowdedness, since they are important factors in the contagion and spread of water-related diseases.

More precisely, the models on diarrhea include dummy variables for the type of toilet facilities (flush toilet, latrine or no toilet facilities), a dummy for whether the household shares the toilet with other dwellings and two measures of household crowdedness (number of household members per room and number of children in the household). As for the hygiene controls, ENDES contains several questions regarding the mothers' hand-washing habits. Given the high correlation among them, we apply Belloni et al (2013) double selection procedure to decide on the variables to be used and include the following covariates: how often the mother washes her hands, whether she washes hands before preparing food and before feeding the child.

Another important aspect to consider is whether households perform any water treatment. It could be possible for households supplied by JASS to receive unsafe water and yet exhibit better health outcomes if, being aware of the poor quality, they treat the water prior to consuming it. To ensure this is not confounding our estimates on communal provision, we include a control indicating whether the household boils the water - a common and effective way to disinfect contaminated water (WHO, 2011).

Geography also plays an important role in the incidence of water-related diseases because it conditions the availability and quality of water, and the topographical characteristics affect the technology that can be used for water systems. For instance, gravity flow water systems are common in the Sierra but much less so in the Coast where often water needs to be pumped. We take geography into account in the following ways. First, we estimate separate models for the Coast, the Sierra and the Selva regions. Second, we control for the altitude at which the household resides. Water tends to be purer at higher altitudes, especially surface water coming from streams, rivers or lakes, and altitude is also correlated with other factors, such as temperature, that might affect water quality.

We complete the list of controls for the diarrhea models with child characteristics (age, gender, whether the child is breast-feeding or not, and information on two vaccines that are particularly relevant for diarrhea: pneumococcal and rotavirus), mother characteristics (age, education and ethnicity), household characteristics, including an income index and household assets,[12] and the population of the district.

The regressions for LBW include the previous controls on sanitation, household crowdedness, hygienic habits and household water treatment, most of the child, mother and household variables, and additional factors that have been found to be important for LBW (Padhie et al 2015, Campbell et al 2015). The latter include: prenatal care (proxied by the number of prenatal visits); child birth order and whether it was a multiple birth; further characteristics of the mother such as age at child's birth, height and whether a smoker; and the type of cooking stove, since pollutants emitted by traditional solid fuels in inefficient stoves generate Indoor Air Pollution (IAP) that has harmful effects on birth weight.

- Table 1 here -

Table 1 presents descriptive statistics of the health outcomes and the list of controls used in the analysis. The first four columns show the summary statistics for the full sample of children, while columns V and VI report the mean values for children living in households served by public provision and by a JASS, respectively.

4.3 Identification strategy

[12] After applying Belloni et al (2013) double selection procedure, the list of household assets included as covariates are dummies for whether the house has natural floor, a radio, electricity, a vehicle, a mobile and for whether the household owns land.

As Table 1 shows, there are important differences between households with public provision and those served by communal organizations. The households served by JASS tend to have more indigenous mothers, with lower educational levels, and are on average poorer. Moreover, they are more crowded, have worse sanitation facilities, fewer assets, and tend to be in smaller and more remote districts (i.e. at higher altitude).

- Table 2 here -

If we look at water service indicators alone, as reported in Table 2, no remarkable differences are observed between both types of provision regarding the source of water and most aspects of the service. Access to piped water is slightly higher for households served by a JASS but this is due to public taps being more common among the JASS. With regard to service indicators, the JASS tend to have a more continuous supply of water than public systems but the service is also subject to more disruptions due to faults and breakdowns.[13] The rates of water storage (which can be a source of infections if either the water or the containers are contaminated) are similar for households under both types of provision. The only indicator that differs clearly between both systems is the use of chlorine in the water. In the case of the JASS water chlorination is overwhelming lower than in the public water systems. Furthermore, the information on district resources at the bottom of Table 2 shows that the households served by JASS tend to be in districts with lower revenues and fewer personnel.

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[13] Having a continuous supply of water is important to avoid the ingress of contaminants that occurs with intermittent supplies, and because it encourages a higher use of water and better hygiene habits.

All in all, the statistics on Tables 1 and 2 make it apparent that the assignment of households between public and communal water provision is not random, but that those households differ in important ways. As discussed, households supplied by JASS have worse socioeconomic characteristics and tend to be in poorer and more remote districts. Moreover, the rates of water chlorination, key to ensuring that water is safe, are significantly lower for the JASS. Thus, we would also expect the households served by a JASS to have poorer health outcomes, and the raw data confirms this conjecture. As observed in Table 1, the incidence of diarrhea and low birth weight is higher among children living in households with communal provision. Even if we control for all the characteristics available, there is still likely to be unobserved heterogeneity leading to households served by JASS having worse health outcomes. That is, we face a simultaneity source of endogeneity: there are likely to be unaccounted factors that simultaneously correlate with the treatment variable, *Communal*, and affect the outcome variable through the error term. In the presence of endogeneity OLS estimation will result in biased estimates. Given the correlation between the treatment and the error term, in this case we would expect OLS estimates to be biased upward.

In order to deal with the endogeneity problem, we pursue an instrumental variable identification strategy. To do this, we need some variable (instrument) that is correlated with the probability of the household being served by a JASS (the treatment) but has no effect on the outcome of interest other than indirectly through its impact on the treatment. The existence of communal water systems is related to a number of factors - see Calzada et al (2017). Yet finding good instruments is not easy, since many of those variables are unlikely to be orthogonal to the error term in (1).

We exploit the legislative changes that affected the provision of water in Peruvian districts and use the arbitrary cut-off of 2,000 inhabitants to classify the district sub-units as urban or rural. Recall that the legislative changes introduced in the 1990s and consolidated in the mid-2000s established a markedly different provision of water within districts: rural population units (defined as the district sub-units with than 2,000 inhabitants and not acting as the capital of the district) were encouraged to be supplied by a JASS (communal provision) whereas urban population units were to be served by EPS or local governments (public provision). Being the capital of the district might be associated with other factors that can affect health outcomes, and thus it does not constitute an exogenous criterion. We will control for this fact in the regressions, but it will not be part of the instrument. In contrast, the population cut-off of 2,000 inhabitants is arbitrary and offers us a source of exogenous variation in the type of water provision.

– Figure 1 here –

Figure 1 plots the treatment variable (the household being served by a JASS) against the (log) size of the population unit where the household belongs. A clear discontinuity is observed around the 2,000-inhabitant cut-off (7.6 in logs). That is, the probability of a household being served by a JASS is considerably higher for small population units than for larger ones. Our identification relies on such discontinuity.[14]

Validity of the instrument requires the following conditions to be met: i) the assignment

[14] Conceptually this instrumental variable identification strategy is equivalent to fuzzy regression discontinuity (RD). We do not claim full implementation of fuzzy RD design here, though, because the small sample size around the cut-off limits the ability to restrict the sample to any bandwidth arbitrarily close to the discontinuity.

rule of households into communal and public water provision is exogenous, ii) it cannot be manipulated by households and iii) there are no other policies or unaccounted factors affecting the health outcome that change discretely at the 2,000 inhabitant cut-off. In the interest of space, we provide a detailed discussion on how all these conditions are met in the Appendix, where further checks on the validity of the instrument are also conducted.

The model that we then estimate is the following:

$$H_{ihdt} = \alpha . Communal_{hdt} + X_{ihdt} . \beta + f(size_{hdt}) + \delta_d + \eta_m + \tau_t + \varepsilon_{ihdt}$$

$$Communal_{hdt} = \pi_1 . Z_{hdt} + X_{ihdt} . \pi_2 + g(size_{hdt}) + \upsilon_{hdt}$$

(2)

There are two main differences with respect to the model in (1). First, the probability of having communal provision is instrumented with Z, a binary variable that takes value 1 if the district sub-unit where the household resides has less than 2,000 inhabitants (0 if it is in a population unit with 2,000 or more inhabitants). Second, the model includes a polynomial on population unit size, $f(size_{hdt})$, to control for unaccounted factors correlated with the size of the population unit, so that the instrument simply picks up the discontinuity in the treatment at the 2,000 inhabitant cut-off.

5. Results

Table 3 reports the results for the two-stage least squares (2SLS) instrumental variable estimation of the linear probability model of a child having diarrhea (Panel A) and a child being born with low weight (Panel B) as set out in (2).[15] All the regressions include the child, mother and household controls described in Section 4.2, month, year and district fixed effects, and also a polynomial on population unit size and a dummy variable for whether or not small population units (i.e. those with fewer than 2,000 inhabitants) act as the capital of the district. Standard errors are clustered by population unit to allow for correlations within those cells. Due to space limitations we do not report the full regression results but just the estimated coefficients on the variable of interest, Communal provision.[16] The models are estimated for the full sample of households, and separately for the Coast, the Sierra and the Selva regions. Each model reports the first-stage results, i.e. the regression of the endogenous explanatory variable, *Communal*, on the instrument and all the exogenous controls, and the results of the Instrumental Variable regression.

- Table 3 here -

The first thing to notice in Table 3 is that the instrument (the population cut-off of 2,000 inhabitants) is generally powerful. The coefficient on the instrument in the first-stage regressions (Columns I, III, V and VII of both Panels A and B) is highly significant across all models. Households located in population units with fewer than 2,000 inhabitants are more likely to be supplied by a JASS than by a public system. According to the estimates for the full sample for diarrhea (Column I of Panel A), they are about 41 percentage points more likely to be served by a JASS. Likewise, the overall R-squared of the first-stage regressions is very high and, after partialling-out the effect of

[15] For comparison purposes, OLS estimation results are reported and discussed in Appendix 1.
[16] Full regression results are available from the authors upon request.

all other exogenous covariates, the instrument still accounts for significant variation in the type of water provision across households. The partial R-squared for the full sample is 0.06 (Column I of Panel A) and the F-statistic for excluded instruments is 83.9, indicating that the instrument is by no means weak. In the model for LBW, these figures are only slightly lower. The partial R-squared for the full sample is 0.05 (Column I of Panel B), while the F-statistic for excluded instruments is 66.2, which is also well above the critical values for weak instruments.

When we split the sample into the three different natural regions of Peru, the instrument appears to be most powerful for the Sierra region, with high F-statistics and a partial R-squared of 0.08 and 0.07 for the diarrhea and LBW models respectively (see Columns V of Table 3 Panels A and B). The partial R-squared and F-statistics are somewhat lower for the Selva region (Columns VII of Panels A and B) but still within reasonable values. However, for the Coast region we obtain a lower partial R-squared (0.02 and 0.01 for the diarrhea and LBW models respectively, see Columns III of Panels A and B), which indicates that the instrument is not so powerful for this area. This is due to the combination of two factors. First, there are considerably fewer population units with fewer than 2,000 inhabitants in the Coast (only about 9% of the sample households, as opposed to 35% for the country as a whole). Second, and more importantly, the JASS seem to be the default water system for many poor households in the Coast because close to 50% of households served by JASS in the Coast are in urban population units. Statistically, these are non-compliers of the assignment rule on which our instrument is based. To the extent that they are in district sub-units with more than 2,000 inhabitants they *should* have public rather than communal provision.[17] Both these facts make the instrument less powerful for the Coast. Moreover, the F-statistics for excluded instruments are 10.3 and 6.3 for the Coast models (see Columns III of Panels A and B). Given such low F-statistics we cannot rule out a potential weak instrument problem that would result in biased estimates. The estimated coefficients for the Coast should therefore be viewed with caution.

The instrumental variable results for the full sample point to the JASS having no differential impact on child health. The estimates for *Communal* are not significant for either diarrhea or LBW –see Columns II of Table 3 Panels A and B. However, the estimations by region suggest that the null impact of the JASS is mainly driven by the observations of the Coast. In the Sierra and the Selva regions the effect of the JASS on diarrhea is negative and significant, with the estimates ranging from -0.098 (Sierra) to -0.163 (Selva) --see Table 3 Panel A Columns VI and VIII, respectively. The estimate for the Sierra, for which we are confident there are no biases due to weak instruments, indicates that children living in households that have access to water via a JASS are about 10 percentage points less likely to experience diarrhea than children living in households supplied by public provision. This is an important effect, given that the mean incidence of diarrhea among children is 13%. The negative and significant impact of communal provision in the Sierra is confirmed for LBW. In that region, children born to households where the water service is provided by a JASS are about 11 percentage points less likely to suffer LBW --see Column VI of Panel B. Regarding the other two

[17] This is in contrast to a share of non-compliers for JASS provision of 25% for households in the Selva region and just 8% for those in the Sierra. Moreover, examination of the data confirms that the households in urban population units in the Coast being served by JASS are on average poorer than the rest of households in that region.

regions, the estimated effect of communal provision on LBW is positive but insignificant for the Selva and positive and significant for the Coast --see Columns VIII and IV of Panel B respectively. Recall, though, that the estimates for the Coast are not over-reliable since they could be subject to weak instrument biases.

Three main conclusions follow from the instrumental variable estimations. First, the JASS do not result in better water-related health outcomes than public water provision in the Coast region. In fact, taking the estimates at face value we would conclude they might even have a detrimental effect there. Second, the results for the Selva region are, at the very least, inconclusive. In contrast, a clear, positive (and significant) effect of communal provision on child health is found for the Sierra. There, conditional on all other controls, the incidence of diarrhea and LBW is lower among children living in households served by JASS.

5.1. Discontinuity regressions for the Sierra region

We conducted further regression analysis to check the robustness of the results found for the Sierra. In particular, we restricted the sample to children in population units closer to the cut-off of 2,000 inhabitants where the discontinuity in the probability of water provision occurs. By focusing on these subsamples, we ensure that the observations are as similar as possible in all other dimensions and that we are indeed isolating the effect of communal water provision. As Angrist and Pischke (2009) explain, 2SLS instrumental variable estimation is then equivalent to the simplest fuzzy regression discontinuity (RD) estimator that uses Z (in this case, the population cut-off of 2,000 inhabitants) as the only instrument for the treatment (communal provision). Using the idea of Hahn, Todd and van der Klaauw (2001) nonparametric instrumental variable procedure, this simple fuzzy RD design is implemented by restricting the sample to observations around the discontinuity and getting rid of the polynomial in population unit size. The only caveat to this strategy is that the relatively small sample size around the population cut-off, particularly above it, results in low estimation power that hinders the use of data-driven bandwidths arbitrarily close to the discontinuity.

- Table 4 here -

Table 4 reports the estimation results for children in the Sierra living in district sub-units closer to 2,000 inhabitants. We start by considering population units with less than 10,000 inhabitants (Columns I of Table 4 Panels A and B) and subsequently reduce the sample to less than 7,000 inhabitants (Columns II), and between 500 and 3,500 inhabitants (Columns III). On the sub-sample of households in population units with fewer than 10,000 inhabitants (which amounts to one third of the full Sierra sample), we obtain coefficients on communal provision that are not statistically different from those found for the full Sierra sample: -0.084 versus -0.098 for diarrhea and -0.088 versus -0.107 for LBW - compare Columns I of Tables 4 and 3, respectively. The estimates do not vary much when we reduce the sample further to neighborhoods even closer to the 2,000-inhabitant cut-off. For example, when we consider population units with fewer than 7,000 inhabitants, despite the low variability on the instrument (only 8-9% of the observations are in population units above the 2,000 inhabitant cut-off), the estimate for diarrhea is only marginally reduced to -0.080, whereas for LBW it is now -0.101 (see Columns II of Table 4 Panels A and B), and both are statistically significant. Lastly, Columns III on Table 4 report the estimates for the observations within a bandwidth of 1,500 inhabitants around the cut-off (i.e. population units of between 500 and 3,500 inhabitants). Not surprisingly given the reduction in sample size, the estimates are much more imprecise. In the case of diarrhea, the standard error is about 3 times larger than in the previous two columns, and so the estimated coefficient is not statistically significant. In contrast, the estimates for LBW are more stable. The point estimate is statistically significant and remains around -0.108, strikingly close to the estimate obtained for the full Sierra sample.

The results on the regressions closer to the discontinuity of the instrument confirm that the JASS operating in the Sierra outperform public systems in terms of their impact on child health.

6. Why does communal water provision work where it does?

In this section we investigate the underlying mechanisms for why communal water provision results in better child health outcomes than public systems in the Sierra and not in other parts of the country. More precisely, we test some of the hypothesis set out in Section 2 with regard to some of the factors that contribute to the effectiveness of communal organizations, namely: homogeneity of the community, social norms and past experience and governance aspects of the JASS.

6.1. Ethno-linguistic homogeneity

As discussed in Section 2, to the extent that individuals with similar characteristics also share similar preferences, they would be more willing to contribute to a collective good and to trust that others will also contribute. We would thus expect communal organizations to work better in more homogeneous communities.

We test this hypothesis with regard to ethno-linguistic homogeneity using Census data on the linguistic composition of Peruvian districts. Although Spanish is the main language in Peru, there are several other languages spoken by different ethnic groups. The most important is Quechua (linked to the ethnic group descending from the Incas) followed by Aymara, Ashaninka and other minority indigenous languages. We calculate Herfindahl-Hirschmann concentration indices (HHI) based on the question included in the 2007 Census that asks for the language one first learnt to speak in, with a higher index indicating a linguistically more homogeneous district. We then interact the *Communal* variable (as well as its instrument) with the *Ethno-linguistic homogeneity* variable and estimate heterogeneous effects of the JASS along this homogeneity dimension. The coefficient on *Communal* would then reflect the baseline differential impact of the JASS, while the interaction term would pick up the additional impact in more homogeneous districts.

- Table 5 here –

Table 5 reports the estimation results for diarrhea (Panel A) and LBW (Panel B) for the full sample of observations. As Column I of Panel A shows, the effect of communal provision alone on diarrhea appears to be negative and significant. However, the estimated coefficient on the interaction term, which is also significant, is practically of the same magnitude and opposite sign. This suggests that for the most homogeneous communities, those with HHI close to 1, the overall effect of the JASS would then be null. In the case of LBW (Column I of Panel B) neither the coefficient on *Communal* nor the interaction term are statistically significant, also implying a null differential impact of the JASS. That is, these results suggest that overall ethno-linguistic homogeneity does not make a difference in the effectiveness of the JASS on child health.

Given that Spanish is the dominant language in most districts, the raw ethno-linguistic homogeneity index is mainly driven by Spanish-speaking communities (or those where Spanish speakers are in the majority). In order to assess the role of homogeneity for just indigenous or non-Spanish communities, in Columns II of Table 5 Panels A and B, we re-scale ethno-linguistic homogeneity to 0 for majority Spanish-speaking districts, while for majority non-Spanish-speaking districts (i.e. those with less than 50% of Spanish-speaking population) ethno-linguistic homogeneity is the concentration index calculated previously. In this case, the coefficient on *Communal* captures the effect of the JASS on the majority Spanish-speaking districts while the interaction term captures the impact of the JASS for the majority non-Spanish-speaking districts, according to their degree of linguistic homogeneity. As observed in Column II of both Panels A and B, the baseline effect of the JASS is null. However, for the districts with a majority of non-Spanish-speaking population, being served by JASS leads to significantly better child health outcomes the higher the ethno-linguistic homogeneity of the district – with the estimated coefficients being -0.197 for diarrhea and -0.107 for LBW.

Lastly, Columns III of Table 5 report the estimates for just the sub-sample of districts with a non-Spanish-speaking majority. There the JASS result in significantly better health outcomes than public provision, with the estimated coefficients being similar to the average impact obtained in Columns II. Even though we do not explicitly control for ethno-linguistic homogeneity in these regressions, the districts in this subsample tend to be quite homogeneous. Therefore, based on the results of Columns II and III of Table 5, we cannot be sure whether it is ethno-linguistic homogeneity or other characteristics of those districts that is behind the positive impact of the JASS on child health.

6.2. Social norms and traditions

Communal work in Peru finds its historical roots in the pre-Columbian tradition called Minka that the Incas used to construct infrastructures and assist in agricultural tasks - Espinoza (1997), Pease (1991) and Altamirano and Bueno (2011). The theory examined in Section 2 stresses the role of traditions in building social capital and cooperative behavior. Similarly, anecdotal evidence and interviews with Peruvian field officials suggest that this long-standing tradition may explain the active involvement of people in the Sierra region in communal projects.

- Figure 2 here –

Since the Inca empire did not extend to all the country with the same degree of intensity, the Minka tradition is not equally present in all communities in Peru. This allows us to empirically assess the role that the Minka plays in the performance of the JASS. In effect, the Inca empire emerged circa 1438 around the city of Cuzco, in the Sierra region. From there it continued its territorial expansion until 1534, when the

Spanish troops led by Francisco Pizarro entered Cuzco and conquered Peru (Espinoza, 1997). The map in Figure 2 shows the historical Inca settlements. The initial settlements are denoted in pink and correspond mostly to districts in the Sierra, and a few in the Selva region. The areas added to the empire in subsequent expansions are colored dark green, while the light green area was never under Inca rule. Using the geographical location of districts, we estimate the heterogeneous effects of communal water provision according to the intensity of the Inca influence. That is, we create 3 dummy variables for districts in i) the first Inca settlements, ii) areas subsequently added to the Inca empire and iii) areas that were never under Inca rule, and interact them with the *Communal* variable. We would expect the Inca norms and traditions to have left a longer-lasting influence in the districts under Inca rule, particularly where the Inca empire emerged and remained strongest, and much less of an effect, or no effect at all, in the other districts.

- Table 6 here -

Table 6 presents the estimation results for diarrhea (Panel A) and LBW (Panel B). As observed in Column I of Panel A, the impact of communal provision on child diarrhea is stronger the higher the intensity of Inca influence: the estimated coefficient is -0.094 for households in the first Inca settlements compared to -0.019 for those in districts that were never Inca (notice that these districts are the reference category), and 0.013 for those that were Inca at some point. Nevertheless, due to high standard errors none of these coefficients are statistically significant. When we simply distinguish between the districts on the first Inca settlements and the rest (Column II of Panel A), we obtain a similar, and this time highly significant, point estimate for communal provision in the first Inca settlements (-0.105) while still an insignificant effect for the other districts. This indicates that although the JASS do not outperform public systems across all the country, they have a positive differential impact on child health in the districts with strong Inca influence. In Columns III through VI in Panel A, we restrict our attention to the first Inca settlements and, within them, to subsamples of population units arbitrarily close to the 2,000-inhabitant cut-off. Except for the very reduced subsample of population units between 500 and 3,500 inhabitants, for which the estimated coefficient is very imprecise, the point estimates are significant around the range -0.09 and -0.10, very similar to the estimates obtained for the Sierra in Tables 3 and 4. For LBW the point estimates for the first Inca settlements are generally negative too (see Table 6 Panel B), albeit much less precisely estimated. We fail to obtain significant effects for the full sample of districts (see Columns I and II of Panel B) and for the subsample of districts in the first Inca settlements (Column III). However, within those districts, when we consider subsamples of population units closer to the 2,000-inhabitant discontinuity (Columns IV and V) the point estimates are significant, ranging between -0.098 and -0.117, and again become unstable and imprecisely estimated for the subsample of population units between 500 and 1,500 inhabitants.

- Table 7 here -

We further check the sensitivity of the results for the first Inca settlements in Table 7. In particular, the following robustness checks are performed: we control for the source of water (Columns I of Panels A and B), we restrict our attention solely to piped water (Columns II), we eliminate the observations of small population units acting as capital of the district (Columns III) to ensure that results are not driven by the capitality factor.

Additionally, we drop children under six-months old in the estimation of diarrhea (Column IV in Panel A), since they are more likely to be exclusively breast-feeding and thus less affected by water conditions, and we consider a lower weight for LBW (Column IV in Panel B). By and large, the positive effect of communal provision on child health is robust throughout all these specifications.

Altogether the estimation of heterogeneous effects based on the geographical Inca influence is consistent with the JASS performing better in those districts where the Minka tradition of communal work is expected to have had longer-lasting effects. This tradition may help coordination among JASS members and contribute to the JASS functioning well there. We provide further direct evidence regarding the latter below.

6.3. Governance of the JASS

To explore our third hypothesis, we use the dataset from SIASAR described in Section 4.1. Since the survey contains information mostly on JASS (around 8% of the total are small-scale public systems) we are unable to use it in conjunction with ENDES to compare communal and public provision. Nonetheless, the information is still very useful for analyzing in-depth differences across JASS.

- Table 8 here -

Table 8 reports average values on relevant aspects of the JASS for the three subsamples of Inca influence considered previously: districts where the first Inca settlements stood, districts that were Incan during subsequent expansions of the empire, and districts that were never under Inca rule. While the number of observations for the first two areas is large and relatively balanced (about 3,200 and 5,500 JASS respectively), the number of JASS surveyed in areas that were never Incan is quite small. This is due to the fact that the survey did not cover the whole of the country and certain areas are underrepresented. This fact calls for caution when comparing the values of the areas that were never Incan to the others.

Panel A of Table 8 reports governance variables of the JASS. As observed, the percentage of legalized JASS and of JASS having their own formal rules (one of Ostrom's design principles for successful collective action) is significantly higher in the first Inca settlements than in other areas of the country. Similarly, the JASS in the first Inca settlements appear to be more active (an average of 3.8 meetings in the last 6 months as opposed to 3.0 and 2.5 for areas with less and no Inca influence respectively), they are more accountable to their members, and significantly more active in promoting environmental sanitation. This is in contrast to the JASS in the first Inca settlements which charge lower fees (maybe because their members are poorer or because they contribute more in the form of voluntary work, or both) and have fewer financial resources (monthly revenues). Lastly, the participation of women on JASS boards and registry-keeping is similar in all the areas.

Panel B presents average values of technical and operational aspects of the JASS. It shows that the age and condition of the JASS water infrastructures in the first Inca settlements are, by and large, comparable to other JASS. However, the JASS in the first Inca settlements appear to be more pro-active, since a higher percentage of them carry out preventive maintenance, have their own technicians and, in a significantly larger number, manage to receive technical support. Further survey information, not reported here, revealed that this support comes mainly from local governments and technical offices.[18] Another important difference is the much higher use of chlorine water treatment reported by the JASS in the first Inca settlements.

Altogether, the evidence in Table 8 confirms the conjecture that the JASS in districts with a strong Inca influence have better governance based on their own formal rules. At the same time, despite their lack of financial resources, they seem to run the service effectively due to pro-active maintenance of infrastructures, water treatment and their ability to obtain external aid. This functioning of the JASS squares well with the hypothesis that the norms and social capital built up by the Minka tradition in those areas foster cooperation among community members and thus result in successful collective action.

7. Conclusions

This paper contributes to the debate regarding the effectiveness of communal organizations by empirically assessing the impact of communal water organizations - the associations known as *Juntas Administrativas de Servicios de Saneamiento* (JASS) - on child health in Peru. Our findings show no homogeneous effects of communal water provision on child diarrhea and LBW throughout the country. If anything, in the districts of the Peruvian Coast public provision could be superior while results for the Selva region are inconclusive. However, we find that the JASS have a robust negative and significant impact on diarrhea and LBW in the Sierra region. This is in line with

[18] Technical offices became compulsory at the end of our sample period (2010-2014) and thus they are unlikely to explain our empirical results.

collective theorists such as Ostrom (1990, 2000) that argue that it is not the type of organization but rather its characteristics and practices that make an organization more or less successful.

The positive effect of the JASS on child health is somehow linked to the ethno-linguistically homogeneity of indigenous communities. Nonetheless, the most plausible factor contributing to the good performance of the JASS that emerges from our analysis has to do with a long-standing tradition of communal work called Minka. During the Inca empire, in the pre-Columbian times, the Incas used the Minka system to construct irrigation channels, roads and other infrastructure, and to organize agricultural activities, and this tradition has survived over centuries in those areas with a strong Inca influence. Our estimation of heterogeneous effects of communal water provision shows that it is in the districts where the first Inca settlements stood (mainly districts in the Sierra and a few in the Selva region) where the JASS outperform public systems. In contrast, communal provision does not have a significant differential impact in areas of less intense or no Inca influence. This is consistent with the hypothesis that social capital and norms (in this case due to the Minka tradition) help solve problems of collective action associated with communal projects, and it is also in line with recent work by Talhelm et al, 2014, Lam and Ostrom, 2009 or Fujiie et al, 2005 that find long-lasting effects of historical institutions on the capacity of communities to cooperate. Detailed survey data on water organizations further shows that in the areas of strong Inca influence (i.e. at the first Inca settlements) the JASS tend to have better governance than the JASS in other areas. In particular, they feature higher levels of self-government, more active boards and more transparent processes. In those areas the JASS also appear to be more pro-active and receive more external aid. All this is consistent with the hypothesis put forward by several authors (Isham et al, 1995, Katz and Sara, 1997; Mark and Davis, 2012) that organizations with more participatory systems create a sense of ownership and achieve a greater involvement of community members.

Our results have important implications as far as the effectiveness of community-based projects is concerned. They suggest that communal projects are not a one-fits-all solution. Despite being the only viable way of providing certain services in some areas of developing countries, their success is not guaranteed. This requires institutions with good governance, based for example on social norms and traditions or built in some other way, to overcome the problems of coordination associated with collective action, and to ensure the active involvement of community members. Lastly, governments and other external agents can also help by providing material resources and adequate technical assistance.

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Table(s)

Tables

Table 1. Descriptive Statistics

Variable	Mean (I)	Standard Deviation (II)	Min (III)	Max (IV)	Public Provision Mean (V)	Communal Provision Mean (VI)
Dummy - child had diarrhea recently	0.13	0.34	0	1	0.13	0.14
Dummy - child weight at birth <2.5kg	0.07	0.26	0	1	0.07	0.08
Dummy - child is a girl	0.49	0.5	0	1	0.49	0.5
Child's age (months)	30.24	17.14	0	59	29.95	30.69
Dummy - child is breastfeeding	0.35	0.48	0	1	0.35	0.36
Dummy -child had pneumococcal vaccine	0.58	0.49	0	1	0.57	0.61
Dummy -child had rotavirus vaccine	0.51	0.5	0	1	0.49	0.53
Mother's age (years)	30.02	7.09	15	49	30.15	29.83
Dummy - indigenous	0.11	0.31	0	1	0.02	0.24
Dummy - mother does not have education	0.03	0.16	0	1	0.01	0.05
Dummy - mother has primary education	0.27	0.44	0	1	0.14	0.47
Dummy - mother has secondary education	0.44	0.5	0	1	0.48	0.39
Dummy - mother has higher education	0.26	0.44	0	1	0.37	0.08
Frequency mother washes hands	2.25	1.77	0	4	2.48	1.9
Dummy-washes hands before preparing food	0.68	0.47	0	1	0.64	0.75
Dummy -washes hands before feeding child	0.31	0.46	0	1	0.33	0.27
Number of prenatal visits	8.7	3.21	0	20	9.01	8.21
Dummy -very low income	0.21	0.41	0	1	0.04	0.48
Dummy -low income	0.26	0.44	0	1	0.2	0.37
Dummy -middle income	0.23	0.42	0	1	0.3	0.12
Dummy -high income	0.18	0.39	0	1	0.28	0.03
Dummy -very high income	0.11	0.32	0	1	0.18	0.01
HH density (HH members/no of rooms)	2.26	1.36	0.1	13	2.11	2.49
No of children in HH	2.37	1.39	0	11	2.15	2.70
Toilet facilities dummy -flush toilet	0.56	0.5	0	1	0.81	0.17
Toilet facilities dummy -latrine	0.35	0.48	0	1	0.15	0.65
Toilet facilities dummy -none	0.09	0.28	0	1	0.03	0.17
Dummy -toilet shared with another HH	0.09	0.28	0	1	0.11	0.05
Dummy -HH boils water	0.79	0.41	0	1	0.8	0.76
Dummy -biomass cooking stove	0.35	0.48	0	1	0.12	0.69
Dummy -HH has natural floor	0.38	0.49	0	1	0.18	0.68
Dummy -HH has fridge	0.41	0.49	0	1	0.56	0.17
Dummy -HH has TV	0.85	0.36	0	1	0.95	0.69
Dummy -HH has radio	0.82	0.38	0	1	0.83	0.8
Dummy -HH has electricity	0.91	0.28	0	1	0.98	0.81
Dummy -HH has a vehicle	0.27	0.44	0	1	0.32	0.19
Dummy -HH has telephone	0.18	0.39	0	1	0.27	0.04
Dummy -HH has a mobile	0.85	0.36	0	1	0.93	0.73
Dummy -HH has internet	0.12	0.33	0	1	0.19	0.02
Dummy -HH owns land	0.32	0.47	0	1	0.15	0.57
Municipality size (1,000 inhabitants)	92.80	151.91	0.53	1,069.6	131.55	33.96
Altitude (1,000 meters)	1.41	1.44	0.003	4.66	1.02	2.01

Table 2. Differences between public and communal provision (% of sample observations)

	Public Provision (I)	Communal Provision (II)
Water source:		
Pipeline inside the house	86.73	82.67
Pipeline outside the house	5.57	4.62
Public tap/standpipe	0.74	7.53
Total piped water	*93.04*	*94.81*
Well inside the house	0.06	0.02
Public well	0.04	0.67
Water spring	0.06	0.21
River, dam, lake, pond	0.02	0.23
Tanker truck	0.37	0.13
Bottled water	5.89	1.34
Other	0.52	2.59
Other aspects of the water service:		
Water available 24h	51.90	62.92
Service discontinued in last 2 weeks	23.66	30.01
Chlorine in water (>0.0mg/l) according to test	60.24	6.07
Stores water	94.48	94.27
Resources of districts:		
Per capita municipality revenue in 2010 (soles)	354.23	346.42
Per capita municipality personnel (for 1,000 inhabitants)	6.19	6.08

Notes: All water indicators come from ENDES while the financial and personnel resources of districts are taken from the RENAMU survey on districts.

Table 3. Instrumental Variable regressions

PANEL A -- Dependent variable: Child experienced diarrhea in the previous 2 weeks

	Full sample		Coast		Sierra		Selva	
	First-stage	IV Reg	First-stage	IV Reg	First-stage	IV Reg	First-stage	IV Reg
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Population unit < 2000 inhabitants	0.407***		0.180***		0.553***		0.461***	
	(0.044)		(0.056)		(0.062)		(0.108)	
Communal provision -JASS		**-0.050**		**0.072**		**-0.098****		**-0.163***
		(0.034)		**(0.121)**		**(0.043)**		**(0.088)**
Partial R-squared	0.06		0.02		0.09		0.04	
F-statistic for excluded instruments	83.9		10.3		80		18.2	
(p-value)	(0.000)		(0.002)		(0.000)		(0.000)	
R-squared	0.78	0.08	0.71	0.06	0.81	0.10	0.71	0.07
Observations	22,436	22,436	8,478	8,478	8,955	8,955	5,003	5,003

PANEL B - Dependent variable: Child's birth weight < 2.5kg.

	Full sample		Coast		Sierra		Selva	
	First-stage	IV Reg	First-stage	IV Reg	First-stage	IV Reg	First-stage	IV Reg
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Population unit < 2000 inhabitants	0.394***		0.149**		0.509***		0.468***	
	(0.049)		(0.064)		(0.082)		(0.145)	
Communal provision -JASS		**0.018**		**0.329****		**-0.107****		**0.060**
		(0.030)		**(0.147)**		**(0.046)**		**(0.053)**
Partial R-squared	0.05		0.01		0.07		0.05	
F-statistic for excluded instruments	66.2		6.3		42.9		14.4	
(p-value)	(0.000)		(0.013)		(0.000)		(0.000)	
R-squared	0.78	0.12	0.69	0.04	0.81	0.14	0.73	0.08
Observations	15,088	15,088	5,962	5,962	5,714	5,714	3,412	3,412

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1. Observations for HH that have been living in the same place since at least a year prior to the birth of the child. Both first-stage and IV regressions include the child, mother, HH, geographical, sanitation, hygiene and crowdedness controls described in section 4.2 (and listed in Appendix 1), a quadratic polynomial on population unit size and a dummy for small population units acting as capital of the district. The diarrhea models also include month, year and district fixed effects and the LBW models, month of birth, year of birth and district fixed effects.

Table 4. Instrumental Variable regressions closer to the discontinuity for the Sierra region

PANEL A -- Dependent variable: Child experienced diarrhea in the previous 2 weeks

	Population units with fewer than 10,000 inhabitants (I)	Population units with fewer than 7,000 inhabitants (II)	Population units of between 500 and 3,500 inhabitants (III)
Communal provision -JASS	**-0.084****	**-0.080***	**0.028**
	(0.038)	**(0.043)**	**(0.135)**
R-squared	0.13	0.13	0.18
Observations	5,972	5,819	1,427
Above cut-off of 2,000 inhab (%)	10	8	10
Below cut-off of 2,000 inhab (%)	90	92	90

PANEL B -- Dependent variable: Child weight at birth <2.5 kg

	Population units with fewer than 10,000 inhabitants (I)	Population units with fewer than 7,000 inhabitants (II)	Population units of between 500 and 3,500 inhabitants (III)
Communal provision -JASS	**-0.088****	**-0.101*****	**-0.108***
	(0.035)	**(0.040)**	**(0.058)**
R-squared	0.18	0.18	0.26
Observations	3,665	3,555	986
Above cut-off of 2,000 inhab (%)	11	9	10
Below cut-off of 2,000 inhab (%)	89	91	90

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1.
Observations for HH that have been living in the same place since at least a year prior to the birth of the child.
All regressions include the child, mother, HH, geographical, sanitation, hygiene and crowdedness controls described in section 4.2 (and listed in Appendix 1) and a dummy for small population units acting as capital of the district. The diarrhea models also include month, year and district fixed effects and the LBW models, month of birth, year of birth and district fixed effects.

Table 5. Instrumental Variable regressions -- Heterogeneous treatment effects for ethno-linguistic homogeneity

PANEL A -- Dependent variable: Child experienced diarrhea in the previous 2 weeks

	Full sample	Full sample	Districts with less than 50% Spanish-speaking
	(I)	(II)	(III)
Communal provision -JASS	**-0.251***** **(0.066)**	**-0.008** **(0.038)**	**-0.199*** **(0.110)**
JASS x Ethno-linguistic homogeneity	**0.269***** **(0.070)**		
Ethno-linguistic homogeneity	-1.384*** (0.093)		
JASS x Homogeneity in majority non-Spanish speaking districts		**-0.197***** **(0.064)**	
Homogeneity in majority non-Spanish speaking districts		2.308*** (0.138)	
R-squared	0.08	0.08	0.11
Observations	22,436	22,436	3,638

PANEL B -- Dependent variable: Child weight at birth <2.5 kg

	Full sample	Full sample	Districts with less than 50% Spanish-speaking
	(I)	(II)	(III)
Communal provision -JASS	**-0.047** **(0.058)**	**0.039** **(0.032)**	**-0.175*** **(0.094)**
JASS x Ethno-linguistic homogeneity	**0.088** **(0.068)**		
Linguistic homogeneity	0.022 (0.087)		
JASS x Homogeneity in majority non-Spanish speaking districts		**-0.107*** **(0.062)**	
Homogeneity in majority non-Spanish speaking districts		-0.076 (0.137)	
R-squared	0.11	0.11	0.17
Observations	15,088	15,088	2,225

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1. Observations for HH that have been living in the same place since at least a year prior to the birth of the child. All regressions include the child, mother, HH, geographical, sanitation, hygiene and crowdedness controls described in section 4.2 (and listed in Appendix 1) and a dummy for small population units acting as capital of the district. The diarrhea models also include month, year and district fixed effects and the LBW models, month of birth, year of birth and district fixed effects.

Table 6. Instrumental Variable regressions -- Heterogeneous treatment effects for Inca influence

PANEL A -- Dependent variable: Child experienced diarrhea in the previous 2 weeks

	Full sample		**Only districts in first Inca settlement**			
	All population units (I)	All population units (II)	All population units (III)	Population units with <10,000 inhab (IV)	Population units with <7,000 inhab (V)	Population units with 500 - 3,500 inhab (VI)
JASS	**-0.019**	**-0.007**	**-0.102****	**-0.106****	**-0.090***	**-0.054**
	(0.076)	**(0.037)**	**(0.043)**	**(0.042)**	**(0.049)**	**(0.236)**
JASS x Inca at some point	**0.013**					
	(0.070)					
JASS x First Inca settlements	**-0.094**	**-0.105*****				
	(0.071)	**(0.029)**				
Inca at some point	0.144**					
	(0.063)					
First Inca settlements	0.218*	0.079				
	(0.117)	(0.095)				
R-squared	0.08	0.08	0.09	0.12	0.12	0.15
Observations	22,436	22,436	4,686	3,178	3,085	763

PANEL B -- Dependent variable: Child weight at birth <2.5 kg

	Full sample		**Only districts in first Inca settlement**			
	All population units (I)	All population units (II)	All population units (III)	Population units with <10,000 inhab (IV)	Population units with <7,000 inhab (V)	Population units with 500 - 3,500 inhab (VI)
JASS	**0.008**	**0.028**	**-0.077**	**-0.098****	**-0.117***	**0.171**
	(0.040)	**(0.032)**	**(0.053)**	**(0.048)**	**(0.061)**	**(0.122)**
JASS x Inca at some point	**0.023**					
	(0.033)					
JASS x First Inca settlements	**-0.003**	**-0.022**				
	(0.036)	**(0.027)**				
Inca at some point	-0.135**					
	(0.059)					
First Inca settlements	-0.089	0.052				
	(0.144)	(0.122)				
R-squared	0.12	0.11	0.14	0.16	0.16	0.30
Observations	15,088	15,088	3,028	1,983	1,911	481

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1.
Observations for HH that have been living in the same place since at least a year prior to the birth of the child.
All regressions include the child, mother, HH, geographical, sanitation, hygiene and crowdedness controls described in section 4.2 (and listed in Appendix 1), a dummy for small population units acting as capital of the district, month, year and district fixed effects (diarrhea models) and month and year of birth and district fixed effects (LBW models)
Regressions with all population units also include a quadratic polynomial on population unit size.

Table 7. Robustness checks for first Inca settlements

PANEL A -- Dependent variable: Child experienced diarrhea in the previous 2 weeks				
	Controlling for source of water	Only piped water	Eliminating small capitals	Eliminating children under 6-month old
	(I)	(II)	(III)	(V)
Communal provision -JASS	**-0.114*** **	**-0.111** **	**-0.097** **	**-0.100***
	(0.043)	**(0.044)**	**(0.043)**	**(0.052)**
R-squared	0.10	0.09	0.10	0.11
Observations	4,686	4,567	4,324	4,188
PANEL B -- Dependent variable: Child weight at birth <2.5 kg				
	Controlling for source of water	Only piped water	Eliminating small capitals	Child's birth weight < 2.4 kg
	(I)	(II)	(III)	(IV)
Communal provision -JASS	**-0.100** **	**-0.107** **	**-0.072**	**-0.118*** **
	(0.049)	**(0.049)**	**(0.047)**	**(0.044)**
R-squared	0.16	0.17	0.17	0.15
Observations	1,983	1,930	1,747	1,983

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1. Observations for HH that have been living in the same place since at least a year prior to the birth of the child. All regressions include the child, mother, HH, geographical, sanitation, hygiene and crowdedness controls described in section 4.2 (and listed in Appendix 1) and a dummy for small population units acting as capital of the district. The diarrhea models also include a quadratic polynomial on population unit size, month, year and district fixed effects, and the LBW models, month of birth, year of birth and district fixed effects.

Table 8. Governance and operational aspects of the JASS

Panel A - Governance variables

Variable	**First Inca settlements** Number of JASS	**First Inca settlements** Average values	**Inca at some point** Number of JASS	**Inca at some point** Average values	**Never Inca** Number of JASS	**Never Inca** Average values
JASS is legalized (%)	3,209	53.8	5,501	43.3	114	34.2
Has its own rules (%)	3,209	59.1	5,501	42.1	114	38.6
Number of meetings in last 6 months	3,209	3.8	5,501	3.0	114	2.5
Number of women in board	3,209	0.7	5,501	0.7	114	0.8
Keeps registry books (%)	3,209	31.3	5,501	31.0	114	32.5
Holds accountable to members (%)	3,209	20.1	5,501	18.2	114	15.8
Keeps accountability reports (%)	3,209	19.4	5,501	17.6	114	14.0
Promotes environmental sanitation (%)	3,209	14.5	5,501	6.1	114	2.6
Average monthly fee	3,209	1.46	5,501	1.67	114	3.84
Average monthly revenues	3,209	215.04	5,501	217.64	114	413.33

Panel B - Technical and operational variables

Variable	**First Inca settlements** Number of JASS	**First Inca settlements** Average values	**Inca at some point** Number of JASS	**Inca at some point** Average values	**Never Inca** Number of JASS	**Never Inca** Average values
Years since construction	2,772	13.4	4,765	13.9	101	12.9
State of water source is good (%)	3,209	56.6	5,501	54.0	114	39.5
State of pipelines is good (%)	3,209	1.1	5,501	9.2	114	21.1
State of water storage is good (%)	3,209	13.8	5,501	13.9	114	5.3
State of water distribution is good (%)	3,209	63.4	5,501	62.3	114	50.0
Performs preventive maintenance (%)	3,208	91.0	5,501	87.6	114	83.3
Has its own plumber/technician (%)	3,208	70.5	5,501	46.2	114	53.5
Receives technical support (%)	3,209	29.3	5,501	7.9	114	7.0
Uses chlorine treatment (%)	3,209	63.5	5,501	39.1	114	46.5

Notes: Average values computed from SIASAR survey data for JASS for the year 2015

Table 9. OLS regressions -- Dependent variable: Child experienced diarrhea in the previous 2 weeks

	Full Sample (I)	Coast (II)	Sierra (III)	Selva (IV)
Communal provision -JASS	**0.003**	**0.033****	**-0.002**	**-0.005**
	(0.009)	**(0.016)**	**(0.014)**	**(0.0170)**
Dummy - child is a girl	-0.020***	-0.022***	-0.018***	-0.018*
Child's age (months)	-0.002***	-0.002***	-0.002***	-0.003***
Dummy -- child is breastfeeding	-0.009	-0.011	-0.008	-0.012
Dummy --had rotavirus vaccine	0.008	-0.010	0.024**	0.011
Dummy --had pneumococcal vaccine	0.027***	0.036***	0.018*	0.032**
Mother's age (years)	-0.000	-0.001	0.000	-0.000
Dummy -- indigenous	-0.025**	-0.009	-0.000	-0.123***
Dummy -- mother has primary education	0.014	0.035	0.024*	-0.053
Dummy -- mother has secondary education	0.023	0.038	0.043**	-0.052
Dummy -- mother has higher education	0.008	0.031	0.032*	-0.090**
Frequency mother washes hands	-0.005***	-0.006***	-0.002	-0.011***
Dummy --washes hands before preparing food	0.001	-0.000	0.001	0.001
Dummy -washes hands before feeding child	-0.007	-0.001	-0.017**	0.003
Dummy --low income	0.0092	-0.022	0.017	0.000
Dummy --middle income	0.010	-0.027	0.050***	-0.019
Dummy --high income	-0.001	-0.025	0.044*	-0.059*
Dummy --very high income	-0.017	-0.049	0.031	-0.038
No of children in HH	-0.007***	-0.005	-0.009***	-0.007
HH density (HH members/no of rooms)	0.007***	0.008**	0.005*	0.009**
Toilet facilities dummy --flush toilet	-0.006	0.015	-0.029*	0.016
Toilet facilities dummy --latrine	-0.013	-0.016	-0.023*	0.010
Dummy --toilet shared with another HH	0.000	-0.005	0.017	-0.018
Dummy --HH boils water	-0.028***	-0.024**	-0.036***	-0.027**
Dummy --HH has natural floor	0.004	0.025**	0.007	-0.018
Dummy --HH has radio	-0.016**	-0.025***	-0.023**	0.005
Dummy --HH has electricity	0.015	0.003	0.033**	-0.001
Dummy --HH has a vehicle	0.009*	0.010	-0.002	0.022*
Dummy --HH has a mobile	-0.010	-0.012	-0.016	0.004
Dummy --HH owns land	0.011*	-0.004	0.019**	0.012
Altitude (1,000 meters)	-0.006	0.136	-0.003	-0.032
Municipality size (1,000 inhabitants)	-0.001	-0.001	-0.000	-0.002
R-squared	0.08	0.06	0.09	0.07
Observations	25,603	9,307	10,311	5,985

Notes: For lack of space, except for communal provision standard errors not reported.
*** p<0.01, ** p<0.05, * p<0.1. All regressions include month, year and district fixed effects.

Table 10. OLS regressions -- Dependent variable: Child's birth weight < 2.5kg.

	Full Sample	Coast	Sierra	Selva
	(I)	(II)	(III)	(IV)
Communal provision -JASS	**0.012**	**0.037*** **	**-0.005**	**0.013**
	(0.008)	**(0.014)**	**(0.014)**	**(0.012)**
Dummy - child is a girl	0.012***	0.008	0.013*	0.012
Dummy -multiple children birth	0.478***	0.432***	0.500***	0.579***
Mother's age at child's birth	0.001***	0.001**	0.000	0.002
Dummy - mother smokes	0.034	0.016	0.081	0.039
Mother's height	-0.125***	-0.133**	-0.105	-0.121
Number of prenatal visits	-0.009***	-0.007***	-0.013***	-0.005***
Birth order	-0.006***	-0.007**	-0.003	-0.007**
Dummy -- indigenous	-0.009	-0.072***	-0.007	0.011
Dummy -- mother has primary education	-0.018	-0.062	-0.020	0.020
Dummy -- mother has secondary education	-0.024	-0.076	-0.015	0.008
Dummy -- mother has higher education	-0.031*	-0.088	-0.009	-0.010
Dummy --low income	0.002	-0.045	0.010	0.001
Dummy --middle income	0.009	-0.032	0.013	0.001
Dummy --high income	0.012	-0.028	0.021	0.003
Dummy --very high income	0.033**	-0.006	0.037	0.011
Dummy --biomass cooking stove	0.005	-0.025*	0.023*	0.007
Frequency mother washes hands	-0.001	0.001	-0.002	-0.004*
HH density (HH members/no of rooms)	0.003*	-0.004	0.007**	0.005
Toilet facilities dummy --flush toilet	0.012	-0.007	0.029**	-0.007
Toilet facilities dummy --latrine	0.003	-0.022	0.025*	-0.017
Dummy --HH boils water	-0.004	-0.013	0.003	-0.000
Dummy --HH has natural floor	0.015**	0.024**	0.003	0.018
Dummy --HH has fridge	0.006	-0.010	0.011	0.024**
Dummy --HH has radio	0.000	0.002	-0.009	0.007
Dummy --HH has electricity	-0.016	0.048**	-0.048**	-0.002
Dummy --HH has a vehicle	-0.003	0.003	-0.014	0.000
Dummy --HH has a mobile	0.007	-0.012	0.019	0.006
Dummy --HH owns land	-0.004	-0.002	0.001	-0.013
Altitude (1.000 meters)	0.056***	0.029	0.069***	0.040
Municipality size (1.000 inhabitants)	-0.001	-0.000	-0.003	0.002
R-squared	0.11	0.10	0.14	0.08
Observations	17,030	6,490	6,533	4,007

Notes: For lack of space, except for communal provision standard errors not reported.
*** p<0.01, ** p<0.05, * p<0.1. All regressions include month of birth, year of birth and district fixed effects.

Table 11. Correlation between the instrument and social and public services

	HH is beneficiary of JUNTOS program (N) (I)	HH is beneficiary of JUNTOS program (N) (II)	Electricity at home (III)	Has participated in vaccination campaign in past 2 years (IV)	Educational center in population unit (V)
Population unit < 2,000 inhabitants	0.034	0.030	-0.028	-0.020	-0.237***
	(0.037)	(0.036)	(0.020)	(0.017)	(0.035)
HH controls	YES	YES	YES	YES	YES
Mother controls	NO	YES	NO	YES	NO
Child controls	NO	YES	NO	YES	NO
R-squared	0.63	0.63	0.53	0.199	0.80
Observations	9,455	9,447	22,600	22,298	18,902

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include a quadratic polynomial on population unit size, as well as month, year and district fixed effects.
(N) Data for participation on JUNTOS program only available for the years 2013 and 2014.

Table 12. Falsification tests --Reduced-form regressions for diarrhea and other health outcomes

	Sierra			First Inca settlements		
	Diarrhea	**Cough**	**Fever**	**Diarrhea**	**Cough**	**Fever**
	(I)	(II)	(III)	(IV)	(V)	(VI)
Population unit < 2,000 inhabitants	**-0.054****	**-0.034**	**-0.041**	**-0.063****	**-0.005**	**-0.013**
	(0.024)	**(0.044)**	**(0.031)**	**(0.027)**	**(0.048)**	**(0.035)**
R-squared	0.10	0.11	0.12	0.10	0.11	0.10
Observations	8,955	8,953	8,951	4,686	4,686	4,685

Notes: Robust standard errors in parentheses, clustered by population unit. *** p<0.01, ** p<0.05, * p<0.1. All regressions include the child, mother, HH, geographical, sanitation, hygiene and crowdedness controls described in section 4.2 (and listed in Appendix 1), a polynomial on population unit size, a dummy for small population units acting as capital of the district, month, year and district fixed effects.

Figures

Figure 1. Communal water provision against (log) size of the population unit

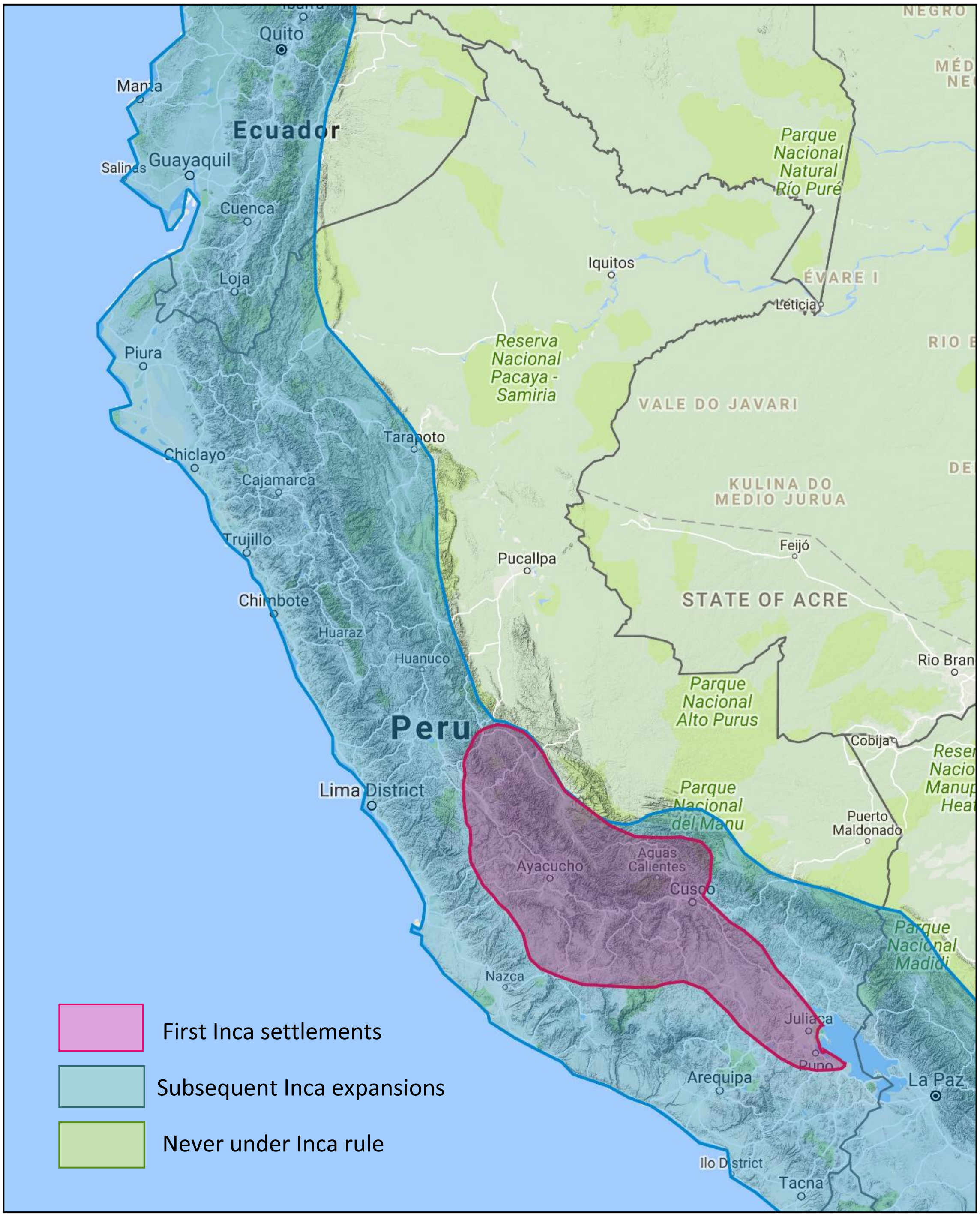

Figure 2. Geographical location of Inca settlements

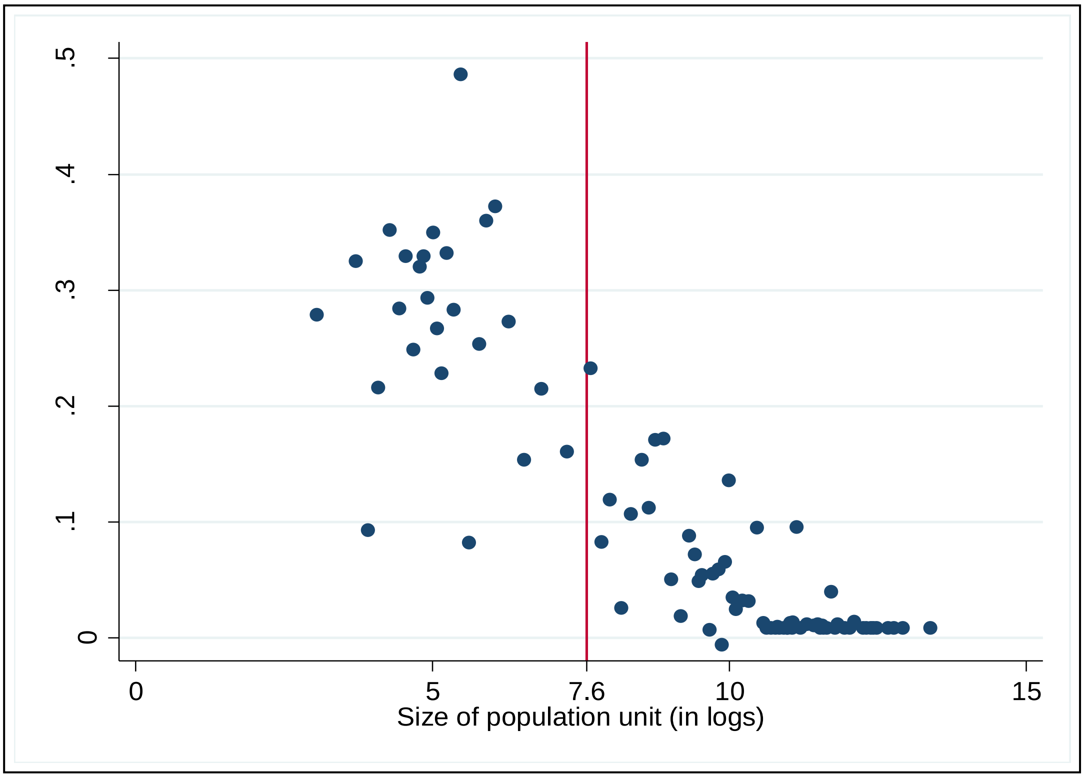

Figure 3. Beneficiary of JUNTOS against the (log) size of population unit

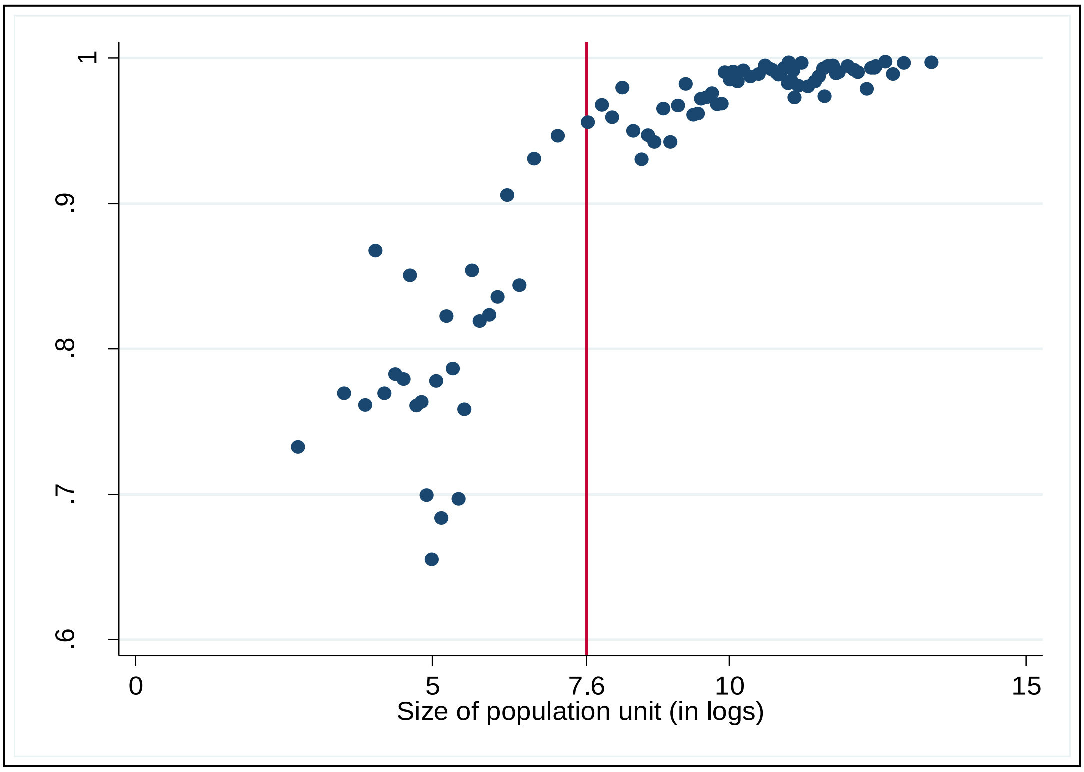

Figure 4. Electricity in the HH against the (log) size of population unit

Figure 5. Participation in vaccination campaign against the (log) size of population unit

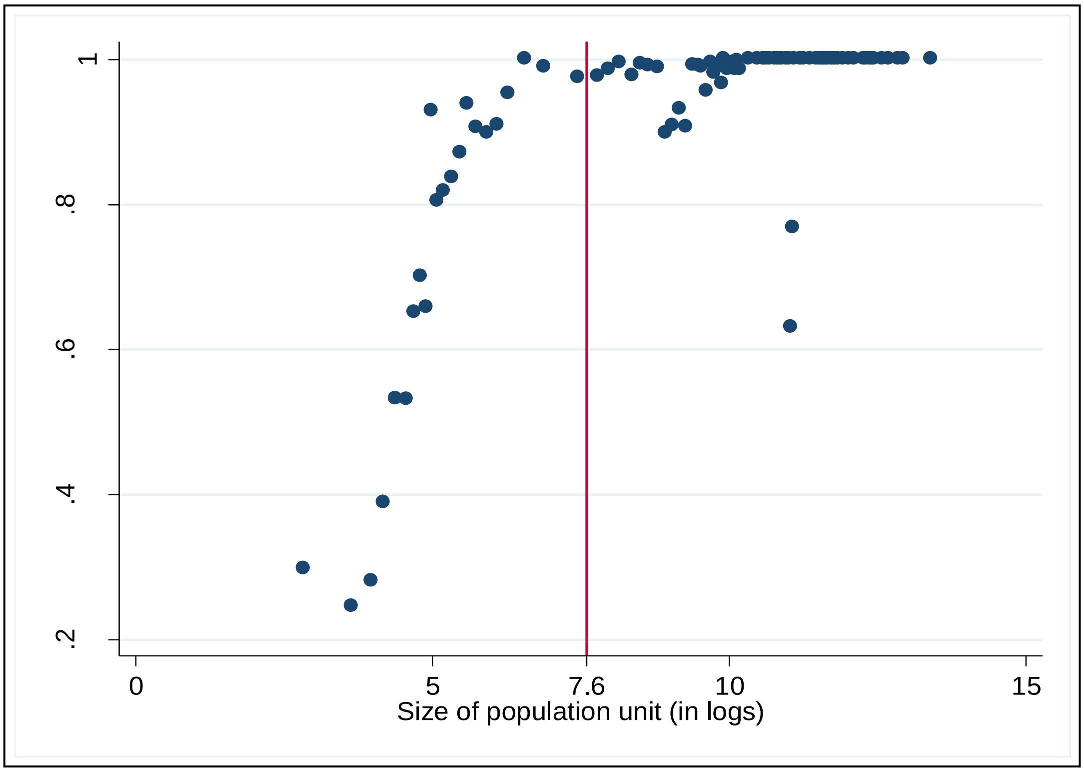

Figure 6. Educational centers in population unit against the (log) size of population unit

Appendix 1. OLS Estimation results

For comparison purposes, Tables 9 and 10 report the OLS estimation results for the diarrhea and LBW models respectively. Estimates for the treatment variable, *Communal*, and the full set of controls, used also in all the Instrumental Variable regression models, are shown. Moreover, the models are estimated for the full sample of households with dummies for the natural regions in Peru (Column I of Tables 9 and 10) and separately for each one of those natural regions: the Coast region (Column II), the Andean or Sierra region (Column III) and the Rainforest or Selva region (Column IV).

– Table 9 here –

– Table 10 here –

As observed, the sign of the estimated coefficient on *Communal* differs across regions. While for the Sierra and Selva regions it is not statistically different from zero in both the diarrhea and LBW models, the point estimates for the Coast are positive and significant. As discussed in Section 4, the potential endogeneity problem seems to result in upward biased estimates.

The controls that appear significantly related to child diarrhea include child gender and age, and also having the pneumococcal vaccine. Hand washing habits, house crowdedness, sanitation facilities in some models and boiling the water are also significantly correlated with diarrhea, with the signs working in the expected directions. Lastly, the coefficients on certain household assets, like having a radio or owning land, are also significant even though the interpretation of the sign is not always easy. In the case of LBW, LBW is negatively and significantly related to prenatal care and the birth order (i.e., the mother having had other babies before) and mother's height, while multiple births or being a girl tend to correlate positively with LBW. House crowdedness and hand washing habits and sanitation facilities are also found to correlated significantly to LBW in some models. Finally, as expected, LBW is positively correlated to high altitudes and to the use of biomass stoves in the Sierra region.

Appendix 2. Validity of the instrument

Validity of the instrument requires that the following conditions are met: i) that the assignment rule of households into communal and public water provision is exogenous, ii) that it cannot be manipulated by households and iii) that there are no other policies or unaccounted factors affecting health outcome that change discretely at the 2,000 inhabitant cut-off too. We believe all these conditions are met as we discuss next. First, the assignment rule is based on an arbitrary administrative classification of district sub-units as rural or urban. Exogeneity of the assignment rule is warranted because the legislative changes regarding the involvement of the JASS in the provision of water were not motivated by differences in health outcomes between the rural and urban sub-units of the districts but rather by the difficulties faced by local governments to offer the water service throughout the district. In many instances the geographical dispersion of the population (that inhibited the realization of economies of scale) and the lack of resources made public water provision difficult, what led legislators to encourage the participation of the JASS. We provide further checks on the exogeneity of the instrument in the subsection below. Second, to the extent that the assignment of water provision systems across population units is motivated by legislative changes it skips the control of households. The only way in which households could manipulate the assignment rule is by choosing their location as to choose the type of water provision. We deal with this potential problem by eliminating the observations from households that changed the place of residence less than a year prior to the birth of the child. Third, one could worry about the instrument being correlated with unaccounted factors that change across rural and urban sub-units. Indeed, being the smallest sub-units of the districts, the rural population units are likely to differ from larger ones in terms of access to other services like health facilities or educational services. Similarly, small and large population units differ in socio-demographic characteristics (for example, the share of indigenous people is higher in rural sub-units) and along other relevant dimensions. However, as long as these characteristics change smoothly, they do not pose a problem;[1] we should only be concerned if there was an abrupt (i.e., discrete) change in relevant factors and/or policies at the 2,000-inhabitant cut-off.

Although it is impossible to check all characteristics and policies as to completely rule out that possibility, we review next the most important programs in Peru as to confirm that in none of them does the eligibility criteria coincide with the administrative classification of population units based on the 2,000 inhabitant cutoff. The most important social program in Peru is the conditional cash transfer program known as JUNTOS. Introduced in 2005 this program aims at alleviating poverty and preventing

[1] We include an exhaustive list of socio-demographic covariates at the child, mother and household level and a polynomial on population unit size, to precisely account for these sources of heterogeneity across rural and urban population units.

the intergenerational transmission of poverty. Beneficiary households get a monthly lump-sum transfer conditional on the children and women in the household attending school and a series of medical checks. The eligibility criteria follows a 3-stage selection process: first, eligible districts are selected based primarily on poverty indicators; within eligible districts, households with children between 0 and 19 year old or pregnant women are selected based on poverty and, finally, there is a community validation of eligible households as to avoid inclusion and exclusion errors of poor households.[2] The eligibility criteria is thus clearly different from the 2,000 inhabitant assignment rule of water provision. We also verify this empirically using data for the years 2013-2014 for which information on beneficiary households of JUNTOS is available at ENDES.

─Figures 3 through 6 here ─

Figure 3 plots whether anyone in the household is beneficiary of JUNTOS against the (log) population of the district sub-unit where the household is located. As opposed to Figure 1 where a clear discontinuity was observed for the type of water provision, there is no evidence of a discrete change at the 2,000-inhabitant cut-off in Figure 3.

- Table 11 here -

Table 11 Columns I and II convey the same information by means of regression analysis. Controlling for covariates similar to those included in the estimation of (2), we find no significant correlation between the 2,000-inhabitant cut-off and being

[2] See Decreto Supremo Nº 130-2004-EF and Perova and Vakis (2009).

beneficiary of the program JUNTOS.

In terms of resources, other relatively important programs in Peru include: the nutrition programs *Qali Warna* (that provides meals and nutritional education to children at ECC and elementary educational centers) and *Vaso de Leche* (providing milk to children between 0-6 years old, pregnant women and women who are breast-feeding), the child-caring program *Cuna Más* for children under 3, and the infrastructure programs *Electrificación Rural* (aimed at extending the electricity coverage) and *Provias* (to build roads).[3] All these programs are targeted to the poor or disadvantaged in some sense (for example, children with malnutrition problems in the case of *Vaso de Leche*) and the eligibility criteria tend to be based at the district level or even higher in the case of some infrastructures. Therefore, they do not coincide with the assignment rule of our instrument. To show some empirical evidence of this, we check the correlation between the provision of important services such as electricity, health services, or education and the 2,000-inhabitant cut-off as we did with for the cash transfer program JUNTOS. Figure 4 plots whether a household has electricity against the (log) population of the district sub-unit, while Figures 5 and 6 do the same for whether the household has participated in vaccination programs and whether there is an educational center at the population unit where the household is, respectively. No discontinuity is observed at the 2,000-inhabitant cut-off for any of these services. Similar conclusions are drawn from the regression analysis reported in Table 11 Columns III through V. With the only exception of the presence of education centers in the population unit where the

[3] See the Peruvian Ministry of Economics and Finance at http://www.mef.gob.pe/.

household is (which, in any case, is negatively associated to the population unit being rural), there is no significant correlation between the 2,000-inhabitant cutoff and the analyzed services. All in all, the evidence presented above makes us confident that no other relevant discrete change takes place at the 2,000-inhabitant cutoff used in our identification strategy.

Appendix 3. Further checks on the validity of the instrument

We present further evidence that supports the instrument meets the exclusion restriction condition, that is, that it has no effect on the health outcome of interest other than through the endogenous variable of water provision. In order to better understand the exclusion restriction condition, let us re-write our model as follows:

$$D_{ihdt} = \alpha . Communal_{hdt} + \lambda . Z_{hdt} + X_{ihdt} . \beta + f(size_{hdt}) + \delta_d + \eta_m + \tau_t + \varepsilon_{ihdt}$$

$$Communal_{hdt} = \pi_1 . Z_{hdt} + X_{ihdt} . \pi_2 + g(size_{hdt}) + v_{hdt} \qquad (3)$$

Notice that this model is just the same as in (2) with the only difference that we now allow for the instrument to also belong in the main estimating equation. The reduced-form equation associated to the model above is:

$$D_{ihdt} = \varphi . Z_{hdt} + X_{ihdt} . \phi + h(size_{ihpt}) + \delta_d + \eta_m + \tau_t + \mu_{ihdt} \qquad (4)$$

where $\varphi = \alpha\pi_1 + \lambda$, $\phi = \alpha\pi_2 + \beta$ and $\mu_{i\square dt} = \alpha v_{\square dt} + \varepsilon_{i\square dt}$. The parameter φ captures the total effect of the instrument on the health outcome of interest. It includes