# Collective Action, Reputation, and Social Support Networks in the Andes of southern Peru

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A dissertation
submitted in partial fulfillment of the
requirement for the degree of

Doctor of Philosophy

University of Washington

2013

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# Abstract

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This research approaches two interrelated aspects of life in an Andean community. First, I explore the management of communally owned herds, gardens and other common pool resources. Specifically, I address how successful collective action (CA) can be maintained in a social environment in which there are enticements to free ride, especially given the lack of punishment in the study community. Second, this research explores the dynamics of agricultural, health advice, and food sharing networks. While the health benefits of inclusion in support networks have been documented around the world, we know much less about exactly how network membership is established and maintained.

Several theories have emerged to explain how CA can arise and persevere. Costly signaling theory predicts that differential participation in CA can convey information about qualities of fellow community members that are otherwise not easily observable, such as cooperative intent, knowledge, work ethic, skill and/or physical vitality. Conveying such information may enhance access to adaptive support networks.

The research presented here proposes that one method for building an agricultural support network is by signaling one's worth as a network partner through participation in CA, which involves predominately agricultural tasks. Findings support my prediction that those who contribute more to CA have greater reputations as reliable, hard workers with regard to CA, and are considered the most respected, influential, and generous people in the community. My predictions that those with greater reputations have more social network partners, are relatively good reciprocal partners, and live in HHs that experienced better health were also supported. In a separate analysis, this research found that access to (and position in) health advice networks is associated with better health, and that those with knowledge about traditional medicines were among the most respected people in the community.

This research adds to a growing literature that focuses on the role reputational incentives play in solving the tragedy of the commons, particularly in contexts where there is minimal punishment of free riders. This work also offers insights into how support networks form, focusing on the role of public contributions (collective action) in honestly signaling qualities that make one a valuable partner.

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# ACKNOWLEDGEMENTS

First and foremost, I'd like to thank the co-chairs of my committee, Professors Donna Leonetti and Eric Smith, for their mentoring during my time at UW. When my ambitions were running low, Donna and Eric were always there, eager to throw another log on the sometimes fainting fire. I'll miss my long and interesting talks with Donna about myriad topics, some anthropological, some not. After listening to me ramble about some peripheral interests, she sent me James Carey's paper on social support networks in the Peruvian Andes, which set this research in motion. Eric was always there to provide guidance when I needed it. A scholar in every sense of the word, he nudged me off the comfortable perch of mediocrity to produce work of which I am truly proud. From the development of this project to the interpretation of its findings, Eric's insights have been invaluable. I look forward to future collaborations with Donna and Eric, whether it's musical, culinary, or academic. Many others have mentored me throughout this dissertation, especially Professor Steven Goodreau, who offered much needed encouragement and advice along the way.

I would like to give special thanks to R. Brooke Thomas, who not only introduced me to the *altiplano* and its wonderful people, but also helped prepare me to successfully "navigate the social landscape" of Nuñoa, as he would say. This research would not have been possible without Brooke (who happens to be a former mentor of my mentor, Eric). I was lucky enough to have spent fun times in Nuñoa with Brooke that I will always remember. I'd like to also thank one of Brooke's students, James Carey. Though I've never met Jim, his work on social support and health in the highlands was extremely inspirational.

This project would not have been a success without the help of two research assistants, Luz Marina Antezana Velasquez and Jhon Vladimir Machaca Caceres. If not for Luz Marina it is likely the study community would not have granted me access. Vladimir was an excellent interviewer and became a good friend of mine, always willing to jump on the motorcycle and venture into the countryside to visit distant

communities. I thank the Cala family for taking me in and provided helpful advice as I adjusted to Andean culture. I would like to thank the mayors of Nuñoa during my stay, especially Jose Silvestre, for giving their approval for this research.

My wife, Lisa Dunlap, tolerated my time abroad and even more time staring blankly at a computer screen. She has been a good sounding board when times were tough, and has been a fabulous copy editor for this dissertation. My parents have always been encouraging and I thank them for biting their tongues throughout my life as I've followed one crazy idea after another.

I'm extremely lucky to have met two wonderful people, Alyse Wheelock and Meagan Mazzarino, who were also conducting research in the area. I will never forget the great times we had in Nuñoa and in the countryside.

Finally, this research would not have been feasible without a generous grant from the US National Science Foundation (grant BCS-0962142).

# DEDICATION

This dissertation is dedicated to my friends in the southern highlands of Peru. Their trust and faith in me will never be forgotten.

# Chapter 1: Evolutionary Perspectives on Collective Action

This chapter explores what social scientists call "collective action problems," which can occur when common-pool resources are managed. I also discuss solutions to collective action problems that have been proposed by evolutionary social scientists, focusing on how reputation, gained through high investment in collective action, can help solve the problems that are often responsible for preventing or unraveling successful collective action. The chapter concludes with a description of the types of collective action that occur in the study community.

## *Collective action*

In this dissertation, collective action (CA) is defined as any occurrence whereby a group of two or more people (a collective) cooperates in order to manage or produce something related to the collective's common-pool resources. A common-pool resource (CPR) is a product that is shared equally among those who are part of the collective. While the successful management of CPRs occurs throughout the world, communally owned resources can result in social dilemmas in which some pay higher costs to generate the CPR, while others fail to pay their share or reap disproportionate benefits (Hardin 1982; Ostrom 1990; Smith and Wishnie 2000). Two CA problems that can potentially inhibit successful group cooperation in collectives like the study community are free riding and overappropriation (Ostrom and Gardner 1993).

Despite the prevalence of CA across human societies, in many cases contribution is not equal; some households (HHs) contribute more to support CA, despite the fact that other HHs who contribute less (or nothing) receive equal benefits. This is an example of free riding, which occurs if individuals do not pay the costs of producing or maintaining the CPR, but are not excluded from enjoying the benefits of the CPR. Overappropriation can occur if the amount of the resource each individual takes is not closely regulated, and some take more than is fair and/or sustainable (Ostrom and Gardner 1993). These factors—free riding and overappropriation—can result in the "tragedy of the commons" whereby selfish behavior

will erode the commons until its demise (Hardin 1968). Despite Hardin's famous proposition (which has been modeled extensively), CPRs and their successful collective management are ubiquitous, which raises the question of how this is accomplished.

### *Evolutionary approaches to collective action*

Collective action problems associated with CPRs have generated a great deal of interest among social scientists, including anthropologists (Agrawal 2003; McCay and Acheson 1987; Olson 1965; Smith and Wishnie 2000; Ostrom 1990; Hardin 1982; Acheson 2006). A diverse set of theories and methods have been used to explain aspects of CA, yet our understanding is incomplete (Ostrom 1990). Of particular interest for evolutionary anthropologists is that successful CA can occur in the presence of free riders and the conspicuous overappropriation of CPRs by some members. Free riders and/or over-appropriators would seem to have an adaptive advantage over those who contribute more to CA or consume fewer CPRs, effectively unraveling successful CA. Clearly, this raises a number of challenges for explicating CA from an evolutionary perspective. Recent ethnographic, experimental and modeling approaches, however, have shed new light on CA (Smith and Bliege Bird 2000; Price 2003; Milinski et al. 2002; Barclay 2004; Panchanathan and Boyd 2004). This section briefly surveys prospective solutions to CA problems, inspired by evolutionary theory, that consider the reputational benefits of prosociality in CA contexts.

#### Punishment and institutional measures

While this review of evolutionary approaches to CA focuses on the role reputation plays in solving CA problems, some evolutionary theorists have modeled noteworthy systems that do not require reputation to be a factor in the successful managing of the commons (Boyd and Richerson 1992). In sum, these models emphasize punishment and institutional measures that increase the cost of free riding to a degree that exceeds its benefits. Social norms and/or governing institutions have been shown to effectively reduce free riding and overappropriation in mathematical models and real-life examples (Boyd

and Richerson 1992; Ostrom 1990, 2000; Smith and Wishnie 2000). While these factors can help solve the tragedy of the commons, they create an additional dilemma since all members likely do not pay the same costs associated with enforcing these norms, what is referred to as the second-order free-riding problem. Solutions to this second-order CA problem that do not involve reputational benefits of enforcers (or costs to non-enforcers) have been proposed (Boyd and Richerson 1992; Gintis 2000; Henrich and Boyd 2001; Boyd et al. 2010). Although these models are compelling, it is likely that successful CA can't be managed by punishment alone. Rather, it may require additional mechanisms—namely reputation—to work in concert with punishment to resolve first- and second-order CA problems.

**Signaling**

For years, biologists, anthropologists, economists and others struggled to explain the presence of certain morphological and behavioral phenomena that appeared, at first glance, maladaptive and/or uneconomical (Zahavi 1975; Mauss 1924; Veblen 1899; Spence 1973). Energetically costly traits and uneconomic behaviors such as peacock tails or altruism offer no clear advantage to the individual, yet come at a great cost. One explanation for this phenomenon goes by many names—conspicuous consumption, handicap principle, show-off hypothesis, costly signaling theory—but each of these paradigms share a common theme: costly displays and behaviors can demonstrate underlying qualities of a signaler, and can provide a net benefit to both signaler and signal observers under the right conditions.

In this dissertation, I concentrate on the costly signal model, which originated independently in economics and biology. In biology, the story begins with a desire to explain how sexually selected traits emerge. Zahavi (1975) proposed that the effectiveness of a sexual display lies in its ability to provide information to the *selecting* sex about the quality of the *selected* sex. By advertising this quality, the selected sex (usually male) will subsequently breed with better mates and/or at higher frequencies. The benefit for the selecting sex (usually female) is the ability to mate with a higher quality male, ensuring that her offspring will possess his adaptive genes or that he'll provide other (direct) benefits to her and her offspring. For a male, there are significant costs associated with this type of mating behavior, such as the

energy required for an elaborate character or behavioral display or courtship, increased risk of predation due to the elaborate display, time spent producing the display, and so on. But it is the cost of the signal that ensures its honesty; that is, a female is certain she is not being tricked into a suboptimal mating by a low quality-male, since he can't afford the signal costs or produces a recognizably weaker signal (Zahavi and Zahavi 1997). Choosy females can mate with the highest quality males by observing their displays carefully, while the best males produce more offspring. Thus, costly traits could be a method of honest communication between males and females who, while having conflicting reproductive interests, can mutually benefit from the exchange in information.

Zahavi's idea did not gain widespread attention until it was shown to be logically cogent when mathematically formalized by Grafen (1990) and others. Four conditions must be met to stabilize a costly signal dynamic: (1) signalers differ in qualities that matter to observers (e.g., health, generosity), and these attributes are difficult to observe in other contexts; (2) the opportunity for deceit by low-quality signalers creates a conflict of interest between signalers and observers; (3) high-quality signalers pay lower marginal signal costs or receive greater marginal benefits from signaling; and (4) observers benefit from the knowledge they gain from the signal and/or future social relations with signalers (Johnstone 1997; Bliege Bird and Smith 2005; Grafen 1990). The third condition is critical, as it makes it unprofitable and/or too expensive to provide misleading signals of quality (Johnstone 1997; Bliege Bird and Smith 2005). Under these conditions, honest communication can evolve despite the sometimes conflicting interests of signalers and signal receivers (Maynard Smith and Harper 2003).

Costly signaling theory has been applied to several anthropological puzzles, including why hunters share meat unconditionally, people engage in costly ritualistic behavior, young men take unusual risks, some contribute more to CA, and societies create large monuments or other "wasteful" displays (Smith et al. 2003; Sosis and Alcorta 2003; Lyle and Sullivan 2007; Neiman 1998). Contributing more to the production and maintenance of a CPR than other community members may be a costly signal that honestly broadcasts adaptive information regarding the signaler's generosity and cooperative intent (Smith and Bliege Bird 2000; Barclay and Willer 2007; Gurven et al. 2000; Gintis et al. 2001), health

(Lyle et al. 2009), physical and/or cognitive abilities (Smith et al. 2003) and/or trustworthiness (Bergstrom et al. 2008). High contributors build reputations as generous, reliable, and/or hardworking people via their conspicuous, honest signals of underlying quality in CA contexts. A favorable reputation can benefit the signaler in a variety of ways, including a higher age-specific reproductive success, higher quality mates, better treatment of their offspring, more reproductive opportunities, greater social support from more people, more allies, greater influence, and greater deference from others (Smith et al. 2003; Sosis 2000; Gurven et al. 2000; Barclay and Willer 2007; Milinski et al. 2002; Barclay 2004; Lyle et al. 2009; Nelissen 2008; von Rueden et al. 2008). Contributing to and evaluating these reputations also has adaptive outcomes for those who observe the signal. Assessing the productivity or reliability of fellow community members in a highly visible environment (CA) allows individuals to develop (or try to develop) social relationships with whom they deem high-quality social network partners. Consequently, a positive reputation may enhance one's access to support networks, maintain one's membership status within an existing network, and/or increase the amount of help received from a support network (Barclay 2004; Bliege Bird and Smith 2005; Gintis et al. 2001; Gurven et al. 2000; Nelissen 2008).

It is important to note that these models don't require the signal to be directed at one sex or another. Rather, information gained from observing the signal is useful to both men and women, and signalers can benefit from social relations with men or women. For instance, knowledge about the skill of a hunter (based on his donation to public feasts) is useful for women (who may consider him as a potential mate) and men (who may consider him a potential ally). Similarly, those who invest more time and energy into CPRs that are vital for HHs signal qualities as detailed above that benefit both sexes. It is also important to note that unlike hunting in most foraging societies, women contribute to CA in the study community, and are also signaling, a dynamic that has been greatly ignored in the literature on signaling behavior (but see Hess and Hagen 2006).

What insights does CST provide to our understanding of the free riding problem in CA contexts? Unlike other models that approach CA, first- or second-order free-riding problems are less difficult to explicate, since the presence of free riders is a somewhat expected outcome of a CST dynamic.

Advertising underlying quality (e.g., sharing meat at public feasts or contributing greater time and effort to CA) inevitably leads to some level of "waste" that then leads to some level of free riding (e.g., eating without contributing to a public feast or enjoying the benefits of CPR without contributing one's fair share). But the presence of free riders will only serve to make the difference between signalers (contributors) and free-riders (or low contributors) more conspicuous. Consequently, costly punishment is not always necessary to stabilize CA, and when punishment is necessary, new signaling opportunities arise, since incurring the costs of punishing others can signal qualities valuable to have in social network partners, such as generosity, loyalty, strength, and so on (Gintis et al. 2001).

**Indirect reciprocity**

A key premise of direct or conditional reciprocity (e.g. reciprocal altruism) is that actors will interact frequently, sharing with others who have shared with them (Trivers 1971). Many cases of human prosociality such as blood donations involve people sharing with others even though it is improbable that they will knowingly interact in the future. However, those who know of the donor's prosocial behavior may choose to cooperate with the person because of his or her prosociality (Lyle et al. 2009). Like CST, indirect reciprocity (IR) considers the reputational benefits of prosocial behavior when explaining group cooperation (Alexander 1987; Roberts 2008) and the successful management of CA (Panchanathan and Boyd 2004). Indirect reciprocity is conceptually rather simple, concentrating more or less on how prosocial individuals can positively assort. From the IR perspective, the "goal" of prosocial behavior is to receive future "reciprocity" from others who observed or know about the initial act, instead of the beneficiary of the initial prosocial gesture, as predicted by models of direct reciprocity. Two critical components of IR are that information about the prosociality of individuals can be effectively spread and known, and that cooperators choose to cooperate with other who share their prosocial propensities.

Using simulations, Nowak and Sigmund (1998) demonstrated that cooperation can spread even if actors have little chance of meeting one another in the future so long prosocial individuals were helped over time. The image score system used in Nowak and Sigmund's model rewarded cooperators by

increasing the image of the prosocial individual in the minds of third party observers, and conversely reduced the score of non-cooperators. The foundation of this simulation is that actors have the ability to observe others who behave in a prosocial manner and reward them by providing future help. Over time, those who have a history of prosocial behavior establish a reputation as such and receive aid from other prosocial actors. While compelling, the "image" explanation of IR in action does not appear to be an evolutionarily stable strategy (Leimar and Hammerstein 2001). Other modes of IR have been proposed, such as the "standing" strategy, which overcomes a weakness of the image score concept – those who do not share with non-cooperators incur costs that affect their image score (Panchanathan and Boyd 2003).

What insights does IR offer for researchers studying the successful management of CA? As discussed below, the evolution and maintenance of large-scale cooperation can occur if free riders are punished (Fehr and Gachter 2002). But who pays the cost of this punishment, whether through the enforcement of social norms or laws within a system operating under IR? Modeling approaches indicate it is possible to exclude free riders from a CPR without paying the significant costs that come with direct enforcement, so long as free riders are shunned from the benefits of dyadic cooperation in social contexts outside of CA. Of course, shunning must be socially acceptable and not lead to reputational costs. Panchanathan and Boyd (2004) have modeled the evolution of IR in a hypothetical CA context, in which there are three strategies: cooperators who contribute to CA and also dyadically help anyone in need, shunners who contribute to CA but only help those who have a prosocial reputation, and defectors who do not contribute to CA or the mutual aid of others. In this dual CA-mutual-aid model, shunning free riders effectively eliminates the second-order free rider problem, since shunning actually provides a benefit to the shunner (avoiding the sucker's payoff). As for defectors, if the costs of exclusion from mutual-aid relations exceed the benefits of free riding, they will either fade away or learn to cooperate (Panchanathan and Boyd 2004). Panchanathan and Boyd's model offers the most convincing argument of the effectiveness of IR in CA contexts. Importantly, their model shows that IR and CST explanations are not necessarily mutually exclusive, since their simulations begin with CA prosociality (signaling), which sets the stage for positive assortment of cooperators (IR).

### *Collective action in Pucucanchita*

Common-pool resources such as communally owned herds and gardens play an important role in the sustainability of life in the highlands of Peru (Gelles 2000; Trawick 2003; Kuznar 2001). In the study community of Pucucanchita (pseudonym), CA is diverse and frequent, ranging from community irrigation projects to refurbishing community buildings. In this section I will survey examples of CA in the study community, discuss the costs and benefits of CA for HHs, and assess the current state of free riding and overappropriation.

#### Agricultural tasks

By far the greatest number of CA tasks concern agriculture. Depending on the season, *campesinos* must organize and conduct these tasks several times a month. Regarding the communally owned herds, residents administer routine vaccinations (and other health prevention measures), selectively castrate those males that have low-quality fibers, and initiate other breeding programs. These tasks require community members to divide the herd and sometimes contain the animals in a fence constructed from rock. I will discuss one type of animal husbandry CA task that I participated in, shearing, which involves the most coordination and requires a large number of participants.

*Esquila*, shearing the wool of the animals, provides an important subsidy for the community. During the first day of my observations the white Suri and Huacaya breeds were shorn. Before the shearing began a short ceremony was performed with the president presiding. The ceremony was performed around a rock, permanently in place, that was used by the men to sharpen their blades. The first round of shearing was of the Suri breed of alpacas, the breed with long, dreadlock-like wool. The animals were brought into the corral and about half were chosen to be shorn. During this time the president and another resident were butchering an alpaca that was to be eaten during the lunch break. There is sexual division of labor with all CA in this community, and *esquila* was no exception. The men did the shearing while the women processed the shorn wool. Women were also in charge of keeping the

animals together (since there is no gate the animals can escape if not watched) and treating the animals when they were cut during shearing.

Shearing is a rather straightforward task that was conducted by a pair of men. Once an alpaca was chosen to be shorn, the two men grabbed it and wrestled it to the ground. One man worked from the head down while the other worked from the butt up; individuals did not tend to switch roles. As the wool for each animal was being shorn it was placed in a pile. Shearing is a fast process that only takes about five minutes to complete from choosing an animal to releasing it after shearing is complete. Shearing is done with large scissor-like instruments with 8-inch long blades. Each man has his own pair which is sharpened often with care and attention. During my observations, about 10% of the animals endured cuts from the blades. After the men yelled "*corto* (cut)," one of the women would come hurriedly with alcohol or iodine to treat the wound. The animals, even those that experience rather nasty cuts, were not treated any further. While some cuts were severe, they were usually laughed off by the men. Joking criticism was made about the quality of the "*esquilero*" who cuts the animal badly. When there was a bad cut most people came to look and a little extra care was given to the animal, but in my experience they never stitched even the most severe cuts. Women also worked in pairs as they collected and processed the wool for transport. After gathering the shorn wool, the women combined it and twisted it together while standing about two meters apart. The women prepared the wool for about three or four minutes, then tied the piece of wrapped wool together and placed it in a pile. The wool was eventually placed in large bags.

When it was time for lunch everyone headed to the community kitchen and meeting area about 1 km away to eat the freshly prepared meal. All of the men and some of the women carried the bags of wool to be stored in a community building. Two or three women had been preparing the meal all morning. They prepared much more food than was needed for the work party. This is not a mistake; each person brought a plastic bag that was filled with meat and potatoes, which amounts to a half kilo of meat and a half kilo of potatoes. The workers took a seat either inside or directly outside of the community building and ate directly from the bag. After finishing eating they tied up their bag and we walked back to the work site. The food taken home is enough for a meal or two, which is a nice incentive for people to come

work, as the food is very tasty. Before returning to work, everyone sat down to chat and chew coca. As usual, the men sat together in one group and the women in another, though nearby enough for chatting between the groups. In fact, the women would often overhear the men talking about something and offer their perspective or criticism, which usually ended in laughter. Most of the time these conversations are in Quechua (sprinkled with some Spanish).

After everyone had a nice wad of coca going, it was back to work. Work continued for another three hours until all of the white alpacas had been shorn. Since the animals were already pinned at this point it was a good time to do several others necessary tasks, for instance separating the mothers from their *crias* (young alpacas), doing pregnancy tests, and vaccinations. In the morning there was one break before lunch and another break between lunch and completing tasks for the day. The breaks last for a half an hour to an hour. The women sit together and talk and drink soda and chew coca. The men sit together passing around some alcohol, drink soda, and chew coca. The men also take this time to sharpen their shears. The second day consisted of shearing the colored alpacas and llamas, which comprises roughly 10% of the community herd. Shearing these animals takes a little more time and extra care since the animals and their wool are more valuable.

Several tasks are required in the community gardens where quinoa, several varieties of potatoes, and other crops are grown. Community members meet twice a year for *cosecha* (planting) and *sembria* (harvesting) to engage in these tasks, though each may span several days. Prior to *sembria*, manure must be gathered and brought to the garden, which is done by hand or donkey and must be carried over difficult terrain. I will discuss my experience planting *papas* (potatoes) in the community. When we arrived the *chacra* (garden) was mostly prepared, with high rows (one-third meter high). There were several piles of manure around the *chacras*. The process begins with workers, men and women, filling a blanket or large piece of thick, woven plastic with several kilos of manure. Two edges of the plastic are tied together and strapped around the shoulder while the other side is left open in order to deposit the manure exactly where the worker wants it. This task is physically demanding, considering the weight of the bag and the difficulty walking with it through the high, rough rows. The manure exited the bag as workers, including

myself, shook the bags back and forth continually and consistently while walking up and down the rows in order to ensure that an equal amount was distributed. It is important to note that all of these *chacras* were on the sides of very steep hills. The top of a *chacra* can be over 50 meters in elevation higher than the lower part of the *chacra*, on precarious slopes as steep as 60 degrees.

After a couple of hours the group took a break, with the men and women sitting in separate groups. My assistant and I were sitting with the men during this break when one of the workers spread a blanket in the middle of our circle. We offered a few two-liter bottles of sodas which were immediately opened and passed around in typical Andean fashion. Slowly, one by one, everyone threw food into the blanket: bread, muffins, and popped corn. After about a half an hour of resting, the president began preparing for the ceremony to bring luck to the harvest. Everyone gathered together, men and women, and a bottle of wine was opened and placed next to a large bag of coca. Each person stood up and walked to the bag of coca, which was in front of the president, and carefully chose three or four leaves. They searched carefully for the perfectly shaped and greenest leaves. The president had already chosen his at this point and was holding the leaves with both hands between his index fingers and thumbs. Each person handed him the leaves they had chosen and the president carefully arranged them one on top of the other with the stems pointing down. Once everyone had given him the leaves, two gentlemen approach the president, one carrying what resembled jewel-like candy, and another holding seeds. Holding these items in his hands, the president walked alone toward the middle of one of the *chacras*. Then, another man carrying a bottle of wine joined him. The coca and seeds were placed in a small hole in the middle of the *chacra* and wine was poured over the top by the president. He then returned to the group, poured a glass of wine, and tossed it on the piles of papas that were about to be planted. Five or more people performed the same ritual, though not everyone participated. I should note that of all of the agricultural ceremonies that I witnessed, this was the most significant. Not only were the details more intricate, but the mood was unusually serious, and one could feel the worry and hope around the success of the coming year's harvest.

After the ceremony, the planting of the *papas* begins. Planting is fairly straightforward. Teams of two (one man and one woman) work together. The women fill a *manta* (blanket) or other blanket-like

fabric/plastic with several kilos of tubers to be planted. The men use a large pick axe to knock a piece of dirt away making a crevice in a row. The women place either one or two tubers into the furrow depending on its size. While the locals handle this work with relative ease, I, playing the role as planter, clumsily stumbled up and down the hill, feeling on the verge of cardiac arrest. It was interesting to see that a bit of competition occurs as the teams "race" up and down the hills. Each team of two, which spans eight or so teams standing a few feet apart, begins planting on the bottom of the hill. Next, without any apparent signal, everyone begins planting, working their way up the steep hill. What makes it interesting is that, instead of continuing back down the hill after reaching the top, each team stops and waits for everyone to finish. My assistant and I finished last each time, though I think the group appreciated the rest they got while waiting for us. Then, back down the hill and the process continues. Notably, there is no "trash talk" or praise, though there may be subtle recognition of the most effective workers during breaks, which tends to be the case with every CA event. Planting takes all afternoon, but participants rest often for a fresh chew of coca and some soda (and a bit of alcohol for the men). While planting occurred, two women in a nearby shed were preparing lunch from a freshly butchered alpaca, and quinoa and potatoes from last year's harvest.

There is an additional type of farming task that should be noted involving the production of *chuño*, a small and nutritious freeze-dried potato that requires quite a bit of processing. After harvest, potatoes are soaked in a stream exposing them to near-freezing water, and later sundried in a field. These potatoes can be stored for over a year. These tasks require guarding against theft at all hours. A person sleeps in a small improvised hut next to a stream during the freeze part of the freeze-dry process, and the *chuños* are monitored while drying in a field close to the community buildings. This is a type of CA that is different from other types of CA since it involves typically only one person who spends the night along the river while they are soaked and another when they are dried.

**Irrigation canals**

Water used for irrigating crops and for domestic use is an important CPR in cultures throughout the world (Lansing 1991; Eastman et al. 1997; Gelles 2000). In Pucucanchita, *acequias* (irrigation canals) distribute water to members of the community to support vital subsistence agriculture and provide water for HH consumption. These *acequias* divert water from snow melt and streams into a main ditch using locally collected materials. The main ditch then divides into smaller, lateral ditches which irrigate pasture and provide water for the HHs and its animals. The dams and other structures of the *acequia* must undergo routine maintenance, and emergency repairs can be required several times per year to repair flood damage. Further, sediment and other debris accumulate in the main ditch and laterals, requiring them to be maintained and repaired regularly. Routine maintenance of *acequias* ensures an optimal flow and distribution of water, which benefits the community as a whole. Additionally, new canals must be trenched from time to time to accommodate additional farming or to replace older *acequias*.

In Pucucanchita, cleaning old canals and digging new ones occurs once a year but takes a few days to complete. The community-led effort focuses on cleaning the main canals (*madres*), whereas the canals that are close to the HH's *cabañas* are maintained by the HH. My description of the community-led effort (i.e., CA) is based on interviews and not observation. Unfortunately, since the annual cleaning of the *acequias* takes place in March, I was unable to participate in this CA (fieldwork was conducted from May to January). On a few occasions I did observe the cleaning and reworking of *acequias* that were located near each HH, and not a part of the irrigation network that the *comunidad* maintains during CA. Regarding CA for the communally owned *acequias*, participants first meet briefly at a staging area, devise a plan, then crews of two typically set out to work the *acequias*. Men and women take part in these events, but as with most CA there are more men at the work site. During cleaning, one person from each team of two works at each side of the *acequia* starting on its origin and progressing down the hill. *Acequias* in this community, depending on where they fall up or down stream, don't tend to get larger than one-half meter wide. Consequently, two adults can move quickly down an *acequia,* tending to the areas that need to be addressed. Families that share *acequias* in the same "network" tend to pair up for

this task. As with the CA tasks that involve a large number of workers (basically all CA tasks except vaccinations and preparation of *chuños*), there is a large meal that is prepared at the staging area, which is usually a team of two or three women. This task is different than other CA tasks in that it is spread out across the community and not a group activity in which everyone is working together in a small area, like a corral. This is important to note, since helpers can gain direct information about the work ethic, skill, and the like of their work partner, but can only gain indirect information about like qualities of other CA helpers for this event.

***Refacción***

In Pucucanchita, several communally owned structures must be maintained, a process referred to as *refacción* in the study community. These tasks require a wide range of skills and are physically laborious. *Refacción* is typically conducted annually on these mid-sized, thatched adobe structures, which are used to conduct meetings, store the community truck, and store food. There is also a community kitchen that must be maintained. Below is a description based on the experiences of my assistant and me during this unique type of CA. There was a short ceremony before things get started. Coca was placed in a glass with wine and the mixture was thrown on the building that would be refurbished. This type of CA involves several tasks that require special skill. Adobe was prepared and applied by a couple of men to replace weathered or damaged structures. Remodeling the roofs (and their frames) was required, using mostly materials collected locally and processed on site. For the roof, women use three different types of grass-like vegetation that is inedible for the herding animals, referred to as *tira ichu*, *caballo*, and *qhesua* by the locals. The *qhesua* is woven into the *tira icho*, which together comprise the "thatched" part of the roof. The *caballo* was used as a weight to hold down the thatched roof around its edges. For the roof frame, locals used *palos* (purchased wood). They cut the posts so they would fit, erected the posts, and tied the wood together with leather from a cow that was butchered (and served for lunch). In addition to the strips of leather, rivets and nails are used to hold the posts together. When there is not enough leather they use *ichu paja*, another type of vegetation growing in the area. Two to three days of work per year are

devoted to maintaining the community buildings, though sometimes repairs must be made at other times of the year.

**The costs and benefits of household investment in collective action**

CA in Pucucanchita involves a large number of tasks which can consume a considerable amount of time and energy and increase the risk of injury and overexertion. Three categories of costs will be discussed here: time costs/conflicts, risk of injury/overexertion and energetic costs. The return benefits from CA investment will also be discussed.

There are considerable time costs and conflicts for HHs who routinely help with these year-round tasks. At minimum, a task will take a half day to complete, while others span several days. The time that is allocated to CA could be used towards other farming and agricultural tasks, and can thus impact HH production. The most detrimental time conflict occurs during the planting and harvesting of crops. Accurately timing these tasks is crucial in this region, and family gardens are harvested or planted at the same time as the community gardens. Shifting planting/harvesting times may make a family's crop more susceptible to early/late frosts, hail storms, and theft by those who have experienced crop failure. These factors, coupled with planting fewer crops (as a result of helping with CA) could impact HH production. In addition to the time conflicts that come with planting and harvesting crops, there are also time conflicts with regard to animal husbandry tasks. Properly timing when the animals are shorn, bred, and vaccinated is crucial. It is likely that HHs must maintain smaller herds in order to facilitate participation in CA. This leads to fewer calories for HH consumption, as well as less income from the sale of wool and livestock. As agropastoralists with little or no external income, the survival of HH members is heavily dependent on its production. Like in other poverty-stricken areas of the world, when production goes down, mortality and illness increase in the Andes (Leatherman 1994, 1996; Carey 1990). It is important to note that HHs, by contributing regularly to CA, also lose time that could be spent doing other activities that benefit the HH, including child care, paid labor outside the community, and education. Losing a viable HH contributor for the duration of a community project is especially difficult for those HHs that have a small

number of contributors, sick HH members, and/or smaller support networks. Taken together, these time conflicts and costs can be very frustrating and difficult for families, and exasperation in this regard was a common theme in conversations among community members, especially when referencing their HH making contributions when others did not.

Field observations noted musculoskeletal injuries, cuts, scrapes, burns and contusions during community projects, and few walked away from these tasks completely unscathed. In Pucucanchita, each task poses a risk, whether it's re-roofing precariously high in the rafters of a community building, wrestling a 200-pound llama to the ground, or shearing a struggling (and biting) alpaca with sharp hand shears. Agricultural tasks by their very nature are dangerous. While reliable, unbiased data on agriculture-related injuries and death in rural Peru does not exist, looking at data from rural US may shed some light on this issue. According to the US Department of Labor, agriculture has been one of the most dangerous occupations (in terms of worker injury or death) for the past several decades; most injuries are the result of animal-related trauma (http://www.dol.gov/). An injury sustained during CA would limit the ability of a person to fully contribute to HH tasks, which could seriously impact HH production for those with limited intra- and inter-HH support.

In addition to the risk of injury, the energetic demands and physical effort required during CA are, at times, extreme. This can lead to overexertion (the second leading cause of injury in US agricultural jobs), which can result in a number of negative health effects in addition to increasing the possibility of future injury (Mital, Pennathur and Kansal 1999). A study in the US found that overexertion was "the most common event or exposure that led to injury or illness in agriculture" (Richardson and Lambert 1997). The high force demands of tasks that may result in overexertion include carrying a 50-pound bag of potatoes up and down a 60 degree hill in difficult terrain; contact stress in the hands and wrists from twisting, rolling, and tying wool in bunches; hours of continuously working the shovel; swinging a hand plow; or hand shearing animals. Again, overexertion or injury is another risk that can affect the amount of work a person can contribute to the HH, thus reducing overall HH production. In sum, every calorie and every workday count for *campesinos*. Calories and time spent during CA participation or lost as the result

of reduced agricultural production (through time lost or injury) can potentially result in acute and long-term health problems (Pitt and Rosenzweig 1985). Indeed, micronutrient deficiency increases rates of illness and death from infectious diseases in developing countries (Black 2003).

While the costs are great, HHs receive benefits from investment in CA. The food produced in the community gardens is distributed equally among community members upon harvest and is prepared during community projects and meetings. Money earned through the sale of animals and wool is also distributed evenly among HHs. I was not granted access to records about how much money each HH receives from the sale of animals. Conversations with community members made it seem as though it is a small amount, perhaps enough to cover costs of food and other items that are purchased at the nearest market for a couple of months. I also was not granted access to the records about how much food HHs received from the community gardens and meat from the community herd. Based on observations of transfers following community meetings and on discussions my assistants and I had with community members, each HH likely receives about 12 kilos of meat, 24 kilos of various types of papas, 12 kilos of quinoa, and 6 kilos of *chuños* per year.

**Free riding and overappropriation in Pucucanchita**

There are potentially three places in which overappropriation can occur in Pucucanchita: overgrazing pastures, overappropriation of water, and differential access to agricultural production from CA. In many developing countries, common grassland is an essential resource for survival (Benin and Pender 2006). Herders who share land for grazing face CA problems that can result in exploitation and degradation of the resource they share (Gebremedhin et al. 2004). In an ideal scenario that is free of CA problems, each herder would have the same number of herding animals and graze each animal the same amount of time. Suppose a selfish herder enters this system and adds animals to his herd and allows his animals to graze longer than other herders do. The result would be a larger and healthier herd for the newcomer. Over time, via rational choice or cultural and/or genetic evolution, the selfish strategy would prevail, and large herd sizes coupled with no-limit grazing would result in pasture degradation. Despite

this widely cited "tragedy of the commons," successful land management of communal grazing land has been documented in several cultural contexts (McCabe and Terrence 1990; McPeak 2005; Ruttan et al. 1999). In some cases, a suite of rules (both formal and informal) exist to prevent herders from benefiting from overgrazing and excessive herd sizes. For instance, in the Amhara region of Ethiopia, certain areas are restricted to grazing for specified periods of time, which allows the grassland to replenish itself. These fallow lands are sometimes protected by guards or trust agreements to further suppress the urge of taking more than is fair (Benin and Pender 2006; Gebremedhin et al. 2004).

Interestingly, there are no formal rules restricting grazing nor is there guarding of fallow fields in Pucucanchita. This is because, unlike other neighboring communities, overgrazing does not appear to be a significant concern for the community. During several hikes I made throughout the community conducting interviews and mapping GPS locations, I never observed any land that appeared overgrazed nor did I ever hear complaints from residents about not having enough pasture for their animals. These observations confirmed conversations I had with residents early on in my research, which at the time elicited a little doubt in my mind given the frustration and even yelling matches about the lack of pasture I'd witnessed in other highland communities. In my opinion, there are likely four factors that account for the abundance of pasture for HHs in the study community. First, there is a fair amount of grazing land between HHs or clusters of HHs. Second, each HH that lives permanently in the community has wet and dry season *cabañas* that are located on opposite sides of the community. This spreads out the amount of grazing that takes place by any HH over the course of the year. Third, small average family size and the limited number of people to draw support from limit herd size for HHs. Finally, I would suspect that there are social norms that prevent HHs from accumulating large herds, which is the only true signal of wealth in the community, though I have no evidence (even anecdotal) to support this proposition. Overappropriation of water is also not a problem in Pucucanchita, unlike in other highland communities. In my opinion, this is due to the abundance of water in the community and that HHs move during the course of the year to ensure year-round access to water and reduce inter-HH competition for water.

There also doesn't appear to be overappropriation with regard to the community's agricultural production. Produce from the community gardens, and money earned from the sale of animals, meat, and wool are closely regulated. The president and the secretary are in charge of the record keeping, and all transactions are conducted in plain view of other community members. While there is likely a little pinching done by those with special access, as is the norm in Peru, I wouldn't expect this to significantly impact HH return on CA investment.

Despite the lack of overappropriation, it became clear early on in my research that unequal investment in CA tasks occurs among HHs in Pucucanchita, such that a relatively small number of HHs subsidize the majority of the costs, while some contribute very little at all. The socio-political structure of Pucucanchita is indeed intriguing. Those who contribute less to CA are not punished. Given that there is no punishment of free-riders in Pucucanchita, and that HHs receive community benefits regardless of their contribution to CA, it is somewhat surprising that the successful management of CPRs occurs. A major goal of this dissertation is to examine what light evolutionary signaling theory can shed on this interesting conundrum. In doing so, I will consider the reputation that high-CA contributors achieve (Chapter 5) and the support network benefits that result from a high reputation (Chapter 6).

# Chapter 2: Life in the Andes of southern Peru

This chapter describes the climate, geography and other ecological aspects of the study region. The history of the indigenous people living in this area (Quechua Indians) is briefly discussed, as are modern aspects of life in the *altiplano*, including the current state of *campesino* health. I also describe the community where this research was conducted.

## *Altiplano ecology*

The research presented in this dissertation was conducted among Quechua Indian agropastoralists living in the high-altitude *altiplano* (ca. 4000m) of Peru. The study community is located in the Nuñoa District (encompassing some 100km$^2$) of southeastern Peru, located in the eastern range of the Andes (Weinstein et al. 1983). This unique part of the world presents extreme challenges for human subsistence due to the severe climate, difficult working conditions, high elevation and resultant low oxygen pressure (Baker and Little 1976).

A breath of air in the *altiplano* contains about 60% of the oxygen molecules that are present in the atmosphere at sea level (Beall 2000). Given the centuries-long exposure to hypoxic conditions that highland populations have endured, it comes as no surprise that morphological and biochemical adaptations have emerged. The shorter stature and larger chests of highlanders compared with native lowlanders suggests that these features evolved to counterbalance hypoxic stress (Baker and Little 1976). Specifically, a smaller body requires less oxygen, and a larger, barrel-like chest allows for greater lung volume. Andean natives appear to have a higher percent of oxygen saturation in addition to a higher concentration of hemoglobin compared with native lowlanders and even Ethiopian highlanders living at similar altitudes. These are clues that both biochemical and physiological adaptations to hypoxic conditions have evolved to help populations cope with low oxygen pressure (Beall 2006). Despite these

biological adaptations to high altitude, in addition to cultural adaptations such as ingesting coca, hypoxia is a severe and unavoidable stress for Andean residents throughout the lifespan (Beall 2001).

The climate in this region of the Andes can be summarized as unpredictable, cold, and either extremely dry or extremely wet depending on the season. Hail storms are common and the possibility of flooding and long periods of drought are always weighing on the minds of *campesinos.* Unexpected overnight frosts and hail storms can occur during spring and summer, and if winter snowfall is heavy, households (HHs) can lose up to 50% of their herd (Kuznar 2001; Weinstein et al. 1983; Goland 1993; Orlove and Guillet 1985). The growing season is from November through March, when the region receives 75% of its precipitation for the year. The remainder of the year is dry and cold, and thus not amenable to farming (Orlove 1977; Weinstein et al. 1983; Carey 1990). Annual precipitation can vary considerably year to year, and can present serious problems to subsistence agriculture since even subtle changes in the amount and timing of precipitation can impact crop success and the availability of grasses for herding animals. Models indicate the predictability of rainfall in the region can be less than 50% over a given year in the highlands (Winterhalder 1994; Kuznar 1990). While rare, severe droughts can occur and may claim up to 60% of a HH's herd (Kuznar 2001). Variation in climate and degree of seasonality increases with altitude. In the Andean *puna* (the ecological zone at 3800m-4500m) where this research was carried out, there is considerably more seasonality, especially with regard to precipitation. To make matters more challenging, climate change in the region is affecting the amount of precipitation that falls in a given year, with the recent trend of drier conditions (Vuille 2008). The future hydrological impact of climate change on *campesinos* will likely be severe, with the strongest impacts resulting from the unpredictability (timing and amount) of annual rainfall and the lack of snowfall.

There is little variation in temperature across a typical year in the Peruvian Andes since the region is located in the tropics. However, there can be a wide diurnal range, with temperatures often dropping below freezing at night during the dry season (Thomas and Winterhalder 1976). Climate change in this region in the past 50 years has been dramatic. The average temperature has increased at an astonishing rate, approximately 0.1° C per decade (Vuille 2008). The exact impact that reduced snow packs and the

absence of centuries-old glaciers will have on water availability for herd animals and families is still unclear. One thing is for sure: the availability of water for *campesinos* is decreasing as a result of patterns of increasing temperatures over time and reduced precipitation. Without sufficient water, human subsistence in this area will be compromised. Consequently, trends in increasing temperature present yet another stressor for *campesinos* and may potentially impact the sustainability of contemporary herding and farming practices.

The geography in this part of the Andes consists primarily of deep valleys, plateaus, and steep terrain. Grasses suitable for herding livestock—particularly alpacas, sheep, and llamas—are the dominant flora in the region (Kuznar 2001; Carey 1990). In the Nuñoa District, vegetation is highly moisture-dependent and can be characterized as endemic, herbaceous perennials that grow very low to the ground (Weinstein et al. 1983). There are also dwarfed trees that do not exceed 1m, but these aren't generally found in the high *puna*. Very few mammals are native to the *altiplano*, but predation from foxes is a constant concern for residents of this region, in some regions claiming an estimated 8% of a HH's herd (Weinstein et al. 1983). Additionally, I've heard stories from a number of *campesinos* about large eagles swooping down and grabbing *crias* (infant alpacas), but this hasn't been empirically confirmed.

The ecological stressors of the *puna* region of the Andes make life difficult for *campesinos*, especially given the fact that they receive very little support from their government. The impact of climate change on the lives of *campesinos* will, in my opinion, be substantial. However, the resiliency of the people of the *altiplano* is strong, dating back to their pre-Incan ancestors, and they will surely adapt to these challenging conditions.

## *Indigenous Peruvian Highlanders*

### A brief history

Archaeological accounts of 4$^{th}$ Century B.C.E. indigenous populations living in the location of modern-day Peru describe a nomadic hunter-gatherer lifestyle, though some temporary horticultural

encampments likely existed at this time. By the 3rd Century B.C.E. there were sedentary communities on the present-day Peruvian coast that built what archaeologists refer to as corporate monuments (Stanish 2001). These monuments, which are indicative of increasing social complexity, housed public ceremonies and functions for elites. In the highlands about this same time, the Kotosh religious tradition predominated (Burger and Burger 1980). While monument building was not as elaborate as those in the coastal areas, the Kotosh tradition built a number of corporate monuments throughout the present-day Peruvian Andes. These large, multi-chamber buildings, constructed for ritual purposes, had several fire pits and were decorated with paintings depicting serpents on the walls. Over time, these monuments became more complex, likely "funded" via surpluses gained through irrigation agriculture and trading with lowland populations, as evidenced by fish bones and shells present in highland archaeological sites (Burger 1995; Stanish 2001). By the 1st Century B.C.E. larger settlements had emerged in the central Peruvian highlands, producing figurines, textiles, and sought after pottery. Despite the increase in social complexity over time, there is no evidence of state society in the highlands during this period (Burger 1995). That is, economic specialization, large wealth disparities, and complex political organization did not appear to vary substantially across the region. It is important to add that whereas coastal societies struggled during this time, the highlands prospered, developing several influential trading centers (Burger 1995; Stanish 2001).

In sum, anthropological accounts of pre-Spanish conquest life in the *altiplano* of Peru paint a pleasant picture, one that unfortunately gets darker over time. Semi-nomadic families living in the highlands likely exploited a range of resources in the region, traveling from ecosystem to ecosystem as the seasons changed. This subsistence strategy kept highlanders from being locked in to the limited resources that a single ecosystem provided, while at the same time alleviated the impacts of regional natural disasters such as drought (Murra 1985). This strategy likely continued even after the formation of nation states. These nation states, divided by regional ethnic groups, formed as early as 5th Century C.E. in Peru, especially in the resource-rich lowlands and coastal areas; however even the resource-poor highlands possessed such dominions (D'Altroy 2003). In the Nuñoa region, the Wari State, which spoke

ancestral Quechua, subjugated the socio-political state of affairs by 6th Century C.E. (Stanish 2001; D'Altroy 2003). The Tiahuanaco culture, which originated in modern-day Bolivia, spread throughout southern Peru, replacing existing ruling states until its collapse in 12th Century C.E. Several "kingdoms" formed following the slow decline of the Tiahuanaco influence in southern Peru, and during the 15th Century the Quechua-speaking Incan empire swept through the area (Carey 1988). Civil war in the Incan Empire erupted during the first half of the 16th Century as a result of siblings competing for control of the Empire. While the integrity of the Empire was challenged as a result of this sibling rivalry, it made no difference since the Spanish Conquest was just around the corner; however, some feel this internecine conflict gave General Francisco Pizarro a key advantage (Stanish 2001; D'Altroy 2003). With the arrival of Spanish forces in the 16th Century, the Empire quickly fell, forever changing the social dynamics of life in the *altiplano*. While several historical accounts solely recognize the presence of the Incans in this area, there were, in fact, dozens of ethnic and/or linguistic groups in the central Andes at the time of European contact (Stanish 2001; D'Altroy 2003). The Incan Empire (counting these various discrete cultural entities) likely exceeded 10 million people at its pinnacle, but was reduced to less than a million in a few decades as a result of disease, warfare, murder, slave labor, and famine following the Spanish Conquest (Carey 1988).

Social life and organization changed quickly after the Spanish gained control of the Peruvian highlands. The Spaniards implemented their land tenure system, greatly limiting the mobility of Quechua HHs. The adaptive strategy of families shifting through different ecosystems over the course of a year was suffocated by this system. Instead, locals were restricted to working a particular locale despite seasonal changes that constrained land use for a good part of the year. This and other changes prompted numerous revolts from Quechua groups during the 18th Century (Carey 1988; Stanish 2001). Despite independence from Spain in the early 19th Century, life in the Peruvians highlands continued to be a challenge. *Haciendas* (large estates) emerged in the highlands as a result of the growing wool market in Europe and the United States. Wealthy Peruvian families from the coastal city centers infiltrated the highlands, taking over land (sometimes by force) and managed the production of wool. The success of

these *haciendas* created an elite group that had a strong socio-political grasp on indigenous highland *pueblos*. *Campesinos* were pushed from their land or worked like serfs on the land of these large estates (Carey 1988). The exploitation of indigenous highlanders led to even more uprisings in the southern highlands, and social reform eventually came to fruition in the earlier 20th Century (Alberti 1981). Despite these efforts, the land and labor of *los campesinos* continued to be exploited by elites until government-led land reform at the end of the 20th Century.

In the mid-20th Century the Peruvian government experienced a coup, in which the military seized control of a system they felt was in disarray. General Juan Velasco, who took control of the government, implemented a series of programs, aimed at reducing economic and social inequalities in Peru. One initiative regarding agricultural reform divided land (much of it former *haciendas*) into cooperatives that were managed by the local government. This agricultural reform converted 76% of the reformed land into state-run cooperatives (Carey 1988). *Campesinos* effectively became workers for these cooperatives, and many (estimated at more than half) were marginalized and left landless. The declining Peruvian economy in the 1960s coupled with the increasing (and conspicuous) disparities in wealth was a recipe for conflict. In the 1980s, several indigenous groups, most notably the Maoist group *Sendero Luminoso* and the Marxist-Leninist group *Tupac Amaru*, began violent crusades against the Peruvian government. In response, the military was granted permission to exercise any action necessary to crush what was deemed terrorist activity by these groups. The result was bloody for all parties involved. The city of Nuñoa, which is only a few kilometers away from the study community, was visited by *Sendero Luminoso* in 1988. As group members searched for government officials, one person was murdered in Nuñoa and two more in nearby Santa Rosa. Small uprisings continued in the Nuñoa District following the downfall of *Sendero Luminoso*, leaving government cooperatives ransacked and, finally, the wealthiest landowners left for good by the end of the 1980s.

Today, Nuñoa is a thriving regional center. It has several primary schools, a hospital, a large Sunday market, relatively clean water, sewage systems, and (most of the time) electricity. Nuñoa has been integrated into the world economy due to the extraordinary wool that this region produces. The road from

Nuñoa that leads to Highway 3S, a major thoroughfare (by Peruvian standards) that links Cusco to Lake Titicaca/Puno, is currently being paved. The implications of this will be huge for Nuñoa since the current mayor hopes to create a tourism market in the region and increase the number of exports from the township. How the road paving will impact *campesinos* living in *el campo* is unclear. The changes may go unnoticed at first, with the exception of those communities that are in closer proximity to Nuñoa, like the study community.

**Health**

Given the lack of governmental support, difficult living conditions, and inequalities associated with socioeconomic change in the region, it is not surprising that highland residents have experienced high infant mortality and adulthood morbidity for decades (Carey 1990; Leatherman et al. 1995). The infant mortality rate (deaths per 1000 people in a given year) in Peru was 181 in 1940 and 105 in 1981, and life expectancy was 36 and 57, respectively. Of course, these regionally aggregated numbers are not representative of the mortality and life expectancy patterns in the highlands, considering health and maternal care in the coastal city centers has been considerably better. In fact, the health of highlanders traditionally has been the worst across all ecological zones of Peru, including the sub-tropical regions (Linares and Pullum 2007). While reliable mortality data for the Peruvian *altiplano* are scant, the estimated infant mortality rate in the highlands was 156 and the life expectancy was 50 in the early 1970s. From the 1960s to the 1980s there was a substantial decrease (ca. 30%) in overall mortality, and infant mortality also dropped significantly (ca. 12%) during the same time period in the highlands (Carey 1988). During the‘80s and ‘90s, mortality data was difficult to collect as a result of numerous, concurrent uprisings. As mentioned, after these uprising were quelled, major government-led health care reform was implemented. Nevertheless, child and maternal health did not dramatically improve, though mortality rates continued to decline over this time in Peru, including in the highlands. During the first half of the 1990s, maternal and infant mortality rates decreased roughly 15% percentage points (Vicuña 2002).

Recently, adult mortality, infant mortality, and maternal mortality rates have decreased in the highlands, though the rates are considerably higher than in other regions of Peru (Linares and Pullum 2007).

While mortality rates have decreased in recent decades, illnesses from infectious diseases and malnutrition continue to have a major impact on the lives of rural Peruvians, especially those living in the highlands (Leatherman et al. 1995; Linares and Pullum 2007; Leonard 1987; Carey 1990). Historically, the greatest health problem in this region has been infectious respiratory illness (Dutt and Baker 1981), and this continues to be the leading cause of morbidity and death. Two factors contributing to respiratory illnesses—exposure to extreme climate and exposure to smoke (from indoor cooking)—unfortunately will continue to impact *campesinos*. The most effective means of reducing respiratory illness is increased access to medicine and/or health care. Malnutrition also has been and continues to be a major concern for highlanders (Leonard 1987). Data from the 1980s indicate that over half of highland HHs were deficient (i.e., less than 90% of the recommended allowance) in the intake of vitamins, minerals, protein and calories. Further, over half appeared to be undernourished at this time (Leonard 1987; Carey 1988). In addition to respiratory illnesses and malnutrition, highlanders suffer from a host of illnesses, including *gripe* (flu) and gastrointestinal problems, which make life difficult (Carey 1988).

Health disparities in Peru have existed for decades, and while the gap is narrowing, highlanders have greater health concerns than those living any other ecological zone in the country. Why do highlanders experience poorer health compared to other Peruvian populations? The principal factors leading to regional health disparities in Peru are differential government aid and differential exposure to environmental stressors. The latter is rather straightforward. Those living in the coastal areas (and even the jungle environments) are not exposed to the conditions that highlanders endure, as detailed in the first section of this chapter. Additionally, the lack of access to potable water greatly compromises health. Despite the challenges of living in *la puna*, rural Peruvians would be much healthier with adequate access to health care and food supplementation. There are significant inequalities with regards to access to health care when contrasting Peru's rural and urban areas. Government money is allotted for rural regions, but in many cases only a fraction actually makes it to its intended target (Linares and Pullum 2007). For

highlanders living in *el campo*, attaining professional medical care can take several days. The Peruvian government has made strides in building health outposts for those *campesinos* living is distant Andean communities. Unfortunately, these outposts are not regularly staffed and lack electricity and medical equipment. Another outreach strategy employs small crews of nurses and a doctor that visit distant villages (trips I made several times), but this strategy faces the same challenges mentioned above with the health care outposts. Clearly, there is no easy solution to improving the health of *campesinos* living in distant communities.

How much does access to health care actually impact health and mortality patterns? There have been government-led movements recently for improving maternal health as a means to reduce maternal and infant mortality. Studies have shown that infant mortality in Peru decreases as access to health care increases (Linares and Pullum 2007). In rural Peru in the early 1990s, prenatal care and the presence of an attending physician during childbirth are strong predictors of whether or not an infant survives to the age of five. By the beginning of the 21$^{st}$ Century, the risk of infant death was five times greater in the absence of prenatal care and 10 times greater in the absence of an attending physician during childbirth (Murillo 2002). While these data show a strong association between access to health care and lower rates of mortality, the relationship between access to health care and other health concerns, such as the prevalence of infectious diseases, is not well understood. However, the aforementioned reduction in mortality rates should be a good indicator of the benefits of point-of-need health care, a service that most *campesinos* lack.

Health is improving in the Nuñoa and in the Andes in general. There is greater access to health care and potable water, a more diverse diet from vendors at the Sunday market, and better ventilated cooking areas in highland townships. However, such improvements have not extended to *campesinos* living outside of these population centers. *Campesinos* in the study community share drinking water with the herding animals that regularly walk through and defecate in their water sources, contaminating them. As stated above, while there are health care outposts in the vicinity of the study community, they are rarely open, lack electricity and sterile working conditions, and do not have the medicine, tools, and

expertise to treat many illnesses and injuries. The diet of *campesinos* is not as diverse as that of Nuñoeños due to the cost, lack of availability and difficulty in transporting these supplements. As mentioned, respiratory illnesses are the most common illness in the highlands, and many attribute it to the cooking and sleeping arrangements of highlanders. At the time of this research, only one HH in the study community had installed a special ventilation device for cooking.

### *Field site*

This research was carried out in Pucucanchita, an agropastoral village of 24 *socios* (distinct economic units represented typically by a HH) in the Andes of southeastern Peru. Pucucanchita is located in the high-altitude *altiplano* (14500 ft., 4420 m). This section will briefly discuss aspects of the HH and provide a snapshot of the socio-economic and socio-political landscape of Pucucanchita.

Pucucanchita was formed in the mid-1980s following government-led land reform. Politics in Pucucanchita are not extremely complex. The *pueblo* functions as what locals refer to as a *comunidad,* or a collective, in which there is no ownership of land. There are several communally owned resources in Pucucanchita, including herds, gardens, irrigation canals, and buildings for storage, meetings and events (as discussed in Chapter 1). Members of the community come together several times a month to manage and maintain these public goods. Pucucanchita is involved in political affairs outside of the community, and has a representative that votes on matters that impact the larger Nuñoa region. There is also a president in Pucucanchita, who is elected every two years. While there is a certain level of prestige to these positions, they are not generally sought after, rather considered a duty. Pucucanchita is so small that some people have served in the positions more than once.

In addition to partial "ownership" in the communal herds and gardens, HHs own their own animals and farm indigenous crops in small plots adjacent to the community garden. While there are no rules regarding herding practices, families tend to herd their animals in close proximity to their residences. Farming activity, on the other hand, is in a central location close to the community gardens. Alpacas are the primary livestock in Pucucanchita, followed by sheep, llamas and cattle. Indigenous crops, including

tubers (e.g., oca, potatoes) and grains (e.g., quinoa), are the principal crops farmed in this region (Orlove 1977). Most families have chickens, and all families in Pucucanchita have dogs for protecting the herds from foxes and thieves. While most of the calories a HH consumes come directly from HH and collective action production, many families do supplement this with food bought in the nearest town, Nuñoa.

There is no electricity in Pucucanchita, and water is obtained by HHs via gravity-fed, hand-dug canals (*acequias*) that channel rain and snow melt. A typical residence has one or more small rock structures with thatched roofs (*cabañas*), usually about 3.5m long, 2m wide, and 1.5m high. In Pucucanchita, and other communities in the high Andes, HHs have one residence for the dry season and another for the wet season due to the changing availability of water and grasses. Many HHs have more than one *cabaña* at each location, either because the HH is composed of a multi-generational family or because there is a separate structure for cooking. Most HHs, however, cook in the same *cabaña* in which they sleep. Using dried manure as a fuel source, families cook on a rock hearth that faces one wall of the cabaña. A typical meal in the Andean HH is a soup made from alpaca or sheep stock with a little meat and lots of potatoes. One favorite (of the author at least) is a plateful of *chuño* (freeze-dried tubers) and a slab of meat (which is three-quarters bone, tendon, marrow, and fat), served with a bowl of savory gravy. Very few vegetables are consumed in *el campo* because they can't be grown and must be acquired from Nuñoa or a more distant town, then transported back to Pucucanchita.

Mobility is somewhat limited for those living in Pucucanchita. The community owns a large truck that serves a dual purpose of transporting animals for sale and taking a large number of community members to the Sunday market. Due to the price of gasoline, the truck is seldom used outside these purposes. If community members want to travel to and from Nuñoa Monday through Saturday, they must do so by foot or bicycle. An advantage, perhaps, for residents is Pucucanchita's proximity to the town of Nuñoa. Less than 10 km away, it is walkable in a day. This is a relatively short trek by highland standards; however, traveling to Nuñoa is typically a trip made to acquire some resource that must be carried back. Women and men can often be seen on the poorly kept road carrying heavy loads strapped on their backs with large blankets.

In many small-scale societies that depend on agriculture, pastoralism, and the management of public goods, certain aspects of individual socio-economic behavior are best understood in the context of the HH (Barlett 1980; Wilk 1989; Netting 1993). Indeed, the HH is the principal economic unit of agropastoralists living in many communities of the Andes. This is especially true in Pucucanchita where very little individual production and consumption occurs outside of the HH. Whether it's produce from the HH's harvest, a bicycle, or money obtained via the sale of animals, everything is "owned" by the HH. While members may play different roles with regard to how resources are distributed (and may have slightly different access to resources), the resources that flow into the HH nevertheless become the property of the HH (Mayer 2002; Platt 1986). There is little prospect for individuals to accrue money or goods and maintain them independently, since *campesinos*, especially in the high Andes, have little opportunity to engage in any economic ventures (e.g., external labor) in which they can obtain money (Mayer 1977; Collins 1986). The importance of the HH as an economic unit is also evident in how reciprocity typically occurs in the Andes. The exchange of goods and services is perceived as occurring between HHs rather than between individuals. For instance, if my neighbor's son helped me vaccinate my herd one day, I may help his father re-adobe his stalls. It is important to note that individuals strongly identify as a member of a HH and are perceived by others as such, whether it's by the name of the HH head or by the name of the residence; each individual or cluster of dwellings has a unique name. The theme of the HH as the principal economic unit is also seen in unofficial rules of attendance to collective action. The expectation in Pucucanchita is that a representative of the HH, not each individual in the community, helps with each event. Furthermore, HHs, not individuals, have voting rights with regard to community affairs.

Intra-HH relations are likely more complex than presented here, though on the surface they seem to operate in a straightforward manner. To put it simply, highland Peru, like most South American countries, is a patriarchal society. It is assumed that the oldest male makes the decisions for HH matters, though this is not always the case. This notion is evidenced by the fact that the HH head is almost always the HH representative at community meetings, voting days, and other community matters. Consequently,

the successes and failures of the head of HH strongly influence views that other community members have toward the HH and its members (Mayer 2002; Platt 1986).

# Chapter 3: Social support and reciprocity in the Andes

This chapter discusses reciprocity and exchange, past and present, among Quechua agropastoralists living in the Peruvian Andes. I also introduce the types of social support networks that are most vital in the study community, and discuss the benefits to households (HHs) that have access to these networks.

## *Reciprocity and exchange in the alitplano*

The *altiplano* region of highland Peru is a harsh environment, and the indigenous people of this area have evolved a suite of cultural and biological adaptations to deal with high altitude stressors, low ecological productivity and a lack of point-of-need health care (Leonard 1989, 1991; Rupert and Hochachka 2002; Beall 2001; Weinstein et al. 1983; Thomas and Winterhalder 1976; Linares and Pullum 2007). Reciprocity and exchange are one means of dealing with the difficult living conditions of the *altiplano* (Carey 1990; Mayer 2002; Allen 2002). Indeed, sharing relationships have been described as "a pump at the heart" of *altiplano* life, and have helped Andean residents cope for centuries (Allen 2002:73).

### Early ethnographic accounts of reciprocity and exchange

It is important to note that most of the literature on reciprocity in the highlands presented in this review comes from the perspectives of economic and socio-cultural anthropology. These sub-disciplines do not necessarily define reciprocity in the same way as evolutionary anthropology, the perspective employed in this dissertation. Ethnographies tend to place a wide range of exchange relationships under the umbrella of "Andean reciprocity," including those that are kin-based, highly reciprocal, reciprocal but asymmetrical (i.e., one party receives a marginally higher benefit), and those that border on outright exploitation (i.e., work parties recruited by elite land owners). In fact, the terms "exchange," "cooperation," and "reciprocity" are sometimes used interchangeably. In describing Andean exchange below, I will use the vernacular of the ethnographers who have written about Andean reciprocity, which

may not be compatible with evolutionary perspectives on reciprocity. Discussions of these systems in later chapters will be framed in evolutionary theory using the models outlined in Chapter 1.

Patterns of reciprocity in the Andes are extremely complex, composed of centuries-old, ubiquitous systems (e.g., rigid, ritual-based kin reciprocity) as well as novel systems that are unique to a region or community. Here, I will focus on systems of reciprocity that have been captured by pre-21st Century ethnographies; in later sections I will discuss features of reciprocity and exchange that occur in the study community. Before exploring these exchange relationships, it is important to briefly note that they do not include *voluntad* relations, those sharing relationships among nuclear family and closely related kin. In the *altiplano* these relationships, which occur mostly within a HH or between two HHs that are composed of close kin, are ubiquitous. The obligations of *voluntad* are so deeply engrained in Andean culture that HHs appear to function as a single economic unit (see Chapter 2). Three systems of (mostly) non-kin reciprocity that are commonly noted in Andean ethnographies—*mink'a*, *ayni*, and *campadrazgo*—date back to the Incan Empire and likely even earlier.

*Mink'a* is a type of exchange in which a family recruits help to complete a major task that involves manual labor, such as roof building (Allen 2002; Carey 1988; Flores-Ochoa 1968). To attract and partially compensate those who participate, the family provides coca leaves, food, and drink (Flores-Ochoa 1968; Gose 1994; Carey 1988). Traditionally, *mink'a* was a useful way of recruiting a work party to quickly tackle a major domestic task, the modern-day American equivalent of providing beer and pizza for friends and acquaintances to help one move. The HH head seeking *mink'a* assistance will formally recruit the work party, which is mostly made up of non-kin. In addition to the meals that are provided during the task, helpers typically also receive coca and food to take home. The amount of food received for the service is not typically arranged beforehand, but rather loosely determined by regional customs and the length of service (Mayer 2002). Unlike *ayni* (discussed below), *mink'a* is not based on what is referred to in the evolutionary literature as reciprocal altruism (Trivers 1971). That is, the HH head that recruits help is not obligated to participate in one of the helper's *mink'a* if recruited. During the 19th Century when wealth disparities increased, work parties (recruited as a form of *mink'a*) were enlisted by

wealthy landowners in the *altiplano*. The ethnographic literature paints a picture of extreme exploitation at this time, as wealthy landowners achieved far greater benefits from this exchange. A wealthy land owner during the *hacienda* era, for instance, could call on locals for help, providing ample alcohol and some food, but little was taken home. Quite simply, at the end of the day the benefits to the worker did not meet or exceed the costs of the physical labor contributed, whereas the landowner profited greatly (Orlove 1977; Gose 1994; Mayer 2002).

Unlike the asymmetric nature of *mink'a* exchange, *ayni* relationships are based on equity and occur, for the most part, among status equals (Allen 2002; Mayer 2002). *Ayni* reciprocal systems, similar to *mink'a*, allow poor HHs to recruit manpower that the HH lacks. These exchange relationships are between non- or distant kin and do not emerge for any other reason than a need for help (Mayer 2002). They can be long-term or short-term, and those who ask for help from a neighbor or friend can be rejected with typically no hard feelings from the other party (Mayer 2002). Not paying back an *ayni* is nearly unheard of and there are serious repercussions if an *ayni* is not reciprocated, namely reputational costs and shunning. The typical *ayni* scenario is as follows: a member of one HH helps the member of another, and the former is fed by the latter. In the near future, a member of the HH who was helped will provide a similar service to the HH who initially provided the help, and will receive a meal in the process. In *el campo* most *ayni* relationships involve agricultural duties, for example, shearing and vaccinating the herd. Pre-1990 ethnographic accounts of *ayni* stress that the favor is always returned in similar *degree* and *type* and usually, if not always, involves manual labor (Carey 1988; Mayer 2002). Regarding type, return service is expected to be of the same kind of manual labor: you help me shear my animals and I'll help you shear yours. Deviations from this or even suggestions to repay an *ayni* with a different kind of service are generally discouraged (Mayer 2002). Regarding degree, the expectation is that the work will require the same amount of time and energy. Repaying a two-day *ayni* debt with one day of service is unacceptable and would likely impact future social relations between the parties.

The *compadrazgo* ritual-based system of reciprocity is a kind of spiritual kinship in which distant kin (outside of the HH) and fictive kin (e.g. *compadres*) provide goods and sometimes labor that are not

necessarily immediately reciprocated, and in fact may never be reciprocated. *Compadrazgo* relationships can be abundant or absent for HHs, and can be significant or completely meaningless. Entering into a *compadrazgo* relationship is as simple as, for example, asking a friend or neighbor to be the godfather or godmother of one's child. From that moment on the parents of the child and the godparents are *compadres*. This could be a lifelong relationship in which the *compadres* are always there for one another with little concern about reciprocity, to a short-lived relationship, spanning only the obligatory attendance of the godparents at various events during the youth of the godchild (e.g. graduation).

**The changing landscape of reciprocity in the *altiplano***

While reciprocity and exchange continue to be important aspects of Andean culture, the frequency, expectations, and practices have changed considerably in recent decades. The rich ethnographic literature on Andean reciprocity that predates the fall of the *hacienda* system (late 1980s) should be considered a "history of reciprocity" in the area instead of indicative of current practices. The systems of reciprocity described above are remembered only vaguely by locals and/or have different meanings than those detailed in ethnographies. This is true not only in the urban areas, but also the rural areas where these systems should have been affected less by the expanding market economy in Peru. Enrique Mayer's (2002: 105) summary of the evolution of Andean reciprocity is salient: "Different forms of reciprocal exchanges have been invented and worked out, elaborated, modified, adapted, or abandoned as external and internal conditions have forced the inhabitants of the Andes to retrench, reduce, or cut down their scale of operations." There is clearly a changing landscape of reciprocity in the *altiplano* of southern Peru, in terminology and kind, and this appears to be true in Pucucanchita, the community where this research was carried out. In my experience living in the *altiplano* in 2010-11 and my conversations with those who have recently spent time in the area, there are two noteworthy changes that these traditional systems have undergone. First, the meanings of the terms (e.g., *ayni*) have changed, and second, a general knowledge of what these terms mean has diminished.

The term *mink'a* is recognized in Pucucanchita, mostly as its recent form from the *hacienda* days, but it isn't practiced in the community. This may be because the contemporary forms of exchange are sufficient to meet the needs accomplished by *mink'a*. Simply, there is a limited need to recruit a work party of more than two non-HH members, since the scope of HH agricultural and other projects is so small. A rare task that does require at least four adults in Pucucanchita is building a *cobertizo,* a shed that protects animals from the elements. This task appears on the surface as *mink'a*, but descriptions of the task by residents seem to resemble more of a modified *ayni*. Conversations with folks from neighboring herding communities, Nuñoa and Ayaviri (small highland townships), Juliaca (bustling highland trade center of ¼ of million people), and Arequipa (large city center with ¾ of million people) reveal that the term *mink'a* can be used to describe a number of exchange systems, ranging from its traditional Incan form to paid labor. According to a colleague working in central Peru, *mink'a* has even been used by non-profits to help organize help from locals.

*Ayni*, on the other hand, remains a term used to describe sharing relationships in highland herding communities including Pucucanchita. However, many HHs engage in *ayni*-like sharing, yet do not refer to it as such. For instance, a HH may state that it received help from another HH, and that it had given the same type of help to said HH, but when asked who in the community it has *ayni* relations with, the answer would be, "none." Of the network measures explored in this study, agricultural support networks have the greatest potential for *ayni* relations. Indeed, these networks are extremely reciprocal (68%). As with most traditional forms of Quechua exchange, the younger people in the Nuñoa area have no knowledge of *ayni* or *mink'a* when asked. For many of the younger families, when asked if they had *ayni* relations with anyone in the community, the interviewee would pause and ask the native interviewer, "what is *ayni*?" *Campadrazgo* relationships haven't changed as much as *ayni* and *mink'a* in the *altiplano* from my observations and personal experiences. These relationships, however, are not very common in the study community and likely play only a small role in sharing behavior.

While the systems of reciprocity and exchange described in the previous section have left a deep imprint in Andean ethnography, one thing remains true: HHs that receive help from more HHs have

healthier families (Carey 1990). This dissertation addresses a central question: Why do some HHs have greater access to support than others in their community? It is important to note that the support networks discussed below can't be neatly categorized as a certain type of Andean reciprocity (e.g., *ayni*), but this does not mean that the past systems don't influence social network dynamics. In my discussion of the highland social networks, I will briefly consider the influence these systems of reciprocity may or may not have.

### *Social support networks in the highlands*

Social networks in highland Peru are demographically diverse, composed of a complex web of kin and non-kin, including nuclear and extended families as well as friends, allies, mates and their families (Allen 2002; Flores-Ochoa 1968; Mayer 2002). As discussed, reciprocity and social support have a long history in Andean Peru, going back to the time of the Incas, and continue to play important roles in Andean social life (Allen 2002; Carey 1988; Mayer 2002). In the herding communities in the vicinity of Nuñoa there are a handful of social networks that can benefit HHs who have access to them. This research focuses on three forms of aid which constitute the majority of sharing/aid in the area: (1) help with agricultural labor, (2) health-related advice, and (3) food sharing.

#### Agricultural support networks

As subsistence agropastoralists, access to social support in the form of help with agricultural tasks is of particular importance to *campesinos* living in Pucucanchita. This research looks at three types of agricultural-related aid that occur in Pucucanchita: labor support with herds and gardens, animal husbandry advice, and tending animals.

Farming tasks, such as preparing and planting gardens, are more efficient and productive with help from outside of the HH. At the bare minimum, completing tasks associated with *siembra* (planting) and *cosecha* (harvest) takes two adults. During the planting of tubers, for instance, one person (typically a

man) digs a furrow with a hand plow in the ground, which has been fertilized with manure and plowed by hand or donkey. Another adult (typically a woman) follows closely behind, dropping a tuber into the hole, all while carrying a 50-pound bag up and down a very steep hill. The tuber is finally covered by a quick kick of dirt or by additional shoveling by the digger. More help means larger gardens and quicker preparation. The smallest team I observed was a team of two people, a young couple new to the community who worked a very small plot while their infant child lay swaddled close by as they worked.

The day-to-day routines of caring for a HH's herd animals can usually be completed without outside help. However, at several points during the year the entire herd must be corralled for tasks which are difficult for a single HH to do on its own (Orlove 1977). Of course, most animal husbandry tasks are physically demanding, as they require workers to wrestle and restrain the animals, as well as manage the task while the animals are doing their best to escape the procedure. One of the tasks that I observed and participated in was *esquila* (shearing of the animals). For a typical HH's herd this task takes at least three adults to complete in a day, though with fewer people it may take two or three days to shear the entire herd. One person is in charge of managing the contained herd and choosing the next animal to be sheared. The other adults will begin the process by grabbing the chosen animal and wrestling and pinning it to the ground. At this point the two adults, typically men, shear the animal using hand shears while pinning the animals down with their legs. The wool is tossed in a pile and is collect by the person managing the herd or an additional person if available (typically a female) who gathers it quickly and prepares the wool for transport by twisting, rolling, and finally tying the fibers in bunches. Of course, this is just one of many tasks that require help from network members. Slaughter and herd evaluation prior to slaughter, earmarking, vaccinations, pregnancy examinations, *esquila*, and castration of low-quality males are just a few tasks that may require HHs to recruit help.

In addition to direct aid, receiving advice and information about breeding methods and vaccination programs is especially helpful since *campesinos* are relatively detached from modern sources of information (e.g., internet, publications) and can't afford to acquire this information/aid from veterinarians. Like the people, herding animals of the region are constantly battling myriad diseases.

Routine, correctly administered vaccinations can prevent these diseases, but a herder must know the latest vaccinations for the most current illnesses/diseases. Income from the sale of wool is important for *campesinos*, so in order to produce the best fibers, one must employ successful breeding techniques. Some shepherds are more connected to information coming through Nuñoa and have special knowledge about vaccination programs. These networks are overlapping with those associated with the general help a HH receives with its animals. That is, those who help one another with *esquila*, vaccinating the herd, and so forth, are also more likely to talk about animal husbandry and share their knowledge. The last and comparatively thinner agricultural network involves watching another HH's herd when the owners need to travel. A HH can't leave its animals unattended due to predation by foxes, straying, and theft. Again, this network overlaps with other support networks, especially those involving aid and advice regarding animals.

There are three qualities that are particularly valuable in agricultural network support members. First, a person must be reliable and provide support in times of need. Inconsistent support from network members (e.g., not showing up on time or at all) can disrupt the delicate timing and coordination involved with critical agricultural events. Second, the person must have a good work ethic. Finally, since agricultural tasks are labor-intensive, a high level of physical fitness and strength is needed. Thus, successful agriculture and farming require recurrent access to reliable and viable network members.

Help is typically recruited by walking to where the HH head is herding his or her animals and asking if the HH would be able to help at a certain time; recruitment can also occur before or after community meetings and projects. While the nomenclature is not always used, agricultural tasks represent *ayni* exchanges more so than any other type of support investigated in this research. While helping a family during *sembria* (planting), I overheard a conversation between the workers. The HH head whose garden was being prepared had three helpers and after planting was finished the helpers shared coca with the HH head and made plans with him about when they needed help with their own gardens. In terms of agricultural support like this, reciprocity is expected. It's not a matter of asking if the beneficiary will return the help, but rather when. What is less clear is whether or not one type of aid is exchanged for

another type. As mentioned above, this is unlikely under the traditional system of *ayni*. Based on my discussion with community members, there are no hard rules for trading one type of aid for the exact same. So, do these broad agricultural networks described above represent *ayni*? In the traditional sense, the answer would be no. But as mentioned, reciprocity in the Andes, like anywhere else in the world, is a dynamic process that is reworked and adapted. As noted these networks are reciprocal in nature (Chapter 6), suggesting that it may be a modified form of *ayni* involving general agricultural aid reciprocity rather than task-specific reciprocity.

**Health advice networks**

The nearest professional health care center for those living in Pucucanchita can be hours away since residents must go first by foot or bike, then by *combi* (minivan taxi service). Many residents do seek out care from nationally funded rural health care outposts. The nearest health care outpost is relatively close for community members in Pucucanchita and can be reached by foot in a few hours. Rural health centers in the Nuñoa District are open sporadically, provide minimal care, and lack electricity and sterile working conditions. Because of these circumstances, coupled with a lack of money to pay for pharmaceuticals, families depend greatly on advice about health-related issues from members of their community.

Locals rely more on traditional medicines than on treatment from the local health care system. These traditional remedies are concoctions of herbs and plants that have been purchased at market or locally foraged. Thousands of remedies can be formulated from different combinations of the dozens of available herbs. The combinations of herbs and exactly how they are prepared for specific illnesses has not been well documented in the highlands (but see Wheelock 2011), and the effectiveness of these remedies has not been confirmed. Unfortunately, I couldn't explore these networks through interviews and observation since they are made up almost exclusively of women, and it would be inappropriate for a man (who is also a foreigner) to barge in asking questions. When it comes to HH health, women are the decision makers. If, for instance, a child is sick, the women of the HH are responsible for healing her,

whether via traditional medicines or making the decision to seek professional care. On a visit to a distant indigenous community with a Peruvian health care team early on in my fieldwork, I was amazed at how few sick children were accompanied by a man. After this and other experiences I wasn't surprised to find that health advice networks were highly sex-biased, though there are a couple of men who are key players in these networks in Pucucanchita.

Despite my limited experiences with these networks, I was able to uncover a few noteworthy patterns from conversations I had with community members. First, there is clear variation in knowledge about traditional medicines. My conversations with community members revealed the importance that is placed on this knowledge and the respect it lends to those who possess it. Only a handful of community members have reputations for expertise in traditional medicines (see Chapter 7). These experts in traditional medicine are sought out by community members because they have a quality that can provide a benefit more powerful than any other network quality: the power to heal.

Health advice networks have likely existed in the Andes for decades, but they do not fit neatly into any of the traditional systems of reciprocity that have been documented by ethnographers. Health advice networks in their very essence are asymmetrical, since advice is passed from someone who has knowledge to someone who does not. The recipient (unless also an expert) can't reciprocate expert health advice. The result is that those who have greater knowledge give more advice than they receive. Asymmetry in aid of this nature may lead to other forms of aid to the healer, such as food sharing, agricultural assistance and other types of aid (i.e., trade). As discussed, *ayni* has traditionally operated as reciprocity that is equal in type and amount. That is, I scratch your back tonight, you scratch mine tomorrow; not, I'll scratch your back tonight, you rub my feet every day next week. Consequently, health advice networks do not appear to function as *ayni* or any other type of traditional Andean exchange that I am aware of.

**Food sharing networks**

I was initially surprised to find that food sharing networks in Pucucanchita were considerably thinner than the other networks investigated in this dissertation (see Chapter 8). Given the serious issue of seasonal food insecurities and nutritional deficiencies that are so prevalent in the area (Leonard 1989; Graham 1997), I presumed these networks to be robust, and quite honestly, prior to fieldwork I expected these networks to be the showcase of my dissertation. It wasn't until the inner workings of Pucucanchita's political system were exposed that the low level of food sharing I observed made sense.

The community gardens in Pucucanchita have historically been very successful and provide a healthy amount of quinoa, *chuño*, and a variety of other tubers for community members. In addition to the food that is received from the community gardens, most HHs also have a garden of their own which supplements the food received from their share of the community gardens. The abundance of starches that HHs have access to from these gardens may explain the lack of food sharing with regards to the starches, but what about the sharing of meat from herding animals? This is an important question since only two food types—meat and starches—comprise the diet of *campesinos*. Whereas the lack of sharing of produce from crops is easily understood, the lack of meat sharing is a little more difficult to explain. Sharing only provides benefits if: (1) available stocks fluctuate at the HH level, and (2) this fluctuation is asynchronous between HHs. Illnesses and cold weather are the principal causes of death for the herding animals in this community. It is likely that *cria* mortality rates as a result of cold weather don't vary much between HHs since exposure is similar (and at the same time). However, those HHs that have better vaccination programs will likely experience lower mortality rates from illness, which could result in asynchronous fluctuations in the availability of meat across HHs. It may very well be that meat sharing was not necessary during 9 months in which I conducted my fieldwork because of lower rates of illnesses among the herding animals. Whatever the case, additional, long-term investigation is needed to better understand food-sharing behavior in this community.

**Benefits of social support network membership**

In the southern highlands, like any other place in the world, inter-HH support networks alleviate social and environmental stressors, such that those with greater social networks are less likely to experience negative health consequences (Carey 1990; House et al. 1988; Cohen and Syme 1985; Brown 1987; Rubenstein 1987; Lomnitz 1977; Kawachi et al. 1996). How exactly does greater social support lead to better health? Generally speaking, those who lack social network ties experience greater stress, which can negatively impact the immunological and neuroendocrine systems. This, in turn, leads to enhanced disease susceptibility and decreased pathogen resistance (Sapolsky 2004; Kawachi et al. 1996; McEwen 1998). In addition to stress reduction, support networks provide direct benefits related to agricultural production. This section considers the potential stress-reducing (and other) benefits that the three types of social networks investigated here—agricultural support networks, health advice networks, and food sharing networks—can provide.

Help with agricultural tasks, such as harvesting crops and advice about animal husbandry, is crucial given a HH's dependence on its crops and livestock for survival (Mayer 2002). Simply put, without a support network, HHs will struggle to survive. *Campesinos* in Pucucanchita do not have the luxury of hiring help for even the most laborious, physically demanding tasks. This creates a serious health issue for those living in high-altitude environments, since exerting too much physical effort could have profound acute and long-term health effects (Bonnon et al. 1999). Those who have a network of people to help with such tasks reduce the amount of physical activity they must exert at a given time. Additionally, in groups where illness and injury are common, having help during times of greater need can prevent a person and his or her dependents from getting sick and can decrease recovery time for the ill (Gurven et al. 2000). While having a larger support network comes with greater network obligations, it might also allow a HH to have more animals and produce more crops, which reduces illnesses resulting from nutritional deficiencies. In addition to the need for labor intensive tasks, having a support network for watching animals enhances mobility for families, allowing them to sell/purchase goods or seek professional medical care when needed. Having a thin network of people to watch one's herd could have

negative health implications, especially when the family is deciding whether or not to travel to seek professional medical aid. If a family member is in need, travel may be delayed due to lack of help watching the HH's herd.

Access to advice about health-related concerns, such as taking specific health measures when ill, can promote health, and these benefits of network membership are particularly important in low-income groups where obtaining professional health care and advice is often not feasible (Kawachi and Berkman 2001). In addition to the direct benefits of health-related advice, there are also important psychoemotional benefits that these networks provide. The assurance that good advice is just around the corner for treating your husband's back trouble and your child's persistent cough provides a sense of security, which can reduce stress (Kawachi and Berkman 2001; Berkman et al. 1992). It is also important to consider that having greater access to health advice may be a favorable position that can be used to leverage services of a different nature. It is possible that one HH provides a neighbor access to information (either directly or indirectly via other network ties) with the expectation that when the time comes that the giving HH needs a hand with, say, an agricultural task, it can ask the neighbor for assistance. HHs that have knowledge or access to knowledge about herbal remedies could potentially build a bank of support it can draw from. Thus, health advice networks potentially have positive health consequences by providing immediate solutions through advice, lowering susceptibility to illness by giving well-connected HHs the assurance of immediate, point-of-need advice, and giving those with a favorable network position a means to leverage other stress-reducing resources (see Chapter 7).

Seasonal variation in nutrient intake, which increases vulnerability to infections, continues to seriously impact health in the Nuñoa district and other areas of highland Peru (Leonard 1989; Leatherman et al. 1995; Graham 1997). While food sharing is not extensive in Pucucanchita, periodic food sharing among HHs can help families who may be struggling due to, for instance, an illness-induced reduction in HH output.

In closing, to deal with the stressors of everyday life, residents of the high Andes rely heavily on cooperative social support networks (Carey 1988; Leonard 1991; Mayer 2002). Although there are clear

benefits to membership in social networks, it is unclear how membership status is established and maintained, and the exact kind of support that leads to adaptive outcomes. How do HHs gain access to adaptive networks in their community? What factors influence the decision-making process regarding whom to include in one's support network? To approach these questions, the remaining chapters explore three interrelated aspects of highland Quechua social life: contribution to collective action, social reputation, and social network dynamics.

# Chapter 4: Field Methods and Study Design

In this chapter, I will introduce the study variables and discuss the methods of data collection that were employed. Permissions, recruitment, and interview context will also be discussed. This chapter begins with a brief summary of the pilot work I conducted for this research.

### *Pilot work*

In December 2008 and January 2009, I conducted a pilot project in a herding community in the same area (Nuñoa district) where I eventually conducted my principal dissertation research. With the help of R. Brooke Thomas (Prof. Emeritus of Anthropology, U-Mass Amherst), who has been working in the region for over 30 years, I met with several contacts who introduced me to community members in Nuñoa as well as the surrounding herding communities. At this time I also received verbal commitments from bilingual (Spanish-Quechua) Nuñoeños who were willing to work as research assistants and received permission from the mayor of Nuñoa to return for my dissertation project.

During fieldwork in *el campo* (countryside) for my pilot study, I had the opportunity to participate in many collective action (CA) duties, such as castration of llama and alpaca *machos* (adolescent males), immunizations of *crias* (young alpacas), administering oral nutrient supplements, documenting demographic aspects of the herds, and herding the animals. I also spent time working with *campesinos* (farmers/herders) in their *chacras* (gardens).

In addition to participant observation, I also conducted interviews about social network membership dynamics and issues of CA in the area. These discussions, coupled with my experiences working in *el campo*, greatly contributed to the design of my later work in the area. Most importantly, I learned about the wide range of CA that occurs in the region, the expectations of community members in terms of investment in CA, and how reputation relates to differential investment in CA. Additionally, I gained valuable insights into cultural perspectives on cooperation, division of labor (by gender, age, etc.),

as well as the different kinds of social network that occur in *altiplano* communities. In sum, the pilot work was invaluable and greatly contributed to the success of this project.

### *Approval and permissions*

This research was approved by the Human Subjects Committee at the University of Washington, Seattle prior to the pilot fieldwork, and a separate application was approved for the long-term fieldwork.

Within a week of my arrival in the town of Nuñoa for my long-term fieldwork in June of 2010, I met with the mayor at the time and asked for his permission to conduct research in the area. He has jurisdiction for the Nuñoa District which includes dozens of small herding communities (including Pucucanchita, where I did my work). Asking permission was more or less a formality, and there was no written contract documenting his permission for me to work in the area. However, being the only *gringo* in town stirs interest and I felt it was important to make my intentions explicit.

Obtaining permission from Pucucanchita, however, was considerably more complicated. While this community does have a governing body, including a president, most decisions are made by majority vote, with one vote per household (HH). I, two other American researchers who were there for short-term research, and our local research assistant visited during one of the community meetings and briefly explained our research interests in the community. We returned two more times during community meetings to clarify certain aspects of our work before final approval was granted. The issue of compensation was not raised during these conversations.

### *Recruitment and Sampling*

Recruitment was initiated immediately after receiving permission to conduct research in the community, though no interviews were conducted at that time. After approval was granted, plans were made to conduct interviews in the herding fields in the vicinity of their *cabañas* (residences). No formal arrangements were made to conduct interviews. We simply hiked around the community recruiting those

we met along the way (as discussed further below). While all 24 HHs were recruited for this study, one HH chose not to participate. Of the 23 HHs that agreed to participate, all participated in two sets of interviews.

It is important to note that the HH that did not participate in the survey was still included in the social network analysis, since other HHs did mention whether or not they had given or received aid from the non-committal HH. The only limitation of not having the opportunity to interview this HH (in regards to the social network analysis) is that I didn't have the chance to confirm exchanges mentioned by other HHs with the non-participating HH. Despite this small drawback, this sample of social network data constitutes what social network analysts refer to as complete network data. This is important to note, since whether or not a researcher has complete network data greatly impacts the types of analyses he or she can conduct.

## *Field methods*

Fieldwork was conducted from May 2010 to January 2011. Most of the data for this research was collected via participant observation and structured interviews. This section will discuss the context of data collection.

### Interviews

Most of the interviews were held in the pastures while community members were grazing their animals, or near their *cabañas*. My research assistant(s) and I would either take a motorcycle from Nuñoa or stay in the village meeting room the night before we sought potential interviewees. We would begin hiking to the villagers' *cabañas* shortly after day break. These trips would take most of the day, with, on average, two or three interviews conducted. Prior to the interview, subjects were read a consent form and asked if they agreed to participate in the study. The interviews were conducted in the preferred language of the interviewee, usually Quechua but often in Spanish with men 30 years old or younger. More times than not, the discussions would involve both Spanish and Quechua. While I conducted some interviews,

most were carried out by my research assistants. I would either take notes or take over the task that the interviewee was doing before the interview, usually watching/herding their animals. My lead assistant, a social worker, had conducted a study for the Nuñoa District in this community before. The importance of her previous work there can't be overstated; she was trusted, well known, well liked and well respected in the community. Following the interviews, interviewees were compensated for their time with various items, including soda water, grains, beans, bread, and coca leaves. Compensation per interview was typically equal to 10 American dollars.

There were two sets of interviews conducted in Pucucanchita. The first set of interviews was conducted in June/July of 2010, and the second in November/December of the same year. The two sets of interviews were identical with three exceptions. First, questions about additional support networks were added to the second interview. As I spent time living in the area and with the study community, I learned of other significant network relations that should be considered— for instance, help watching one's herds and/or children when a family must leave the community. Second, demographic information about the HH and their herds were not recorded during the second interview to alleviate interview fatigue. Finally, the reputation measures were recorded during the second interview only. This was because I wanted to build trust and rapport with the community before asking their personal opinions about fellow community members' social reputations.

Interviews were also conducted with the current and past presidents to obtain records (both archival and by memory) of those families who invested in CA in the past. Other types of community involvement, such as volunteering for certain governing positions were also documented from interviews with past dignitaries. All of these data were cross-checked by other community members for accuracy.

**Participant observation**

My assistants and I attended all community projects in Pucucanchita from June 2010 through January 2011, participating in a wide range of CA from helping shear the animals to planting crops (the different types of CA are detailed in Chapter 2). Participant observation was a method incorporated

primarily to measure investment in CA, but it turned out to be a useful tool for learning about additional aspects of Quechua social life, gaining visibility with community members, establishing trust, and building relationships.

Several types of data were recorded during participant observation in CA. First, the names of each person who attended the CA event were recorded. In addition, the amount of time each person helped and the job they participated in was documented. Finally, my local research assistants and I independently rated the work ethic of each person on a scale from 1 (low effort) to 10 (great effort). Additionally, during participation in these projects, conversations were tracked and social interactions and exchanges were observed.

## *Variables*

This research aims to understand why community members invest in CA despite incentives to free ride. In order to explore this topic several variables were considered, and can be broadly grouped into five categories: CA investment, social reputation, social support networks, HH attributes, and health.

### Investment in collective action

Data on investment in CA was collected via participant observation, interviews, and archival data. Investment in CA was measured in time (hours) contributed by each HH. Information on investment in CA for two years prior to the start of this research was obtained via interviews with the current and previous presidents of the community and from records these individuals had regarding community projects. These data were cross-checked via discussions with community members in addition to other leaders at the time. Using the observational, interview, and archival data, the total number of hours contributed to CA for the past two years was estimated for each HH. If two members of a HH were present during an event, their hours were summed and attributed to the HH; this "double contribution" was rare, only occurring three times. There was never an instance when more than two members of a HH were present at a community project at the same time.

**Reputation**

Reputation was assessed at the end of this project, during the final set of interviews. This research looks at two aspects of reputation in this community. First, a person's reputation specifically in terms of their investment in CA was assessed with two questions. Subjects were asked to name members of their community who were the *most reliable* and, in a second question, were asked who were the *most hardworking* in their community when participating in CA projects. Second, the interviews included three separate questions about who subjects felt, generally speaking, were the *most respected*, *most influential*, and *most generous* people in their community. For each set of questions a free-listing method was used in which participants could name as many people as they wished. Only adults (18 years of age and older) were asked questions about the reputations of other community members. Though subjects were not instructed to name adults, only adults were in fact named. The reputation score for each measure was determined by the total number of times a person was mentioned. If more than one member of a HH was mentioned for a reputation measure by an interviewee, then their scores were summed and attributed to the HH; this occurred six times (but only for members of two HHs). At least one member from each participating HH responded to these questions, but no more than two per HH responded. The five questions resulted in five HH reputational variables, in addition to a total reputation score (sum of each HH head's five reputation scores).

**Social support networks**

The networks discussed below are the principal types of support that are given and received in this region of the *altiplano* and were identified during observations and discussions during my pilot work as well as during the course of my dissertation fieldwork. Social network data were collected on agricultural labor help, help watching animals, medical advice, and food sharing. These data were combined to form broader social network categories, referred to in this dissertation as *agricultural support networks* (agricultural labor help, animal husbandry advice and watching animals), *medical advice networks* and *food sharing*. A network combining all of these network data was also analyzed.

For the agricultural support network, social network data were collected on three types of help with agricultural life. First, community members were asked who they had aided and from whom they had received aid with agricultural tasks during the past *el tiempo de cosecha* (harvesting season) for the first interview set and *el tiempo de siembra* (planting season) for the second interview set. Second, participants were asked if they had watched or cared for anyone's animals in the six months prior to the interview. Finally, participants were asked to whom they gave and from whom they received animal husbandry advice during the past *tiempo de siembra.* The first set of network data were collected during both the first and second interviews, while the latter two network measures were collected during the second set of interviews only. The agricultural support network included directed ties from all three agricultural social relations described above. The analysis of this network is the focus of Chapter 6. For the medical advice/aid network, subjects were asked to whom they had given health advice and from whom they had received health advice in the month prior to the interview. These questions were asked during both the first and second interviews. The health advice network included directed ties from these health-related social relations. The analysis of this network is the focus of Chapter 7. Social network data on food sharing networks were also collected during both sets of interviews. Subjects were asked to whom they had given food and from whom they had received food from in the month prior to the interview. A directed graph for the complete support network, which includes the entirety of the network data mentioned above, was also analyzed. These data are reported in Chapter 8.

The interviews we conducted asked subjects from whom they received aid and to whom they gave aid. Data of this nature are advantageous in that the researcher can cross-check the data to see if there is consistency in stated sharing relationships. In the nomenclature of social network analysis, consistency in stated relationships (i.e., HH 5 said they gave to HH 20 and HH 20 said they received from HH 5) is called concordance; discordance is when there is inconsistency in a stated relationship (i.e., HH 5 said they gave to HH 20 but HH 20 said they didn't receive aid from HH 5). This research assumes concordance, meaning if HH 10 said they received aid from HH 2, but HH 2 didn't mention providing aid to HH 10, then it is assumed that the transaction simply slipped the mind of the HH 2 interviewee. Two

bits of evidence influenced the decision to assume concordance. First, there simply is nothing to gain by claiming that your HH gave (or received) aid to (from) another HH. Second, while we assured confidentiality in the interview, it is likely that any temptation to lie would be suppressed by suspicion that their fib will be discovered; this is due to the prevailing mentality in this small tightly knit community, as well as the fact that interviewees knew we would ask the same question about social relationships of other HHs. For instance, if a respondent incorrectly said their HH shared with HH 9, they knew that we would be confirming that sharing relationship by asking HH 9 who they received help from. It is also important to note that reciprocity is a core value among the Quechua, and a reoccurring theme in ceremonies and the oral history of these people (as discussed in Chapter 3).

**Household data**

Since this research aims to understand why some HHs contribute more to CA than others and why some HH heads have greater reputation than others, it is important to consider explanatory factors other than those predicted here. In the context of the study area, candidates include the ratio of helpers in the HH to the size of the HH's herd (per capita herd size), differences in HH wealth, ratio of dependents to helpers, age of the HH head, kin relations, and distance between HHs.

HH work demand increases with larger herds, which might constrain attendance at community projects. During the daytime when CA projects take place, a HH's herd must be continuously watched so that the animals do not stray, are not stolen, or do not fall victim to foxes or other predators. Since alpacas are notoriously edgy and need access to grass and water when being corralled for long periods of time, containing one's animals in a corral while helping with community projects is generally not an option. During the first set of interviews, herd sizes owned by each HH were recorded for the types of animals that are grazed in the area (alpaca, sheep, llama, and cattle). Work demand of the herd relates not only to herd size, but also to the number of people in the HH who can help with animal husbandry tasks. Consequently, the potential effect that herd size has on attendance to CA is measured using the ratio of helpers in the HH to the size of the HH's herd, what I refer to as per capita herd size.

Differences in wealth across HHs are negligible in this community and I was hard-pressed to find any measure of wealth. First off, ownership of material items is rare, probably due to the lack of money and the need for mobility (HHs have a *cabaña* for the rainy season and another for the dry season). The only noteworthy variation in wealth would be a HH's herd size, and thus per capita herd size can double for a proxy of wealth.

Family structure may impact how much time HH members can invest in CA. For instance, a HH of eight comprised of two adults, four young children, and elderly grandparents may not be able to contribute as much to CA as other HHs due to the time constraints of child care, taking care of agricultural duties and other HH tasks. The possible impact of HH structure on attendance to community projects was assessed using a dependency ratio measure. The dependency ratio is usually defined as the number of people in a HH aged <15 and >64 to those aged 15-64 (Cohen 2003). Children's work (especially helping with agricultural tasks) is very important to HHs in this region, and children over the age of eight were regularly observed watching the HH's herds. Having children over the age of eight, consequently, could free up time for other HH members to attend CA projects. The traditional dependency ratio described above was adjusted as follows to better fit the cultural context of the study area: the number of people in a HH aged 0-8 plus those 65 years of age and older were considered dependents.

This research focused on understanding the potential role social reputation plays in enhancing social support. Factors other than reputation, of course, may influence how much social support is given and received, such as distance between HHs, kin relations, and the length of time a HH has lived in the community. Regarding the former, studies have shown that distance between HHs is a powerful determinant of whether or not a sharing relationship between two HHs occurs, such that HHs that live closer are more likely to have a sharing relationship (Nolin 2010). During the course of this research, GPS coordinates for each HH were recorded and used to calculate straight-line distances between each HH, as well as the average distance that each HH was from all other HHs in the community. Kin relationships were evaluated using genealogical data collected during the interviews. Despite the low degree of kinship

in this community, a proxy of genetic relatedness between HH was considered because of the potentially strong effects it can have on sharing behavior. Since this is a HH-level analysis, the coefficients of relatedness between members of a particular HH and another HH were summed. If the sum of coefficients was equal to or greater than 0.125 (which amounts to the expected fraction of shared alleles between first cousins), then those HHs were considered "kin." This demarcation was based on discussions with community members, and what they considered true *afinidades* (kinship). It is possible that those HHs who have lived in the community longer may have more social ties in the community or may have stronger reputations, so time spent in the community (in years) was also considered in the analyses.

Since reputation may increase with age (Silverman and Maxwell 1978; Buss 1990), it is advisable to control for the possible effects age has on the link between investment in CA and reputation. Two age measures were used: the age of the head of HH, defined as the oldest male living in the HH or the oldest woman if a man was not present, and the mean age of the male and female heads of HH. There were no HHs wherein the grandfather was present and he was not considered the head of HH. While the oldest male typically represents the HH in the study community and other areas of the highlands, the reputation of the female head of HH is important in many aspects of social life. A HH consisting of a widow in her late 80s who was living alone (and did not contribute to community projects) was excluded from the age-reputation analyses. The results reported in this dissertation are for the first method, since each method more or less yielded the same results and my speculation is that the first measure of age is more concise. The age of the male HH head was squared and included as a variable in the analysis; including age-squared as a variable controls for the likelihood that the ability to contribute to CA (which can impact reputation) decreases with advanced age.

Other HH data collected included how much money each HH had spent on food and other expenses in the two weeks prior to the interview. The duration of two weeks was chosen since most HHs travel to the market every few weeks, and to sharpen recall accuracy. The interviews also asked how many animals or how much wool they sold in the past year and how much money they received from

these transactions. Finally, the interviewees were asked if anyone in their HH had a paying job, though I was advised by my assistants not to ask how much income those jobs brought the HH.

**Health**

The health of members of a HH may also affect their ability to contribute to CA, as well as constrain the contributions of other HH members who must care for the ill or take over their HH tasks. Health data for community members was collected in June/July and November/December of 2010. Community members were asked if they had experienced any of 20 symptoms in the past month that are common in the area. Parents responded for their children. Symptoms were chosen based on discussions with medical staff who work in the area, interviews with people who live in the area, and past research in the Nuñoa area (Carey 1990). After participants were asked if they had experienced these symptoms, they were asked to name any other symptoms they had experienced in the past month. The total number of symptoms experienced by each HH member was summed, and this value was divided by the total number of HH members. From this, the average number of symptoms experienced by each member of the HH was deduced (what is referred to as a symptomatological index). This method was used to produce three total measures of HH health: average number of symptoms per HH member for (a) May/June 2010, (b) November/December 2010, and (c) for both time periods combined. These measures are used as a proxy for general health of the HH. Subjects were also asked if any of the HH members were not able to contribute to HH or community duties due to their illness, and how many days of work they missed as a result of their illness.

### *Level of analysis*

Analyses with regard to participation in CA and social support networks for this research were conducted at the HH level, following a widely accepted perspective on HH economies in small scale societies that depend on agriculture, pastoralism, and the management of public goods (Barlett 1980, Wilk 1989, Netting 1993). The HH is the principal economic unit of agropastoralists living in many

communities of the Andes since production and consumption occurs strictly within the HH. Whether it's produce from the HH's harvest, a bicycle, or money obtained via the sale of animals, everything is "owned" by the HH. Of course, there are different roles with regard to how resources are distributed (the male HH head is typically in charge of this), but the resources that flow into the HH become the property of the HH (Mayer 2002, Platt 1986). In this community there is little opportunity for individuals to accrue money or goods and maintain them independently (Mayer 1977, Collins 1986). This is because few *campensinos*, especially in the high Andes, engage in any economic ventures (e.g., external labor) in which they can obtain money. Importantly, the exchange of goods and services is perceived as occurring between HHs rather between individuals. In addition to this HH economic perspective, individuals identify as a member of a HH and are perceived by others as such, whether it's by the name of the HH head or by the name of the residence (each individual or cluster of dwellings has a HH name that is not related to the family's name). Further, attendance at CA events is not enforced, but it's expected by a representative of the HH, not each individual in the community. This is likely why there were so few instances in which a HH had more than one member present at a particular CA event. It is also important to restate that HHs (not individuals) have voting rights with regard to community affairs.

The reputation measures focus, however, on individuals since reputation in this area is assayed principally by the social status of the head of HH, and the concept of a "HH reputation" is a vague one at best. Qualitative assessments and past research in the Andes indicate that the successes and failures of the male head of HH influence the attitudes that other community members have toward the HH and its members (Mayer 2002, Platt 1986). Simply put, the reputation of the male head of HH (and in some cases the female HH head) determines how the HH is perceived as a whole, as he (and sometimes she) is responsible for making the HH decisions, such as the buying and selling of goods, agricultural practices, and who is sent to help with CA. Other bits of evidence, including the fact that the HH head is almost always the HH representative at community meetings, voting days, and other community matters, suggest that the focus should be on the reputation of the HH head. As it turns out, 96% of those mentioned during the reputation questions were either the male or female head of HH.

# Chapter 5: Group cooperation and social reputation

This chapter explores the relationship between a household's contribution to collective action and the household head's social reputation in various categories. Descriptive statistics for the independent variable (labor time investment in collective action), dependent variables (social reputations), and covariates are reported, followed by inferential statistical tests of the predicted relationship. I conclude this chapter with a discussion of the results in the purview of evolutionary signaling theory.

## *Statement of the problem*

Common property institutions such as communal ownership of herds and gardens play an important role in the sustainability of life in Pucucanchita, a small herding community in the highlands of Peru where this research was carried out (see Chapters 1-3 for details on the study community). Despite the importance of these institutions, communal ownership can result in social dilemmas in which some pay higher costs to generate the collective good, while others fail to pay their share or reap disproportionate benefits (Hardin 1982; Ostrom 1990; Smith and Wishnie 2000). Interestingly, successful management of common property systems involving collective action (CA) still occurs throughout the world despite the obstacles of free riding and overappropriation. While the means of overcoming the social dilemmas associated with CA are varied, one solution may be that those who contribute more receive reputational benefits. A good reputation can provide myriad benefits, whether social (e.g., greater number of allies), economic (e.g., more resources/aid received), or both (Smith 2004; Gurven and von Rueden 2006; von Rueden et al. 2008).

This research proposes that those households (HHs) that invest more in costly forms of communally beneficial projects (i.e., CA) have HH heads who, as a result of their HH's generosity, have better reputations for various qualities. Drawing from costly signaling theory, I propose the following hypothesis:

### *Hypothesis 1*

Households that invest more time (in hours) in CA will have household heads who have a greater reputation in their community as:

a) hard working contributors to collective action
b) reliable contributors to collective action
c) generous community members
d) respected community members
e) influential community members

### *Descriptive statistics*

In this section, descriptive statistics for the independent (investment in CA) and dependent (reputation) variables are reported, in addition to the covariates that were considered for testing Hypothesis 1. Also, descriptive bivariate correlations between key variables and their associated scatterplots are presented. Correlation tests use Pearson's *r* and are two-tailed. Data were analyzed using SPSS 19.0.

**Investment in collective action**

Data on a total of 2444 person-hours over 22 CA projects (some lasting several days) were obtained via direct observations (1016 person-hours) and reviewing records and conducting interviews with leaders (1428 person-hours). The observational data and archival/interview data on total hours invested per HH were highly positively correlated ($r=0.791$, $n=24$, $p<0.001$). The time ranged from 0 to 211 hours (median=97.0).

**Social reputation**

A total of 32 adults over 17 years of age (of whom 52% were female) responded to questions about the reputation of their fellow community members. Though subjects were not asked to only name adults (59 adults live in the community), only adults (i.e., people 18 years of age and older) were in fact chosen. Of the total responses, 68% of those named were men. There were a total of two women who were considered head of HH, one being a widow and the other a former president whose husband spends most of his time away from the community for employment reasons. In cases in which women were named but were not head of HH, credit was given to their husbands; in all of these cases the women were female heads of HH. Two questions, "hardworking" and "reliable," asked about reputation in terms of CA. Three questions, "generous," "influential," and "respect," asked about reputation for these qualities, not mentioning CA. The five questions resulted in five reputational variables for each HH head, equated by summing the number of times a HH head was mentioned. I also considered a total reputation score, which summed the five reputation scores for each HH head. For each set of questions a free-listing method was used in which participants could name as many people as they wished. Scores for HH heads ranged from 0 to 21 (median=7.00) for "hardworking," from 0 to 15 (median=2.50) for "reliable," from 0 to 12 (median=2.50) for "generous," from 0 to 20 (median=3.00) for "influential," from 0 to 16 (median=3.50) for "respect." Scores for the total reputation score ranged from 1 to 77 (median=18.00). (See Chapter 4 for detailed information about data collection on CA investment and social reputation.)

**Covariates**

The key hypothesis of this research is that there are reputational gains from helping with CA. In exploring the predicted relationship between investment in CA and reputation, several factors that may confound this relationship should be considered (Diagram 5.1). This section reports the descriptive statistics for the covariates considered for use in the analyses for this chapter. These include morbidity, dependency ratio, per capita herd size, age of HH head, and years spent in the community (Diagram 5.1).

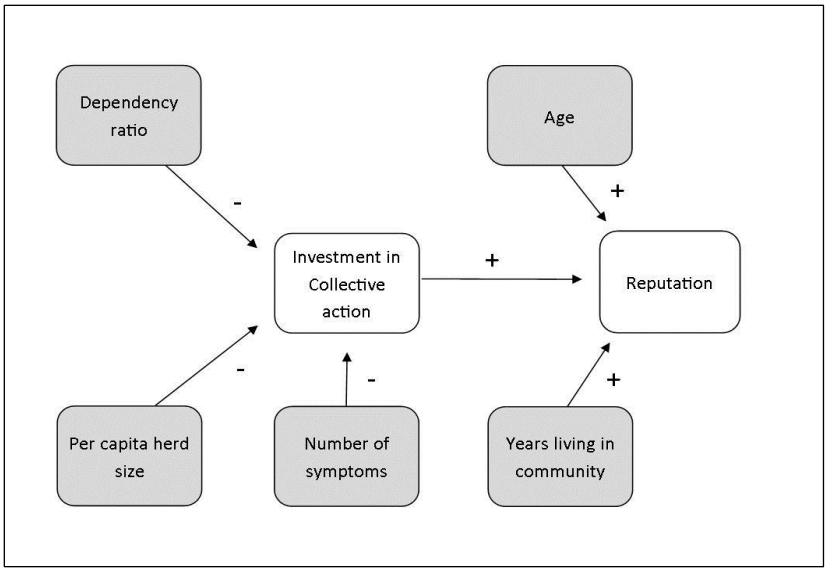


**Diagram 5.1.** Causal diagram showing the predicted relationship between investment in CA and reputation with the associated control variables (shaded boxes). Plus signs indicate whether or not the covariate is expected to increase (+) or decrease (-) the dependent or independent variables. For instance, a greater dependency ratio is expected to impede (-) a HH's ability to contribute to CA.

Poor health may reduce a HH's ability to contribute to CA; therefore, it is advisable to include a measure of HH morbidity as a covariate. The average number of illness symptoms per individual in the community during the first recall period (June 2010) was 8.29 (SD=3.01), and was 6.27 (SD=1.67) for the second recall period (November/December 2010). The average number of symptoms for an individual (community-wide) combining the two periods was 7.28 (SD=2.12). (See Chapter 4 for a definition and methodology of illness symptoms.)

The relative number of dependents in a HH may also impact the amount of time that a HH can invest in CA. HH size ranged from one to seven in this community of 81 people. The average HH size was 3.37 (SD=1.81), with an average of 1.37 (SD=1.09) dependents per HH (using the adjusted dependency ratio as explained in Chapter 4. On average, HHs in this community were comprised of 33% dependents. In the study community, women play a vital role in CA, helping with a wide range of duties from manual labor to preparing large meals for the work party. Consequently, the male-female ratio of each HH was not considered to impact investment in CA.

Having a larger herd can also impede a HH's ability to contribute to CA. The average herd size for HHs was 57 animals; HHs averaged 28.0 alpacas, 23.6 sheep, 4.1 cattle, and 1.8 llamas. Of course work demand is related not only to the number of animals that a HH has, but also to the number of people in the HH who can help with animal husbandry tasks. Thus, I considered the effect of the ratio of the HH's herd size to the number of helpers in the HH (i.e., per capita herd size) on investment in CA.

Two factors that can influence the reputation of a HH head are age and how long the HH has been in the community. The average age of the HH head was 60.2, ranging from 32 to 85. The longer a HH has lived in the community can potentially impact the reputation of the HH head since he or she has a longer track record as a strong (or weak) contributor to CA. Given this possibility, the number of years a HH has spent in the community was considered as a potential covariate. The average number of years spent in the community (which was founded in 1984) was 17.88 years (SD=6.92), ranging from 3 to 25 years.

**Bivariate correlations**

This section reports two different sets of bivariate analyses conducted for Hypothesis 1. First, the relationships between hours invested in CA and each of the five reputation measures, in addition to the total reputation score (the sum of the five reputation scores for each HH head) are reported. Second, the ten possible bivariate relationships across the five reputation measures are explored.

***Investment in CA and reputation***

The relationship between time invested in CA by a HH and the reputation scores of the HH head was first explored using Pearson's coefficient, *r*. These results show that each reputation score is highly correlated with investment in CA (Figure 5.1-5.5). Reliability (CA reputation) had the highest correlation coefficient (Figure 5.2), followed by generosity (general reputation) (Figure 5.3), hardworking (CA reputation) (Figure 5.1), respect (general reputation) (Figure 5.5) and influence (general reputation) (Figure 5.4). As mentioned, the five reputation scores were summed for a variable that is referred to as the

total reputation score. Not surprising, total reputation score also exhibits a strong correlation with a HH's investment in CA (Figure 5.6).

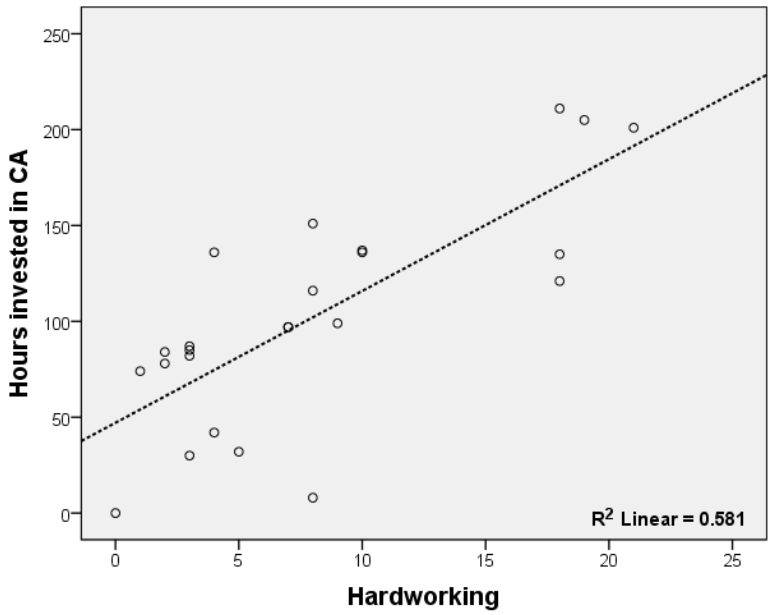


**Figure 5.1.** The relationship between hours invested in CA and reputation score for "hardworking" in terms of help with CA. The variables are positively correlated (Pearson's $r$ =0.762, N=24, $p$<0.001).

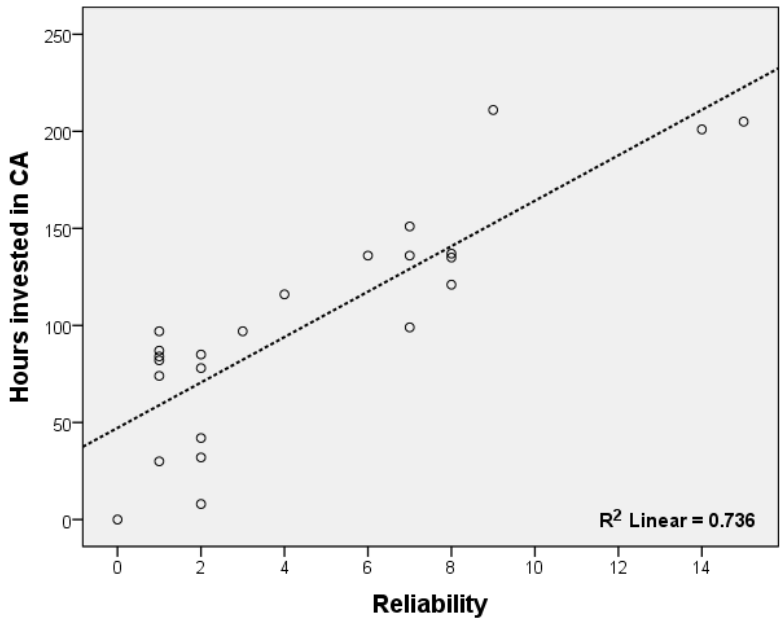


**Figure 5.2.** The relationship between hours invested in CA and reputation score for "reliability" in terms of attending CA. The variables are positively correlated (r=0.858, N=24, p<0.001).

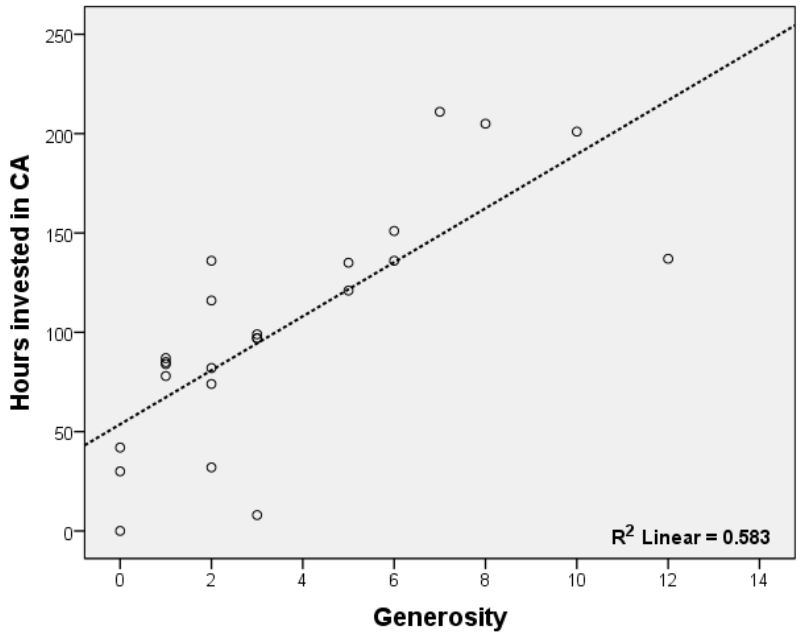


**Figure 5.3.** The relationship between hours invested in CA and reputation score for "generosity." The variables are positively correlated (Pearson's *r*=0.763, N=24, *p*<0.001).

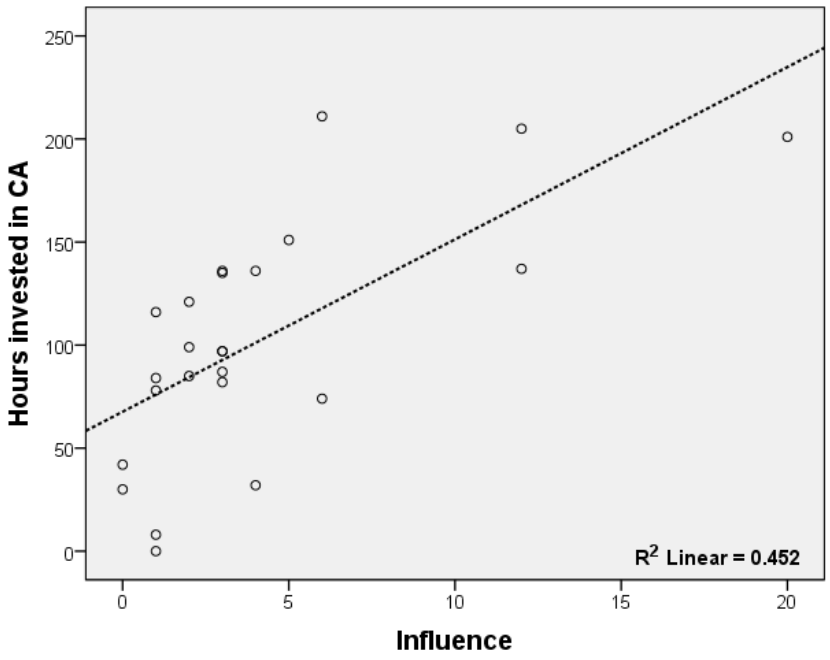


**Figure 5.4.** The relationship between hours invested in CA and reputation score for "influence." The variables are positively correlated (Pearson's $r$ =0.672, N=24, $p$<0.001).

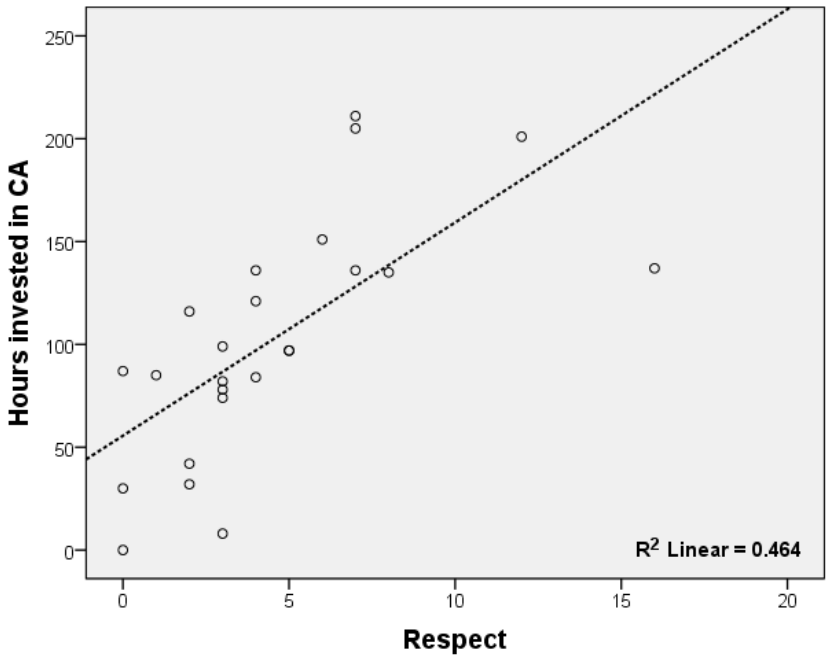


**Figure 5.5.** The relationship between hours invested in CA and reputation score for "respect." The variables are positively correlated (r=0.682, N=24, p<0.001).

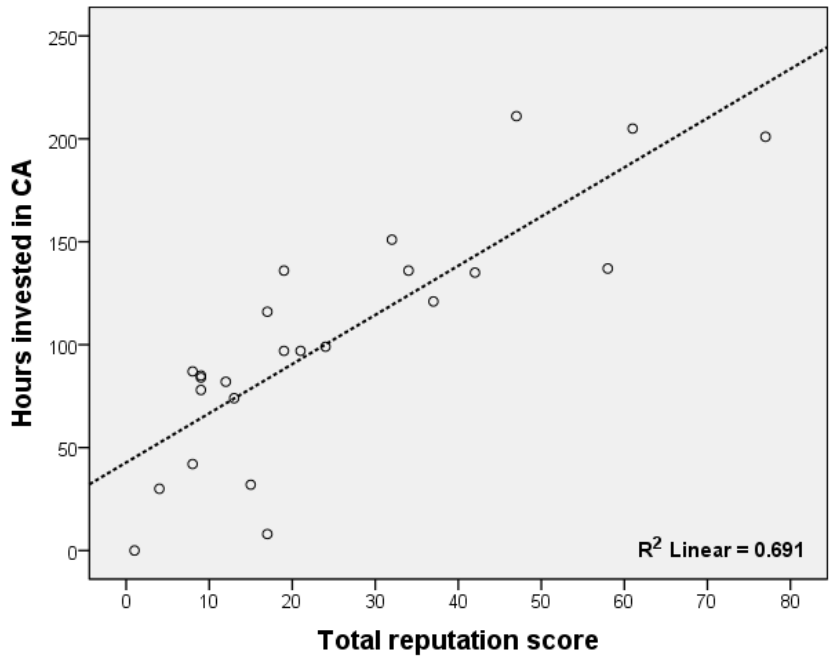


**Figure 5.6.** The relationship between hours invested in CA and total reputation score. The variables are positively correlated (Pearson's *r* =0.831, N=24, $p<0.001$).

***Correlations between reputation measures***

Looking at relationships between reputation measures can provide insight into which types of reputation are related, and to what degree. Relationships among the reputation measures were explored using Pearson's *r*. Looking first at the CA reputation measures, reliability is most strongly correlated with the other CA reputation measure, hardworking (Table 5.1). Generosity is correlated with reliability and hardworking more so than any other general reputation measure (Table 5.1). The highest correlation, at .934, is between generosity and respect. In fact, looking across the ten correlations, each measure yields a stronger relationship with generosity than any other, with the exception of hardworking, which has a stronger association with reliability.

**Table 5.1.** Pearson coefficients for reputation measures.

| | Respect | Influence | Generosity | Reliability (CA reputation) | Hardworking (CA reputation) |
|---|---|---|---|---|---|
| Respect | 1 | | | | |
| Influence | .773*** | 1 | | | |
| Generosity | .934*** | .827*** | 1 | | |
| Reliability (CA reputation) | .706*** | .748*** | .835*** | 1 | |
| Hardworking (CA reputation) | .643*** | .607** | .776*** | .892*** | 1 |

***p<.001, **p<.01

## *Variable selection*

For the possible confounding variables mentioned above, two analyses, partial and bivariate correlations, were conducted to determine which potential confounders were in fact impacting the predicted relationship between CA investment and social reputation. In this section, results from these tests are reported.

### Partial correlations

The partial correlation test is an analysis that looks at the relationship between two continuous variables and includes an additional variable as a control. It is a very useful analysis for identifying potential extraneous variables that may in some way influence the relationship between the independent and dependent variable, and can thus offer insight into variable selection for the inferential tests of Hypothesis 1. The results show conclusively that none of the covariates undermine the relationship between time invested in CA and total reputation score (Table 5.2).

**Table 5.2.** Pearson coefficients and p-values from partial correlations of investment in CA and total reputation score, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Investment in CA and Total reputation score | None | .831 | <.001 |
| | Age | .850 | <.001 |
| | Morbidity | .858 | <.001 |
| | Dependency | .825 | <.001 |
| | Morbidity*Dependency | .847 | <.001 |
| | Years in community | .829 | <.001 |
| | Per capita herd size | .833 | <.001 |

**Bivariate correlations**

Correlations between the potential confounding variables and the independent variable, investment in CA, were analyzed as these results can also provide insight into variable selection for the inferential test of Hypothesis 1. Morbidity is not significantly correlated with investment in CA, though the coefficient is negative as anticipated (Table 5.3). HH dependency ratio, while resulting in a much higher *r* didn't show a statistically significant relationship with investment in CA, and this relationship was in the opposite direction than anticipated (as dependency increases so too does investment in CA). The interaction term morbidity*dependency shows a similar pattern. Per capita herd size, however, is positively correlated with time invested in CA, and shows a marginally significant association (Table 5.3). When considering per capita herd size as a measure of wealth, this relationship in meaningful (greater wealth frees up time to invest in CA), whereas understanding per capita herd size as something that hinders a HH from investing in CA (due to time or labor conflicts between CA investment and herd care) is not.

**Table 5.3.** Correlations between potential confounding variables and the independent variable, investment in collective action.

| | Morbidity | Dependency | Morbidity*dependency | Per capita herd size |
|---|---|---|---|---|
| Pearson's *r* | -.051 | .281 | .182 | .411 |
| *P* | .814 | .184 | .395 | .058 |

Correlations between the potential confounding variables and the dependent variable, reputation, were also conducted. Morbidity is not correlated with reputation, though the coefficient is negative as anticipated and approaches statistical significance (Table 5.4). Years living in the community, while resulting in a higher *r*, didn't achieve statistical significance. Per capita herd size, however, is positively correlated with time invested in CA, and shows a marginally significant association (Table 5.4). As a result of the direction of this relationship with reputation and time invested in CA, from here on I will refer to per-capita herd size as a measure of wealth.

**Table 5.4.** Correlations between potential confounding variables and the dependent variable, reputation.

| | Morbidity | Age | Years in community | Per capita herd size |
|---|---|---|---|---|
| Pearson's *r* | -.307 | .190 | .244 | .356 |
| *P* | .144 | .374 | .250 | .104 |

Although the partial correlations and bivariate tests suggest an absence of significant extraneous variables, a few covariates, based on their slight associated with either the independent or dependent variable, were included in the predictive analysis. Morbidity (measured in terms of number of symptoms) was included as a covariate in the linear regression model since it was marginally (negatively) correlated with reputation (r=-307, p=.144), as was per capita herd size (though positively correlated) (r=.356, p=.104). Dependency ratio, morbidity*dependency ratio (interaction term), and years in community were not included in the model since there were no statistically significant relationships between these variables and reputation score, and because these variables didn't affect the CA-reputation association.

### *Predictive analysis*

To test Hypothesis 1, the relationships between investment in CA (independent variable) and each reputation score (dependent variables) as well as the total reputation score were assessed individually using linear regression models. All tests reported in this section are one-tailed; data were analyzed using SPSS 19.0.

The linear models indicate strong relationships between investment in CA and the five reputation measures. Time invested in CA was predictive of the two reputation measures regarding one's reliability and work ethic while helping with CA, controlling for several factors (Table 5.5). Time invested was also predictive of the general reputation measures regarding generosity, influence, and respect, as well as the overall reputation score (Table 5.5). The individual linear regression models with respect, influence, generosity, reliability and hardworking, and the total reputation score as dependent variables explained 56%, 57%, 73%, 79%, 82%, and 82% of the variation in reputation score, respectively. These data support Hypothesis 1a-e.

Age was a significant predictor of respect, influence and generosity, and was a marginally significant predictor of the overall reputation score. Morbidity was predictive of a hardworking reputation such that as the number of symptoms decreased, reputation score increased.

**Table 5.5.** Standardized beta coefficients from separate linear regression models for each reputation measure as well as the total reputation score (dependent variables).

| | General reputation | | | CA reputation | | All |
|---|---|---|---|---|---|---|
| Independent variables | Respect | Influence | Generosity | Reliability | Hardworking | Total rep score |
| Investment in CA | .691** | .591** | .806*** | .889*** | .706*** | .813*** |
| Age | 1.83† | 2.47* | 2.07* | .325 | .193 | 1.39† |
| $Age^2$ | -1.80† | -2.51* | -2.03* | -.238 | -.013 | -1.31† |
| Morbidity | -.116 | .032 | -.049 | -.141 | -.415*** | -.184† |
| Per capita herd size | -.167 | .094 | -.139 | -.087 | .111 | -.015 |

***p<.001, **p<.01, *p<.05, † p<.1

## *Discussion*

This research seeks to understand why some HHs contribute more than others to CA, despite the benefits that can be gained from free riding. From the perspective of signaling theory, there is great potential for reputational gains from helping fellow community members, especially in widely observable social environments such as CA. If, indeed, a costly signaling dynamic explains high contributions by community members in Pucucanchita, several criteria should be met: (1) signalers differ in qualities that matter to observers (e.g., health, generosity), and these attributes are difficult to observe in other contexts; (2) the opportunity for deceit by low-quality signalers creates a conflict of interest between signalers and observers; (3) high-quality signalers pay lower marginal signal costs or receive greater marginal benefits from signaling; and (4) observers benefit from the knowledge they gain from the signal and/or future social relations with signalers (Johnstone 1997; Bliege Bird and Smith 2005; Grafen 1990). The third condition is critical, as it makes it unprofitable and/or too expensive to provide misleading signals of quality (Johnstone 1997; Bliege Bird and Smith 2005). Under these conditions, honest communication can evolve despite the sometimes conflicting interests of signalers and signal receivers (Maynard Smith and Harper 2003). While signal costs are less important in a signaling dynamic at equilibrium, the dynamic social system that is Pucucanchita CA shows no indication of a stable signaling venue. Thus, it is important to first consider the costs of investment in CA and what these costs may tell observers about differences in the quality of their fellow community members.

### The costs of household investment in collective action

In some communities of the southern highlands, CA is diverse and frequent, involving a large number of tasks which can consume a considerable amount of time and energy and increase the risk of injury and overexertion. From a costly signaling perspective, the cost or risk of participating in community events can convey rather specific information about underlying qualities of fellow community members that are otherwise not easily observable, such as cooperative intent, knowledge, and/or physical

vitality. Two classes of costs associated with CA in this community which can provide important information about contributors will be discussed here: time costs/conflicts and risk of injury/overexertion.

There are considerable time costs and conflicts for HHs who routinely help with these year-round community projects. The time that is allocated to CA could be used towards other farming and agricultural tasks, and can thus impact HH production. There are also time conflicts that occur since a HH needs to plant and harvest its crops at the same time as these tasks must be completed for the community's gardens. Shifting planting/harvesting times may make a family's crop more susceptible to early/late frosts, hail storms, and theft by those who have experienced crop failure. There are also time conflicts with regard to animal husbandry tasks, such as shearing the animals, breeding, and implementing vaccination programs. As agropastoralists with little or no external income, the health of HH members is heavily dependent on production at home. Like in other poverty-stricken areas of the world, when production goes down, mortality and illness increase in the Andes (Leatherman 1994, 1996, Carey 1990). Losing a viable HH contributor for the duration of a CA project is especially difficult for those HHs that have a small number of contributors and/or sick HH members.

Field observations noted musculoskeletal injuries, cuts, scrapes, burns and contusions during community projects, and frankly few walked away from these tasks completely unscathed. In Pucucanchita, each task poses a risk, whether it's re-roofing precariously high in the rafters of a community building, wrestling a 200 pound llama to the ground, or shearing a struggling (and biting) alpaca with hand shears. Agricultural tasks by their very nature are dangerous. An injury sustained during CA would limit the ability of a person to fully contribute to HH tasks, which could seriously impact HH production for those with limited intra- and inter-HH support. In addition to the risk of injury, the energetic demands and physical effort required during CA are, at times, extreme. This can lead to overexertion, which can result in a number of negative health effects in addition to increasing the possibility of future injury (Mital, Pennathur and Kansal 1999). The high force demands of, for example, carrying a 50 pound bag of potatoes up and down a 60 degree hill in difficult terrain, or contact stress in the hands and wrists from twisting, rolling, and tying wool in bunches, hours of continuously working the

shovel, swinging a hand plow, or hand shearing animals, are just a few of the tasks that can result in overexertion. Again, overexertion or injury is another risk that can affect the amount of work a person can contribute to the HH, thus reducing HH production.

Only those who can handle the demands of CA can contribute regularly, especially those tasks that pose a higher risk or are physically demanding. So, HHs with physically fit, coordinated, strong contributors are less susceptible to overexertion and injury. Further, only those HHs that have certain qualities, such as valuable within-HH support dynamics, good work ethic, generosity, and good animal husbandry and farming skills can endure the time costs and conflicts that come with contributing to CA.

Finally, it is important to note that every calorie and every workday count for *campesinos*. Calories and time spent during CA participation are lost as the result of reduced agricultural production (through time lost or injury), can potentially result in acute and long-term health problems (Pitt and Rosenzweig 1985). Also, micronutrient deficiency increases rates of illness and death from infectious diseases in developing countries (Black 2003).

**Costly signals and reputation building in the highlands**

Collective action events in the highlands are social environments wherein participants, by incurring a variety of costs/risks for the benefit of the community, signal various qualities to fellow community members. These signals could reap future social benefits for high quality signalers, namely via the reputations they gain. From a costly signaling perspective, a link should exist between the cost or risk involved in the signal and the information that is transmitted. Specifically, higher quality signalers should pay lower marginal costs. In signaling systems that aren't at equilibrium, the cost reduces the possibility of deceit by lower-quality signalers, ensuring the honesty of the signal and enhancing broadcast efficiency. Given the costs of participation outlined above, several inferences can be made about the qualities that are being signaled. For instance, only those HH made up of productive, hardworking and healthy individuals can incur the costly toll of CA over time. Further, only those truly generous and reliable HHs are willing to routinely invest in CA at the expense of their own HH

production. These qualities, variation in quality, the likely benefits received by signal receivers, and other signaling dynamics are discussed in this section.

***Signaling cooperative intent***

This research supports other ethnographic and experimental research showing that those who signal their reliability and value (as a mate, ally and/or social network member) by contributing disproportionately to CA establish a positive reputation for generosity. In some cases, it appears this reputation leads to relatively higher levels of cooperation from more people, and a higher likelihood of receiving aid in times of need (Gurven et al. 2000; Barclay and Willer 2007; Milinski et al. 2002), a prospect explored in Chapter 6. Contributing more than others to CA may be a particularly effective signal of cooperative intent in small-scale societies, such as those of highland Peru, where community members depend on collective goods, and where the presence of multiple observers enhances broadcast efficiency (Smith and Bliege Bird 2000).

Reciprocity and fairness are concepts that have a long history in Andean communities in Peru (Mayer 2002; Allen 2002; Flores-Ochoa 1968). For several aspects of life in this area—from agriculture to informal health care and advice—it is vital to have support to draw from, especially in times of need. Given the fact that not everyone in the community is equally reciprocal, the decisions about whom to include in one's network should not be random; preference should be given to fellow community members who are more likely to reciprocate and provide aid in times of need. Having low-quality network members (e.g., not showing up when needed) can disrupt the delicate timing and coordination involved with critical agricultural events. Thus, it is important to know who are the most reliable, trustworthy, and generous people in the community, and costly CA provides an ideal social environment in which to obtain this information. Of course, there is always a possibility that a HH contributes to CA, builds a reputation, takes the network benefits and runs, like a groom who spends money on an expensive wedding ring (a signal of generosity), but later doesn't follow through as a generous person (Bliege Bird and Smith 2005). There is one important reason why this is not an issue in Pucucanchita – word spreads

fast and wide in a community of 24 HHs. Just as a reputation for CA investment can emerge, so too can reputation (good or bad) as a social support member. The long-term benefit of strong social support relationships is too great to risk for short-term gains of defecting where there are only so many HH to draw support from.

Two further bits of data support the signaling cooperative intent proposition. First, community members clearly recognized that those who invested more in CA as reliable and hardworking contributors to CA, and second, those who invested more in CA were considered more generous than their fellow community members. In fact, generosity was most strongly associated with investment in CA compared with all the other reputation measures. This may speak to a more exact specification of reputation that is signaled via CA contributions.

***Signaling physical vitality, knowledge and other qualities***

Qualities other than generosity, including skill, knowledge, physical ability, and health have been shown to be signaled in different CA contexts (Smith et al. 2003; Sosis 2000; von Rueden et al. 2008; Lyle et al. 2009). For instance, hunters in many foraging populations share a portion of their prey unconditionally at public feasts. These social venues provide something of a stage wherein community members can distinguish hunter quality, while high quality hunters can develop reputations for qualities related to their hunting success, such as strength, skill, and productivity. In addition to a full belly, observers benefit from the information they obtain about the hunters' potential as allies or mates. Hunters, as a result of the reputations they gain, have more and higher-quality mates, more offspring, and/or better treatment of their offspring (Smith 2004; Gurven and von Rueden 2006).

CA in the highlands, in many ways like meat sharing by hunters at public feasts, is a social environment wherein people can signal qualities that community members are interested in learning about. As discussed, having access to skilled and viable agricultural help from people outside the HH is critical. CA tasks can be very laborious and in some cases require special skill, not to mention strength and endurance. Furthermore, HHs must rely on their own knowledge or that of others in their community

to care for their livestock, since veterinarian services are too costly for *campesinos* living in this community. The same knowledge that is vitally important for taking care of HH herds is needed for the communal herds, and is demonstrated during CA tasks involving the herds (See Chapter 1). By demonstrating their skills, signalers can develop larger social support networks, and those who include signalers in their network benefit from the special qualities of signalers. These prospects are the focus of Chapter 6.

***Variation in generosity, physical vitality and other qualities***

There is considerable variability in HH attendance and contribution to community events, but do community members recognize differences in generosity? This is an important question in CST perspective, since the signal must be observed by other community members, and differences in signal quality should be recognized. Pucucanchita is a very small community, and those who attend community events are acutely aware of who is present and who is not. Before tasks begin, there is quite a bit of socializing as members (usually segregated by gender) share and chew coca while talking about the task that is about to begin, who is going to do what, who is not present, and why they are not present. Word of mouth is a particularly effective way of communicating which HHs did not contribute (and why) at community projects for those who were not there to directly observe this, and gossip along these lines is commonplace. In this highland community, attendance at community projects is not mandatory, and HHs who do not send help in their absence are not punished, though absences may be recorded. Because there is no punishment, attendance to community projects can often be a contentious topic of discussion at community meetings and during casual conversations among community members. The ethnographic evidence that suggests that community members are aware of differences in CA investment is supported by the quantitative analyses that decisively show those HHs that invest more hours to CA are perceived as more reliable and hardworking when it comes to contributing to CA. Even more compelling is the fact that the most prosocial HHs are also considered to have the most generous HH heads.

In addition to variability in contribution to CA, ethnographic assessments indicate there are differences in work ethic, skill, knowledge and risk that are observable during CA. While no job is risk-free in Pucucanchita, there is variation in participation across CA tasks that may result in differences in risk exposure. For instance, during the annual remodeling of the community buildings, there are several tasks that range from low-risk (e.g., applying adobe) to high-risk (e.g., re-roofing). Field observations recorded patterns in work among participants, indicating the same individuals tended to engage in the riskier tasks, while others consistently chose to do less risky tasks. Differences in work ethic were also observed; some consistently worked the more physically demanding tasks and/or simply worked harder at their job than others, while others took more breaks, arrived late, and/or left early. These differences are clearly recognized by CA attendees and are oftentimes a topic of conversation during lunch and other work breaks. For example, discussions arose about close calls or teasing of others for poor performance, mistakes, or not showing up to previous CA tasks.

There were also clear differences in knowledge and proficiency in animal husbandry, planting, construction and other CA tasks. For instance, in the case of vaccinating the community herd, only three people were observed managing these tasks, which involves dividing the herd, providing instructions to helpers, and administering the vaccination. In regards to skill, there are certain jobs that some *campesinos* are simply better at than others. Whether it's cooking the lunchtime meal, shearing the animals, or the many tasks involved with constructing/refurbishing community buildings, these tasks require special knowledge not possessed by all community members. While a handful perform specialized tasks, others more or less engage in tasks that anyone can do (e.g., making adobe, being a "human fence" to block the animals during husbandry tasks, watching/holding down animals), stand around waiting to be told what to do, or not showing up at all. While this could be explained simply as functional division of labor, as there are no restrictions to what a person is allowed to do during CA, given they have the skill required. Importantly, the social value that is placed on these tasks differs; in fact, those who performed the jobs that few others could (e.g. organizing successful breeding programs) were considered the most respected and influential in the community.

### *Conclusion*

Several quantitative findings from this research support the criteria for a costly signaling dynamic. Investment in CA is costly for HHs and these costs are observable (and recognized as costly) by other community members. Further, participants differ in qualities related to the signal costs that observers benefit from learning about, and these qualities are difficult to observe in other social contexts. Chapter 6 further explores this signaling dynamic, looking at how signalers potentially benefit from the signal and if and how the signal honestly advertises underlying generosity.

### *Limitations*

This study looks only at the role investment in CA plays in a HH head's social reputation. There are likely other factors that impact social reputation which are difficult to capture quantitatively, such as inter-HH grudges, HH successes and failures in agriculture, religious beliefs and so on. Another limitation is that the data I have on investment in CA relate to a roughly two year period prior to the assessment of reputation. Contributions to CA prior to that time that could have contributed to reputation (good or bad) are not captured here. Nevertheless, it is likely that community members are continually gauging and recalibrating their perceptions of one another; if so, a two year period of investment data should be sufficient.

# Chapter 6: Agricultural support networks and health

This chapter explores the relationship between the household head's social reputation and his or her household's access to agricultural support, measured here as the number of households from which a focal household receives aid and advice. The relationship between social support and HH-level morbidity, measured as the average numbers of symptoms each household member experiences (i.e., per capita morbidity) is also explored. Finally, I will investigate whether or not frequent collective-action contributors are in fact reliable reciprocal partners, as predicted by signaling theory. Descriptive statistics for key variables and covariates are reported, in addition to inferential statistical tests of the stated predicted relationships. I conclude this chapter with a discussion of the results from the perspective of behavioral ecology.

## *Statement of the problem*

For decades, indigenous (Quechua) populations living in the southern highlands of Peru have experienced high infant mortality and adult morbidity (Carey 1988; Mayer 2002; Leonard 1989; Leatherman et al. 1995). This is due in part to the region's low ecosystem productivity, economic marginalization, difficult working and living conditions, and more recently, climate change (Leatherman et al. 1995; Thomas and Winterhalder 1976; Vuille et al. 2008). Research in a variety of cultural contexts indicates that a lack of social support increases stress, which can negatively impact the immune and neuroendocrine systems, in turn leading to acute and long-term health problems (Kawachi and Berkman 2001; Kawachi et al. 1996; Sarason and Sarason 1985; Berkman et al. 1992). On the other hand, membership in social support networks have been shown to reduce mortality and morbidity rates, and this is true across socioeconomic groups (House et al. 1988; Cohen and Syme 1985; Brown 1987; Raikes and Thompson 2005; Rubenstein 1987; Lomnitz 1977; Kawachi et al. 1996). This is because social support networks provide myriad health-promoting benefits through direct aid, advice, and/or providing a sense of

security (Balaji et al. 2007; Berkman et al. 1992; Burchinal et al. 1996; Dennis and Ross 2006; Hall et al. 1987; Kawachi and Berkman 2001). It is no surprise, then, that inter-household support networks have been shown to alleviate social and environmental stressors in the southern highlands, such that those with larger social networks are less likely to experience negative health consequences (Carey 1990).

There are three commonly cited pathways whereby social networks can produce adaptive outcomes (Kawachi et al. 1996). First, direct health care from network members and advice about health related concerns, such as taking specific health measures when they are ill, can promote health (Kawachi and Berkman 2001). These benefits of social network membership are particularly important in low-income groups where acquiring professional health care is financially unfeasible. Second, social support networks can provide psychoemotional benefits for network members by providing a sense of security and belonging. The assurance of support that comes with social network membership can reduce stress related illness (Kawachi and Berkman 2001; Berkman et al. 1992). Finally, direct support such as food sharing, financial support, and help with subsistence tasks can produce adaptive outcomes (Wills 1985; Carey 1988; Kawachi et al. 1996). This final pathway is particularly important in the context of agricultural support networks. Receiving aid with difficult manual labor tasks can reduce the amount of stress to which a single person is exposed. *Campesinos* do not have the luxury of paying for help for even the most physically demanding tasks. This creates a serious health issue for those living in extreme environments, since exerting too much physical effort could have profound acute and long-term health effects (Bonnon et al. 1999). Those who have a network of people to help with these tasks reduce the amount of physical activity they must exert at critical times, which can reduce the incidence of stress-related illnesses (Sapolsky 2004; Kawachi et al. 1996; McEwen 1998).

It is important to note that in *Pucucanchita*, where illness and injury are common, having help during times of greater need (e.g., broken hand, sick child) can reduce the likelihood that a person and his or her dependents get sick, and can decrease recovery time of the ill (Gurven et al. 2000). In this region, where there is no easy access to professional health care, being ill (or experiencing a series of illnesses in

the HH) can result in a rather bleak downward spiral in which HH production decreases, illness/injury recovery time decreases, and health further deteriorates (Leatherman 1996).

**Agricultural support networks in Pucucanchita**

Social networks in highland Peru are demographically diverse, composed of a complex web of kin, friends, allies and mates and their families (Allen 2002; Flores-Ochoa 1968; Mayer 2002). The importance of a HH's access to support networks in the highlands cannot be overstated. Indeed, sharing relationships have been described as "a pump at the heart" of life in the *altiplano* (Allen 2002:73). These networks have a long history in Andean Peru, going back to the time of the Incas, and play a major role in managing reciprocity in contemporary life in Andean Peru (Allen 2002; Carey 1988; Mayer 2002). While the landscape of sharing is ever-changing in the *altiplano*, a HH's dependency on social support continues to be vital. Access to social support in the form of help with agricultural tasks is of particular importance for *campesinos* (rural farmers/herders), given their reliance on HH agricultural production.

This chapter focuses on the benefits of having a large agricultural support network, specifically with having help with planting and harvesting crops, animal husbandry tasks and advice, and watching animals when a family is away from the community. While each HH can manage its herd most of the time, at several points during the year the entire herd must be corralled for tasks which are difficult for a single HH to do on its own (Orlove 1977). Herd evaluation prior to slaughter, earmarking of the young, vaccination, pregnancy examinations, *esquila* (shearing wool), and castration are just a few tasks that may require HHs to recruit help. Of course, most agricultural tasks are physically demanding, as they require workers to wrestle and restrain the animals, as well as manage the task while the animals are doing their best to escape the procedure. All of these events require a great deal of coordination, since a small group (who are mostly non-kin) must be organized, at times, with little notice. Additionally, the tasks must be completed promptly, since the herd becomes restless after even short periods of confinement (Orlove 1977).

Farming tasks, such as preparing and planting gardens, also require help from network members. At minimum teams of two or three men and women complete tasks associated with *siembra* (planting) and *cosecha* (harvest). During planting, for instance, one man plows a furrow, another drops the seed or rhizome, and sometimes a third will follow filling the furrow with manure (Allen 2002). These events require careful timing, which can vary from season to season due to early rains or the prospect of late frosts (Orlove 1977). It is important to note that most of these tasks are labor intensive, necessitating a high level of strength and physical fitness, and skill. Thus, successful agriculture and farming require recurrent access to reliable and viable network members.

In addition to direct aid, receiving advice and information about breeding methods and vaccination programs is especially helpful since *campesinos* are relatively detached from modern sources of information (e.g., Internet) and can't afford to acquire this information/aid from veterinarians. Like the people, herding animals of the region are constantly battling myriad diseases. Routine, correctly administered vaccinations can prevent these diseases, but a herder must know the latest vaccinations for the most current illnesses/diseases. Income from the sale of wool is important for *campesinos*, so in order to produce the best fibers, one must employ successful breeding techniques (e.g., selective castration, etc.) Finally, a HH also needs others to watch its herd when they need to travel. A HH can't leave their animals unattended due to predation by foxes, straying, and theft. It is necessary, then, to have a network in the community to draw from when they need to travel. A thin network in this regard could have negative health implications, especially when the family is deciding whether or not to travel to seek professional medical aid. If a family member is in need, travel may be delayed due to lack of help watching the HH's herd.

While the benefits of access to social support networks are quite clear, important yet under-investigated questions about these networks remain. How do HHs gain access to adaptive networks in their community? What factors influence the decision-making process regarding whom to include in one's support network? I also seek to answer the question: what are the exact benefits of having a large agricultural support network in this community?

These questions are approached using reputational, social network and health data collected in Pucucanchita, a small agropastoral collective (24 HHs) in the highlands of southern Peru. Residents living here are of Quechua decent. Pucucanchita is located in the high-altitude *altiplano* (ca. 4400 m). This region presents severe challenges for human subsistence, due to the high elevation and resultant low oxygen pressure, aridity and severe climate (Thomas and Winterhalder 1976; Orlove 1977). Crop-destroying hail storms and overnight frosts can occur during spring and summer; if winter snowfall is heavy, households can lose up to 50% of their herd as a result (Kuznar 2001). These factors, along with the difficulty of modifying the environment, result in low ecosystem productivity and marginal subsistence (Thomas and Winterhalder 1976; Orlove 1977). Consequently, in Pucucanchita, residents rely heavily on social support, which makes this village an ideal place to study the potential relationships among social reputation, social support, and health.

### *Hypotheses 2-4*

Hypothesis 1 of this dissertation (Chapter 5) examined the relationship between investment in collective action and the social reputation of the HH head. Results indicated that those HHs that invest more in group cooperation have HH heads who are among the most reputable in the community. This chapter presents data that examines the benefits of having a high reputation in the community by testing the following hypotheses.

**Hypothesis 2** examines the relationship between the social reputation of the head of HH and the support the HH receives from other HHs in the community. Hypothesis 2 (H2) states: HHs that have a reputable HH head will have greater indegree network centrality (i.e., a larger support network).

**Hypothesis 3** (H3) concerns the relationship between indegree network centrality and HH-level morbidity, and states: HHs that received aid from more HHs will experience, on average, fewer illness episodes among its members.

**Hypothesis 4** (H4) tests the assumption that signalers are honestly signaling their underlying generosity.

### *Descriptive statistics*

In this section network descriptives are reported, as well as the descriptive statistics of covariates that are used in testing Hypotheses 2-4 that were not reported in Chapter 5. Descriptive bivariate correlations between key variables and their associated scatterplots are also presented.

#### Network descriptives

Social network data were collected on three types of help with agricultural life. Participants were asked whom they had aided and whom they had received aid from with agricultural tasks during the most recent *tiempo de cosecha* (harvesting season) or *tiempo de siembra* (planting season). Second, participants were asked if they had watched anyone's animals and if they had anyone watch their animals in the 6 months prior to the interview. Finally, participants were asked to whom they gave and to whom they received animal husbandry advice during *el tiempo de cosecha.* The former network data were collected during both the first and second interviews, while the latter two network measures were collected during the second series of interviews.

Networks with *directed* ties include data that represent the flow of resources to and from HHs instead of counting a tie between HHs if only one member of the dyad provided aid (i.e., *non-directed* network). Networks with *valued* ties have data representing the amount of aid that was provided, while a *non-valued* tie simply recognizes that aid was given or received. The social network constructed for this analysis includes directed, non-valued ties for all three agricultural social relations described above. That

is, the agricultural network is an amalgamation of the three types of support discussed above. The network density of the support network used in this analysis was 0.17, meaning that, of the 552 possible ties in this network, 17% (N=94) occurred. In a social network that uses directed ties indegree network centrality is the number of ties that a node (HH) receives aid from, while outdegree is the number of HHs to which a particular HH gives aid. The average indegree and outdegree (which are the same since there is an in-tie for every out-tie) was 3.92 in the agricultural network, and ranged from 0 to 12.

**Covariates**

Several factors should be considered that may confound the relationship between reputation and social support, and the relationship between social support and morbidity (Diagram 6.1). This section reports the descriptive statistics of the covariates used in the analyses for this chapter that have not been reported thus far in this dissertation: distance and kinship. Descriptive statistics for other covariates used in these analyses – morbidity, per capita herd size, and dependency ratio – can be found in Chapter 5.

Studies have shown that distance is a powerful determinant of whether or not a sharing relationship between two HHs occurs. Specifically, HHs that are in closer proximity are more likely to have a sharing relationship (Nolin 2011). During the course of this research, GPS coordinates were recorded for each HH. Using these data, I calculated the average distance of each HH from all other HHs in the community. The average distance between HHs in the community (considering distances between HHs for both wet and dry season residencies) was 5.29 km (SD=5.12).

Kin relationships were evaluated using genealogical data collected during the interviews. Since this research employs a HH-level analysis, the possible coefficients of relatedness between members of a particular HH and another HH were summed. For instance, if the only kin relations a HH has within the community is two first cousins, then the focal HH received a kinship score of (.125)*2=.25. If the sum of coefficients was equal to or greater than 0.125 (which amounts to the expected fraction of shared alleles between first cousins), then those HHs were considered "kin." This demarcation was based on discussions with community members, and what they considered true *afinidades* (kin). The number of HHs with

which a focal HH shared kin relations (as defined above) was summed and used in the linear regression model. Eight HHs (33%) had no kin relations ≥0.125, ten HHs (42%) shared kinship with one HH, four HHs (17%) had kin in two HHs, and two HHs (8%) had kin in three HHs.

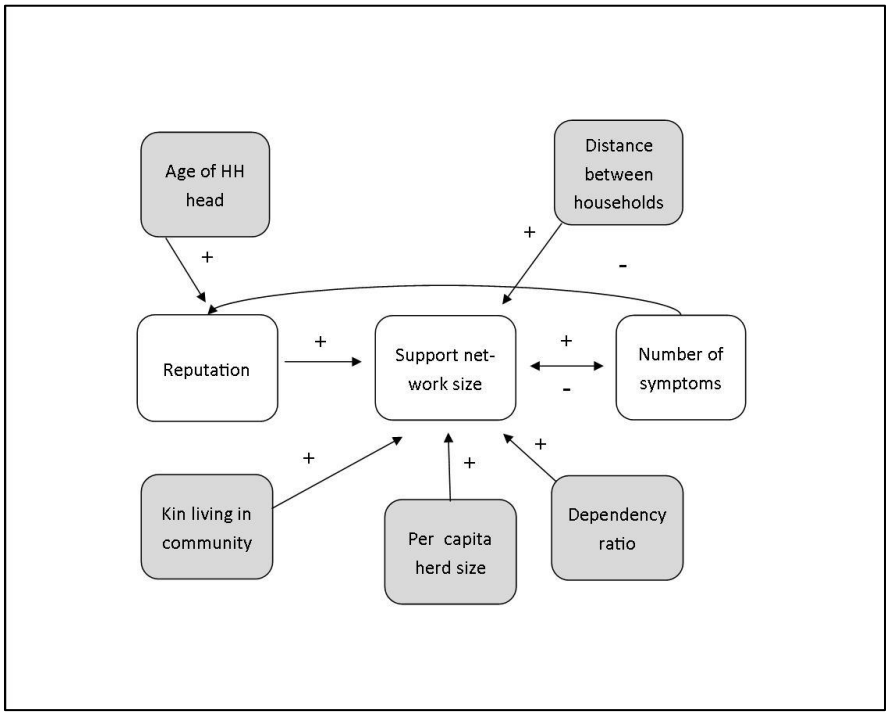


**Diagram 6.1.** Causal diagram showing the predicted relationship between social reputation, support network size, and number of illness symptoms experienced. Control variables are in shaded boxes. Plus signs indicate whether or not the covariate is expected to increase (+) or decrease (-) the dependent and/or independent variables. For instance, a greater dependency ratio may increase the size of the HH's support network.

**Correlation between independent and dependent variables**

This section reports descriptive correlational analyses for each hypothesis. The predicted relationship between social reputation and support network size was explored using Pearson's *r*, as was the relationship between support network size and HH morbidity. Correlations for H4 (the relationship between proportion of in-ties reciprocated and both investment in CA and reputation) were analyzed using Spearman's *rho*. Spearman's *rho* was chosen for this analysis because it is influenced less by

outliers (compared with Pearson's *r*) in a small sample such the one used in these analyses, and does not assume a normal distribution. The correlation tests using Spearman's *rho* and Pearson's *r* are one-tailed.

Results indicate that total reputation score of the HH head is highly positively correlated with the social network size of his or her HH (Figure 6.1). There is also a negative relationship between indegree network centrality (network size) and morbidity, as expected (Figure 6.2).

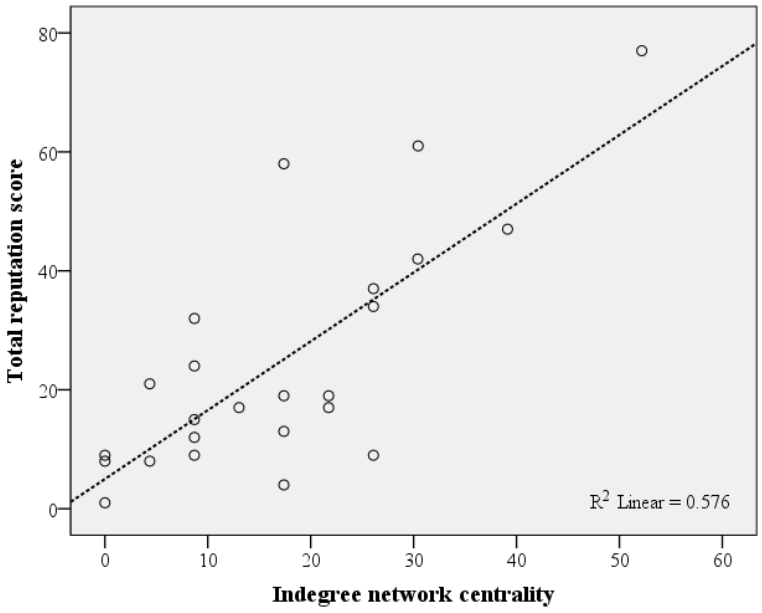


**Figure 6.1.** The relationship between total reputation score and normalized indegree network centrality. The variables are positively correlated (Pearson's r = .759, 1-tailed p< .001, n = 24)

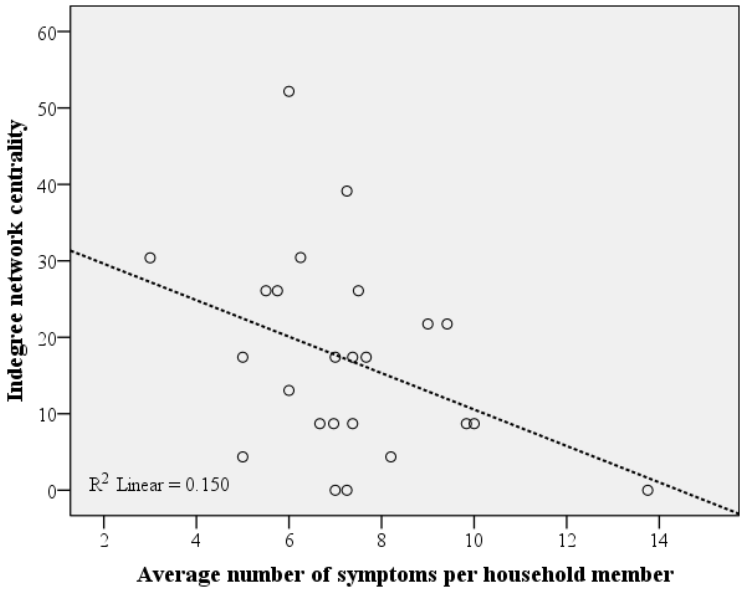


**Figure 6.2.** The relationship between a HH's network centrality (normalized) and per capita morbidity. The variables are negatively correlated (Pearson's r = -.387, 1-tailed p=.031, n=24)

Hypothesis 4 predicts that those HHs that invest more in CA (and subsequently have better reputations) are better (more reliable) network partners; this is essentially a test of signal honesty. Bivariate correlations show positive relationships between investment in CA and support reciprocated, and reputation and support reciprocated (Table 6.1). Although these results do not reach conventional levels of statistical significance, these findings suggest that high CA contributors and reputable HH heads are higher quality network members with above-average reciprocity rates.

**Table 6.1.** Bivariate correlations between the proportion of in-ties reciprocated and (a) reputation score and (b) investment in CA.

| Variables | *Spearman's rho* | *P* |
|---|---|---|
| Investment in CA | .295 | .110 |
| Reputation | .245 | .156 |

### *Variable selection for testing Hypotheses 2 and 3*

Two analyses, partial and bivariate correlations, were conducted to determine which, if any, potential confounding variables impact the predicted relationship between social reputation and network centrality (H2). These tests were also run to determine potential confounders for the relationship between network centrality and morbidity (H3).

**Partial correlations – Hypothesis 2**

A partial correlation test is an analysis of the relationship between two continuous variables and includes an additional variable as a control. It is a very useful analysis for identifying potential confounding variables that may in some way influence the relationship between the independent and dependent variable, and can thus offer insight into variable selection for the inferential tests of Hypothesis 2. The results show that none of these covariates have a major impact on the relationship between reputation score and network centrality (Table 6.2).

**Table 6.2.** Pearson coefficients and p-values from partial correlations of the total reputation score and normalized indegree network centrality, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Total reputation score and Network centrality | None | .759 | <.001 |
| | Age | .743 | <.001 |
| | Morbidity | .858 | <.001 |
| | Dependency | .749 | <.001 |
| | Kinship | .766 | <.001 |

**Partial correlations – Hypothesis 3**

For the same reasons described above, partial correlation tests were used to test for potential confounding variables in the relationship predicted in Hypothesis 3. Despite the relative modest relationship between indegree network centrality to begin with (Pearson's r = -.387, 1-tailed p = .031, n = 24), three control variables—age, dependency, and kinship—had little impact on the social support/morbidity relationship. After controlling for per capita herd size, however, the social support/network association increased noticeably (Table 6.3). This implies that there may be an important interaction between network centrality, morbidity, and per capita herd size.

**Table 6.3.** Pearson coefficients and p-values from partial correlations of normalized indegree network centrality and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Network centrality And Morbidity | None | -.387 | .031 |
| | Age | -.410 | .058 |
| | Dependency | -.416 | .048 |
| | Kinship | -.388 | .067 |
| | Per capita herd size | -.570 | .007 |

**Bivariate correlations – Hypothesis 2**

Correlations between the potential confounding variables and the dependent variable (social support), were analyzed, as these results can also provide insight into variable selection for the linear regression model. Results show that age, dependency, and kinship were not correlated with network centrality (Table 6.4). Years living in the community is marginally (positively) correlated with network

centrality, and per capita herd size is also positively correlated with network centrality; distance is negatively correlated with network centrality (Table 6.4).

**Table 6.4.** Correlations between potential confounding variables and social network size.

| | Age | Dependency | Kinship | Years in community | Per-capita herd size | Distance |
|---|---|---|---|---|---|---|
| Pearson's *r* | -.050 | .270 | -.046 | .402 | .550 | -.453 |
| *P* | .820 | .202 | .829 | .052 | .008 | .030 |

**Bivariate correlations – Hypothesis 3**

None of the potential confounding variables—age, kinship, per capita herd size, and dependency—were correlated with average number of illness symptoms experienced (Table 6.5).

**Table 6.5.** Correlations between potential confounding variables and the average number of symptoms experienced.

| | Age | Kinship | Per capita herd size | Dependency |
|---|---|---|---|---|
| Pearson's *r* | .198 | .245 | .086 | .049 |
| *P* | .365 | .248 | .702 | .820 |

### *Predictive analyses for Hypothesis 2 and 3*

This section uses a series of regression models to test H2 and H3. All regression tests are one-tailed. Non-network data were analyzed using SPSS (19.0) with alpha set at .05. Network data were analyzed in UCINET (6.0). Figure 6.3 was produced (via UCINET) with NetDraw 2.09. Distances between HHs were calculated using ArcGIS 10.0.

Hypothesis 2 was tested using a linear regression model with indegree (normalized) as the dependent variable and the total reputation score as the independent variable. Per capita HH morbidity

was included in the linear regression model since it was negatively correlated with indegree centrality (Figure 6.2), as was years spent in the community (though positively correlated) (Table 6.4); both were included as covariates (Table 6.4). Distance between HHs was negatively correlated and per capita herd size was positive correlated with indegree centrality, and both were included as covariates. Number of kin relations, dependency ratio, and morbidity*dependency ratio were not included in the regression model, since there was no relationship between these variables and indegree network centrality, and partial correlations (between reputation and indegree), controlling for these variables, indicate they do not affect the reputation/social support relationship.

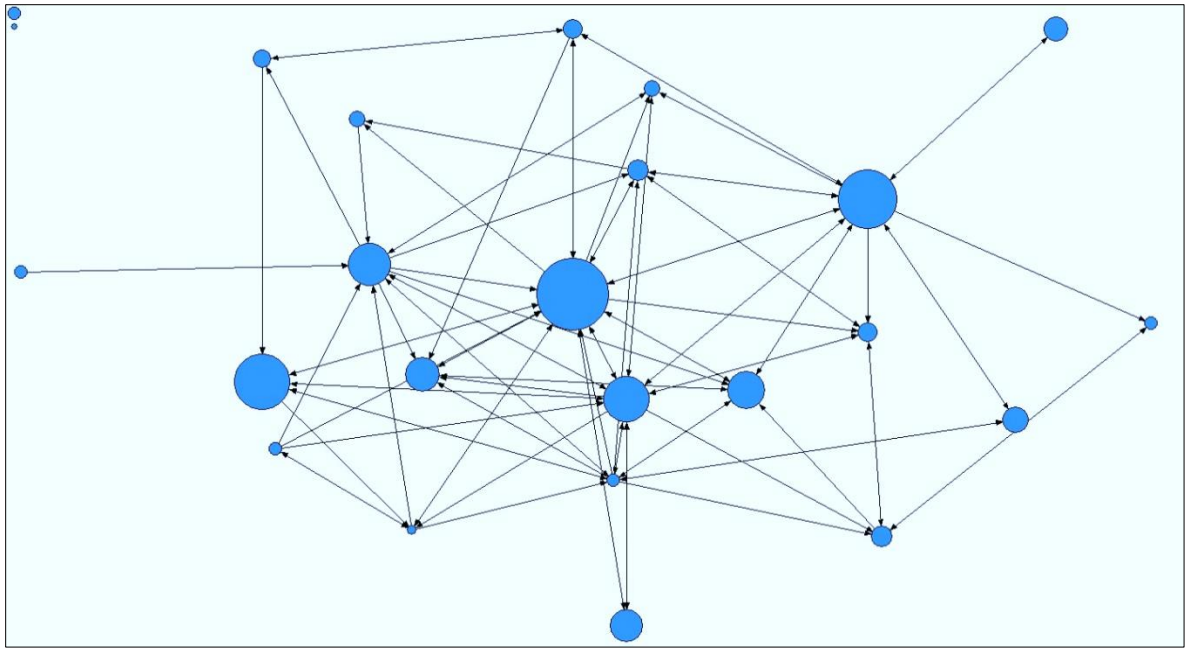

**Figure 6.3.** This network graph represents the agricultural support network in Pucucanchita. Arrows indicate direction of aid. Node size is proportional to reputation score. Reciprocity of the network in terms of proportion of dyads that are reciprocal is 0.52, and 0.68 in terms of the proportion of arcs (ties) that are reciprocated. HHs with the greatest degree network centrality are closer to the center of the graph. The two nodes in the upper left hand corner represent "isolates," those HHs who did not give or receive agricultural support during the time frame of this study.

Hypothesis 2 predicts that the most reputable HH heads in the community will have more network ties with regards to help with agricultural tasks and animal husbandry advice. This hypothesis is supported. The strong bivariate correlation between reputation and normalized indegree network

centrality (Figure 6.1) was further supported using a multiple linear regression model. The total reputation score was highly predictive of indegree network centrality, after controlling for other factors (Table 6.6). Distance and per capita herd size were also significant predictors of network size, while morbidity was weakly predictive of network size. In other words, those HHs with more sharing partners had more HHs living close to them, had somewhat healthier families, had larger per capita herd sizes, and had reputable heads of HH.

**Table 6.6.** Multiple linear regression model with *social support network size* (indegree network centrality) as the dependent variable and reputation, distance, morbidity, dependency and years living in community as independent variables. The model is significant ($F$=11.68, $df$=5, $p$<.001) and explains 80% of the variance in support network size.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Reputation | .470 | 3.43 | .002 |
| Distance | -.313 | -2.20 | .022 |
| Morbidity | -.186 | -1.33 | .102 |
| Years in community | .075 | .559 | .292 |
| Per capita herd size | .267 | 1.92 | .037 |

Hypothesis 3 predicts that HHs with larger agricultural support networks will experience fewer per capita symptoms. This hypothesis is supported. A multiple regression test, including kinship, dependency, and per capita herd size, reveals that indegree is a powerful predictor of morbidity (measured as the average number of illness symptoms per HH) (Table 6.7).

**Table 6.7.** Multiple linear regression model with *morbidity* as the dependent variable and indegree network centrality, kinship, dependency, and per capita herd size as covariates. The model is significant ($F$=2.33, $df$=4, $p$<.1) and explains 60% of the variance in morbidity.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Indegree network centrality | -.657 | -2.79 | <.001 |
| Kinship | .157 | .779 | .200 |
| Dependency | -.078 | -.355 | .529 |
| Per capita herd size | .449 | 1.85 | .006 |

### *Tests of mediation*

A primary motivation of a mediation analysis is to identify underlying mechanisms that are influencing the relationship between an independent (x) and dependent variable (y) (Diagram 6.2) (Baron and Kenny 1986). Simply, the mediation model proposes that (x) influences a mediator (m), which subsequently influences (y) (MacKinnon et al. 2007). The mediator is said to govern the relationship between (x) and (y), in other words providing an avenue for the causal pathway between (x) and (y). The assumed causal relationship, then, is (x)→(m)→(y). Mediation models consider what is referred to as direct and indirect effects. The direct effect is a measure of the impact (x) has on the (y) when (x) is increased by one unit, holding (m) constant. The indirect effect is the reduction of (x) on (y) as a result of (m), and thus measures how much mediation is occurring.

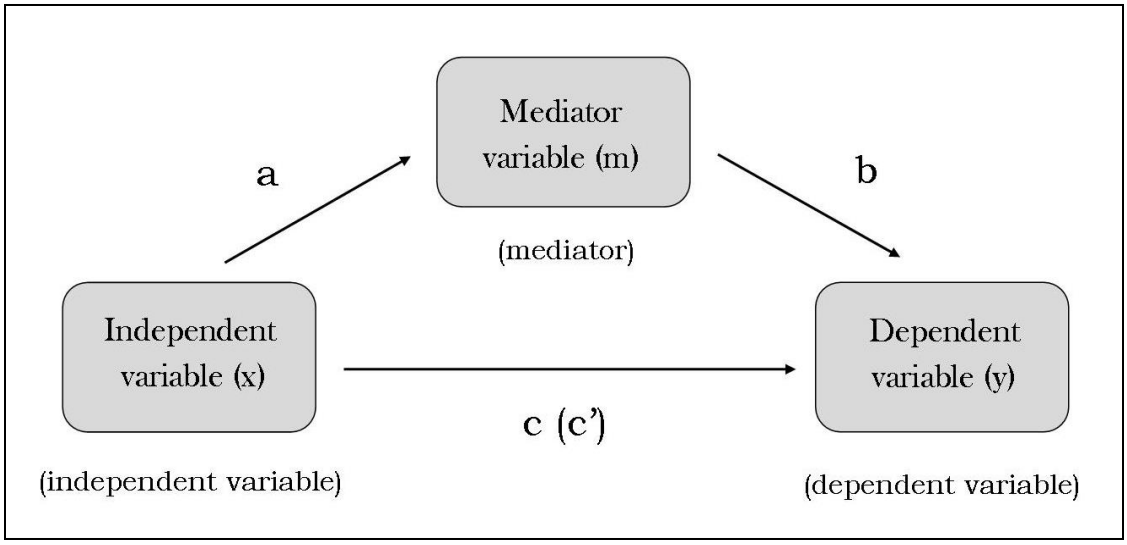


**Diagram 6.2.** The mediation model. Path a is the relationship between (x) and (m), path b is the relationship between (m) and (y), holding (X) constant. Path c is the relationship between (x) and (y), and c' is the relationship between (x) and (y) holding (m) constant.

Results from the linear regression models testing H1 and H2 (See Chapter 5 for comprehensive results of H1) indicate that those HHs that contribute more to CA have reputable HH heads, and that reputable heads receive agricultural support from more HHs. But these analyses do not provide a complete picture of the relationship between these highly correlated variables. A test of mediation with reputation as the mediator, investment in CA as the independent variable, and social support as a dependent variable can tell us whether reputation indeed provides a pathway from CA investment to social support. This is especially important since CA investment is strongly correlated with social support, begging the question – Is it CA investment that leads to reputation which in turn leads to a larger support network (i.e., H1-H2) or does CA directly lead to a larger support network, regardless of its association with reputation?

Three conditions should be met in order to determine if a mediation test is appropriate. First, CA investment (x) should be a significant predictor of social support (y); this criterion has been met (Standardized Beta = .713, 1-tailed, $p < .001$, $n = 24$). Second, CA investment should be a significant predictor of the mediator (reputation); this criterion has been met (Standardized Beta = .831, 1-tailed, $p < .001$, $n = 24$). Importantly, correlating reputation with social support is not sufficient when demonstrating

a mediation effect since the reason they are correlated could be the result of (x) "causing" both (m) and (y). Consequently, reputation should be a significant predictor of total support network, controlling for CA investment; this criterion has been met (Standardized Beta = .538, 1-tailed, $p < .021$, $n = 24$).

This analysis incorporates bootstrapping with the Preacher-Hayes bias correction (Preacher and Hayes 2008). Bootstrapping provides advantages when analyzing small samples since the technique increases statistical power (Shrout & Bolger, 2002). Bootstrapping is a non-parametric, resampling technique in which observations are repeatedly randomly sampled. The process is best summarized in the following series of steps. First, data on CA investment, reputation, and social support are randomly pulled for one of the 24 HHs. The data are then "reset" (i.e., the one HH that was pulled is put back) and this process is repeated until a new sample of 24 HH has been completed. It is likely, then, that data from a single HH is represented multiple times in the same bootstrapped sample. Next, a mediation model is run for the bootstrapped sample, in which the indirect effects are calculated. This process is repeated 5,000 times and a distribution of indirect effects is formulated. Using this distribution, the mean and confidence intervals are calculated for the indirect effects of the bootstrapped sample. If zero is not present in the confidence intervals then a mediation effect is occurring. The normality assumption (that the sample is normally distributed about the mean) is not violated, since the several thousand bootstrap samples produce what we'd expect to be a normal distribution.

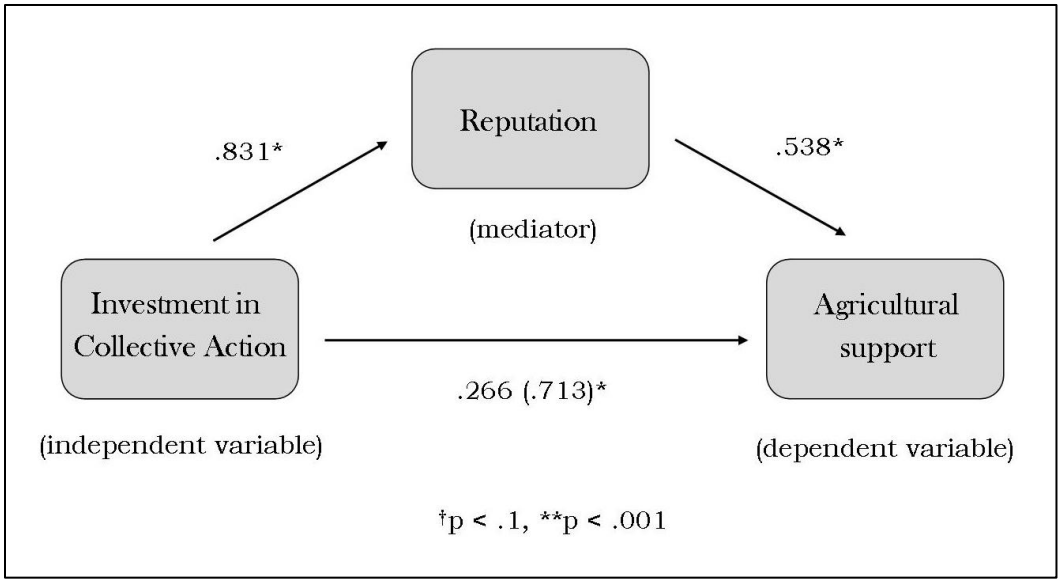


**Diagram 6.3.** Standardized beta coefficients for the direct and indirect effects of the mediation model.

For this analysis, 5,000 bootstrap samples were generated. The direct effect from CA investment to network size (controlling for reputation) is. 266 (standardized) and is not statistically significant (p = .297). As CA investment increases by one unit (1 hour), network size (normalized) increases by .353 units. The bootstrap estimated indirect effect from CA investment to network size equals .102 and is marginally significant (p = .074). For the indirect effect, as CA investment increases by one unit, network size increases indirectly via total reputation score by .102 units. The 95 percent bias corrected bootstrap confidence interval (5000 trials) is from -.004 to .231, and since zero is in the confidence interval (though by an extremely small margin), it should be concluded that the indirect effect is not different from zero. These results provide evidence of a slight mediation effect of reputation on the CA investment-social support relationship.

Results from the linear regression models testing H2 and H3 indicate that those HHs that have reputable HH heads receive agricultural support from more HHs (Table 6.6), and that those with large support network live in HHs that experience fewer illnesses (Table 6.7). Reputation is marginally correlated with morbidity, and thus it is possible that a high reputation leads directly to lower morbidity rather than reputation leading to a larger support network, which in turn leads to lower morbidity. A test of mediation with social support as the mediator, reputation as the independent variable, and morbidity as

a dependent variable will help provide some meaning to the relationship of these correlated variables (Diagram 6.4). The three standard mediation pre-tests suggest that a mediation test should be considered: reputation is a significant predictor of morbidity (Standardized Beta = -.307, 1-tailed, p=.072, n = 24); reputation is associated with agricultural support (Standardized Beta = .759, 1-tailed, p< .001, n = 24); and social support is a marginally significant predictor of morbidity, controlling for reputation (Standardized Beta = -.363, 1-tailed, p< .127, n = 24). Although this latter test did not reach conventional levels of statistical significance, I decided to proceed with the mediation test given that (a) the one regression test that doesn't reach conventional levels of significance is very near statistically significant values and (2) social support is such a strong predictor of HH-level morbidity even after controlling for several factors other than reputation (Table 6.7).

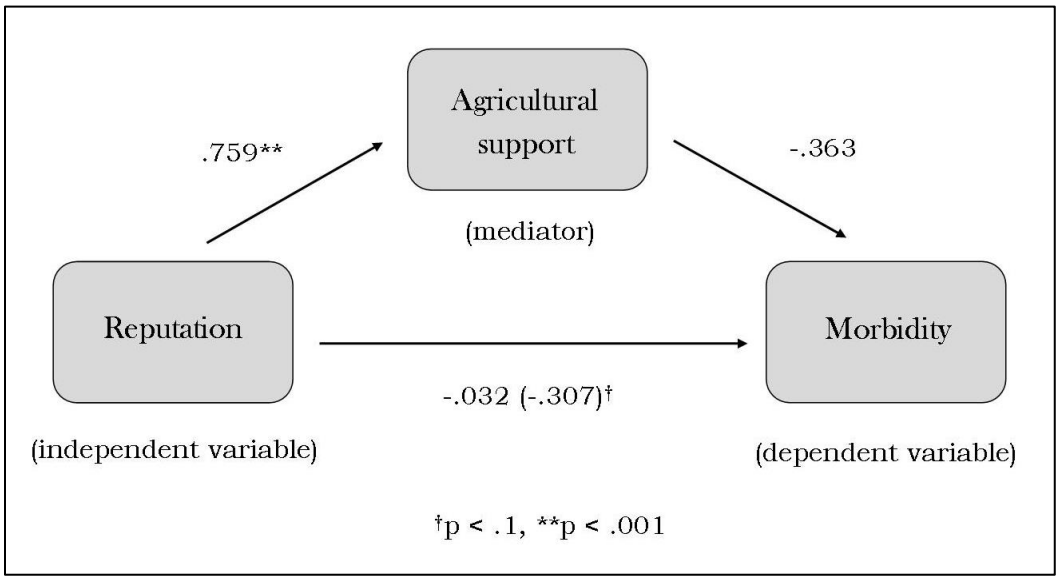


**Diagram 6.4.** Standardized beta coefficients for the direct and indirect effects of the mediation model.

The same bootstrap protocol was used to see if social support was mediating the relationship between reputation and morbidity. The direct effect from reputation to morbidity is -.003 and is not statistically significant (p = .918). As reputation increases by one unit, morbidity decreases by .059 units. The indirect effect from reputation to morbidity is -.029 and is not statistically significant (p = .202). For the indirect effect, as reputation increases by one unit, morbidity decreases indirectly via network size by

.029 units. The 95 percent bias corrected bootstrap confidence interval (5000 trials) is from -.096 to .011. Given these results there is only evidence for weak mediation at best.

The tests of mediation presented above do not approach the concern that those HHs that are sick can't contribute as much to CA, and perhaps poor health explains variation in CA contributions rather than reputation signaling. However, CA investment is not correlated with morbidity (r = -.051, 1-tailed, p = .407), indicating that simply being healthier than average does not explain variation in CA contribution.

## *Discussion*

### Distance, kinship and per capita herd size

Findings indicate that distance between HHs is an important determinant of HH support network size, controlling for several other factors. This corroborates the findings from other research on cooperation in small-scale societies (Nolin 2010; Gurven et al. 2000, 2004; Ziker 2004). One surprising finding, in contrast to many studies of cooperation, is that there is no significant association between kinship and outdegree (aid given) or indegeee (aid received) network centrality. My guess is that since there are only a handful of HHs that have a cumulative *r* of .5 (17% of HHs) the effect is small. Perhaps it's not so surprising given the findings from research by Allen-Arave and colleagues (2008). Considering the fact that distance is a powerful predictor of network size within this community, it is highly unlikely that community members are drawing significant support from kin outside of the community. The time and energetic costs of a half or full day of travel likely exceed the potential indirect fitness benefits.

Per capita herd size turned out to be an interesting variable. As a proxy for wealth, it is a surprising predictor of *higher* morbidity. It may be that some HHs have more animals than is feasible. That is, the number of HH helpers that are available is insufficient given the size of the HH's herds, leading to overexertion. On the other hand is the fact that wealth is positively associated with (and predictive of) social network size (Tables 6.4 and 6.6), the latter variable, of course, is predictive of *lower* morbidity. Another clue, from the partial correlational tests, may shed some light on this issue. Together, these results are compelling and create a thirst for further explanation and analysis.

**Honest signaling**

An important question about signaling "generosity" via CA contributions is: do signalers actually follow through with their generosity or do signalers "play" generous, then take the support network benefits and end the social relationship without reciprocating? This question approaches two assumptions that are critical to a signaling equilibrium. First, the signal should honestly reflect an underlying quality of the signaler and, second, signal receivers should potentially benefit from observing the signal. Findings demonstrate that those who invest more in public goods are also reliable social network partners; specifically, high contributors to CA (and those with the highest reputations) reciprocate with a greater proportion of their network members compared to lower contributors and those with lower reputations. These results suggest that contributions to CA are a reliable signal of partner quality, and that signal receivers benefit from including high contributors in their support networks.

## *Conclusions*

Chapter 5 of this dissertation found that those HHs that contribute more to CA have HH heads with higher reputation scores. This result (H1), coupled with the results presented here (H2, H3), support my overarching argument that greater reputations, achieved through costly investment in CA, lead to larger support networks. These larger networks in turn lead to better HH health.

These results help explain how successful CA can endure despite conspicuous, unpunished free riding in this community. Free riding, which occurs if individuals cannot be excluded from enjoying the collective benefit without paying the costs of producing or maintaining it, can unravel cooperation (see Chapter 1 for a complete discussion). Various solutions to the free-riding problem have been proposed in the social and biological sciences, including indirect reciprocity (Milinski et al. 2002; Panchanathan & Boyd 2004), punishment and other institutional measures (Boyd and Richerson 1992; Boyd et al. 2010; Ostrom 1990, 2005), signaling and partner choice (Noë and Hammerstein 1994; Frank 2009, Bshary and Noë 2003; Roberts 1998; Barclay & Willer 2007; Smith & Bird 2000; Gintis et al. 2001), and group

competition/selection (Bowles 2006; Boyd & Richerson 2010). Here, I consider what insights signaling theory offers.

Several quantitative findings from Chapter 5 support a costly signaling argument for high investment in CA. Investment in CA is costly for HHs and these costs are observable (and recognized as costly) by other community members. Further, participants differ in qualities related to the signal costs that observers benefit from learning about, and these qualities are difficult to observe in other social contexts. This chapter sought to understand exactly how signalers benefit from the signal and if and how the signal honestly advertises underlying quality. Findings show that high-quality signalers benefit via their special access to social support, which can lead to fitness-related health benefits. Findings also support the supposition that high quality signals are good reciprocators in other social contexts (thus honest signalers).

### *Limitations*

One limitation of this study is that, while the "signaling generosity/cooperative intent" proposition is supported, it is unclear if those who signal their physical vitality, knowledge, and other qualities actually follow up with those qualities when they help their network members. For instance, it can't be determined from these data if those who demonstrate a good work ethic during CA are actually hardworking when helping out their network members.

This chapter reports data on the number of ties a HH has with other HHs, rather than the actual amount of aid that is received. It could be argued that the strength of the network tie and/or overall aid received is more important than simply the number of in-ties a HH has. As mentioned, for this analysis I use an amalgamation of tasks to define the agricultural network. Since these tasks involve different measures (time helping with shearing vs. advice about vaccination programs) it would be nearly impossible to develop a value for each tie. Regardless, I feel that the width of the network (i.e., network size) is more important than the strength (amount of support) when it comes to agricultural networks,

since agricultural-related need tends to be short-term, sporadic, unpredictable, and by no means a daily affair.

# Chapter 7: Health advice networks

Using ethnographic data from a small Andean herding community, this chapter investigates the relationship between a household's *access to* and *position in* an informal health advice network and the health of its members. I also explore the relationship between a household's access, generosity, and position in this advice network and the social reputation of the household head. Descriptive statistics for key variables and covariates are reported, in addition to inferential statistical tests of the aforementioned relationships. Results are analyzed within a behavioral ecology framework.

## *Statement of the problem*

The indigenous people of the Peruvian Andes (Quechua Indians) are a demographically dominant but politically weak group with a long history of economic marginalization and poor health. These factors, coupled with living in an environment of low ecosystem productivity, make it difficult for families to acquire a consistent and adequate supply of food and other resources. These stressors are exacerbated by the lack of access villagers have to professional medical care. These unfortunate circumstances have resulted in decades of high infant mortality, high adulthood morbidity, and other health problems (Carey 1990). One important strategy for coping with the everyday stressors that highlanders endure is social support networks.

Considerable research has shown that membership in social support networks reduces mortality and morbidity rates (House et al. 1988; Cohen and Syme 1985; Brown 1987; Rubenstein 1987; Lomnitz 1977; Kawachi et al. 1996). Access to advice about health-related concerns, such as taking specific health measures when ill, can promote health, and these benefits of network membership are particularly important in low-income groups where obtaining professional health care and advice is often not feasible (Kawachi and Berkman 2001). In addition to the direct benefits of informal health care (i.e., advice and direct aid), there are also important psychoemotional benefits that these networks provide. For instance,

knowing that good advice for treating your child's illness is just around the corner provides a sense of security, which can reduce stress (Kawachi and Berkman 2001; Berkman et al. 1992). High levels of stress, of course, increase disease susceptibility and decrease resistance to pathogens (Sapolsky 2004; Kawachi et al. 1996; McEwen 1998). Thus, these networks potentially have positive health consequences by providing immediate solutions through advice, in addition to lowering susceptibility to illness by giving well-connected households (HHs) the assurance of immediate, point-of-need help.

This chapter focuses on social support in the form of health advice with regards to treating illness symptoms. The nearest professional health care center can be hours away for *campesinos* since most do not have vehicular transportation, and the rural health care centers that are closest to highlanders (which they visit by foot or bike) are open sporadically, provide minimal care, and lack electricity and sterile working conditions. Furthermore, it is simply not financially feasible for most highland Peruvians to acquire specialized professional health care. Because of these circumstances, families depend greatly on advice about health-related issues from members of their support network. In Pucucanchita, a highland community where this research was carried out, locals rely more on remedies that are concocted from locally foraged or purchased herbs and served as teas than on treatment from the local health care system. It is important to note that residents actually prefer traditional medicines when it comes to non-urgent illnesses and injury, although *campesinos* will seek professional care if the medical situation becomes desperate.

Given this reliance on traditional medicines, the importance of having knowledge about these remedies, or knowing others who do, can't be overstated. If these local remedies in fact lead to better health, then we should expect that differences in access to knowledge about traditional medicines will lead to HH-level health disparities. Additionally, it is likely that having knowledge of this nature (and/or being well connected to such knowledge) is a valued quality which may impact how one is perceived, how one is treated, and even affect how much influence the HH has in community affairs. Those who have greater knowledge likely give more advice than they receive, and asymmetry in network aid of this

nature may lead to greater "generosity" reputations or reciprocity in other forms, such as food sharing, agricultural assistance and other types of aid.

Social network analysis is an excellent framework for analyzing highland advice networks and how they affect, and are affected by, health and social reputation. Social network analysis employs mathematical and statistical methods to describe and analyze the patterns linking individuals or HHs (Friedman and Aral 2001; Carrington et al. 2005; Wasserman and Faust 1994), and is increasingly being used in anthropological analyses (Dunbar and Spoors 1995; Johnson 1994; Nolin 2010). Four network measures will be used to investigate Pucucanchita's health advice network: degree centrality (both indegree and outdegree), inCloseness centrality, and betweenness centrality. Degree centrality in a directed network, as discussed in the previous chapter, is a measure of how much aid is received (indegree centrality) and how much is given (outdegree centrality) (Everett and Borgatti 2005; Wasserman and Faust 1994). The former measure will be useful in understanding how access to knowledge of traditional medicines impacts health. Outdegree network centrality is a good indicator of those HHs that are sought out by other HHs for advice. This measure will shed light on the possible relationship between those who provide the most and best advice and how well their HHs are respected in the community. Those who have the best advice are also likely to live in healthier families because of their expertise in treating illnesses.

InCloseness centrality is a measure of the "network distance" that a focal node is from all other nodes in a directed network, considering only the indegree on the node. Specifically, inCloseness is calculated as the inverse of farness, which is the sum of the distances a focal node is from other nodes in the network in terms of the farthest paths (Everett and Borgatti 2005; Wasserman and Faust 1994; Hanneman and Riddle 2005). The shorter the distance (in terms of network paths) a focal node is from all other nodes, the more central it is in the network. This network measure is particularly useful when examining the value of a focal node's position in terms of availability of information. In the context of this study, it gauges a HH's access to health advice and should thus provide insight into the possible

health benefits of having a favorable position in the community's health advice network. Further, having a favorable network position is desirable and is likely a quality that is well respected.

Betweenness centrality, on the other hand, is concerned with the frequency with which a node acts as a bridge between other nodes. High betweenness is usually associated with controlling information and its spread throughout the network (Everett and Borgatti 2005; Wasserman and Faust 1994; Hanneman and Riddle 2005). Imagine a scenario in which your child is sick with an illness that you do not know how to treat. You know that Mrs. White likely has a treatment for the illness, but you don't know her directly, at least not well enough to approach her. However, your good friend Mrs. Jackson knows Mrs. White and your friendship with her allows you to obtain the much-needed information. Intermediates like Mrs. Jackson, who can provide access to valuable knowledge, have some power in the exchange of information. Therefore, high betweenness, like outdegree centrality, may be an attribute that is respected in this community since these HHs have greater influence in the flow of health advice through the network. Higher betweenness may also lead to better health since these HHs have greater access to advice.

### *Hypotheses 5 & 6*

Disparities in knowledge and access to knowledge about traditional medicines occur in Pucucanchita. Two important questions are (1) do HHs that have greater knowledge (or greater access to knowledge) regarding traditional medicines have healthier families and (2) do those HHs that have greater knowledge (or greater access to knowledge) about traditional medicines have well-respected HH heads? Hypotheses 5 and 6, respectively, address these questions.

**Hypothesis 5** tests the relationship between a HH's health advice network size/role and the general health of the HH. Hypothesis 5 (H5) states that the following network qualities will lead to better HH health:

a) receiving advice about traditional medicines from more HHs (i.e., high indegree centrality)
b) having greater knowledge of traditional medicine (i.e., high outdegree centrality)

c) being closer in network distance from other HHs in the network (i.e., high inCloseness centrality)

d) acting as a bridge for information flow (i.e., high betweenness centrality)

**Hypothesis 6** tests the relationship between health advice network size/role and the reputation of the HH head. Hypothesis 6 (H6) states that the following network qualities will enhance such respect:

a) high outdegree centrality

b) high inCloseness centrality

c) high betweenness centrality

### *Descriptive statistics*

In this section descriptive statistics for indegree centrality, outdegree centrality, inCloseness, and betweeness centrality, as well as the total non-collective action general reputation score are reported. Also, descriptive bivariate correlations between key variables and their associated scatterplots are presented.

#### Independent variables

This chapter explores the social network data that were collected on advice HHs give and receive regarding the use of traditional medicine to treat illness and injury. Participants were asked to whom they had given advice and from whom they had received advice in the two weeks prior to the interview. These data were collected during both the first (June/July 2010) and second interviews (November/December 2010). The Pucucanchita advice network includes directed, non-valued ties from both sets of interviews. The network density was 0.19, meaning that, of the 552 possible ties in this network, 19% (N=104) occurred.

Four measures of network centrality were employed as independent variables in these analyses: indegree, outdegree, inCloseness, and betweenness. In a social network that uses directed ties (i.e., ties that indicate who gave to whom) indegree network centrality is the number of ties that a node (HH)

receives aid from, while outdegree is the number of HHs to which the focal HH gives aid. The average indegree and outdegree (which are the same since there is an in-tie for every out-tie) was 3.50 for this network, with indegree ranging from 1 to 8 and outdegree ranging from 1 to 11. The data were normalized as follows: each HH's indegree and outdegree was divided by the number of possible ties that a HH could have. The average normalized indegree and outdegree was 15.22, ranging from 4.35 to 34.78 and 4.35 to 47.83, respectively. InCloseness centrality was measured using Freeman's geodesic path centrality. This measure considers farness as the sum of the lengths of the shortest paths from all other HHs in the network and the focal network. Closeness is calculated as 1/farness. The closeness measure (normalized) is formulated by dividing the focal HH's inNearness by the highest inNearness in the graph. The average normalized inCloseness was 41.64 ranging from 22.12 to 53.49. Betweenness measures the frequency with which a node acts as a bridge between other nodes. Betweenness is normalized by expressing it as a percentage of the maximum betweenness an actor could possibly have given the network structure (Everett and Borgatti 2005; Wasserman and Faust 1994). The average normalized betweenness was 7.02 ranging from 0 to 20.18.

**Dependent variables**

Two dependent variables, social reputation and morbidity, are considered in this chapter's analyses. The reputation variable used in this analysis excludes the reputation data collected on (collective action) CA, instead focusing on the three general reputation measures. Using a free listing method, participants were asked three separate questions about who they felt were the most generous, influence, and respected people in their community (see Chapter 5 for more details on data collection). The three questions resulted in three reputational measures for each HH head and were equated by summing the number of times each HH head was mentioned. Scores for HH heads ranged from 0 to 12 (median=2.50) for "generous," from 0 to 20 (median=3.00) for "influential," and from 0 to 16 (median=3.50) for "respect." For the analyses in this chapter, each HH was denoted a "total" reputation score by summing the reputation scores for generosity, influence, and respect. The total reputation score ranged from 0 to 42

(median=8.50). Per capita morbidity, measured as the average number of symptoms each member of a HH experience combining the two periods, was 7.28 (SD=2.12). See Chapters 4 and 5 for more details on data collection and additional descriptives.

**Correlation between independent and dependent variables**

The predicted relationships between the four network measures used in H5 (indegree, outdegree, inCloseness, and betweenness) and HH-level morbidity was explored using Pearson's *r*, as was the relationship between the three network measures employed in H6 (outdegree, inCloseness, and betweenness) and social reputation. Given the directional nature of my hypotheses, all correlational test significance values are one-tailed.

***Hypothesis 5***

Results indicate that indegree and outdegree centrality are negatively correlated with per capita HH morbidity (Figures 7.1, 7.2). There are also noteworthy relationships between inCloseness and betweeness network centrality and health, though the results do not reach standard measures of statistical significance (Figures 7.3, 7.4).

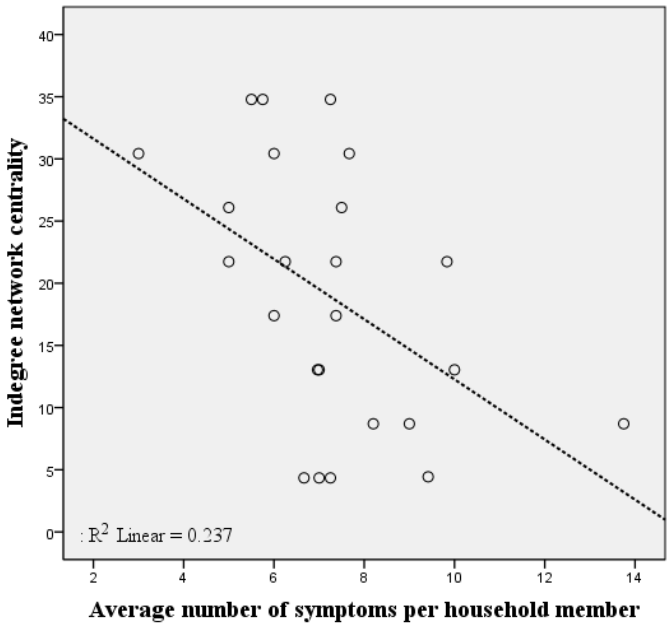


**Figure 7.1.** The relationship between indegree network centrality (normalized) and per capita morbidity. The variables are negatively correlated (Pearson's *r*= -.487, 1-tailed p=.008, n=24).

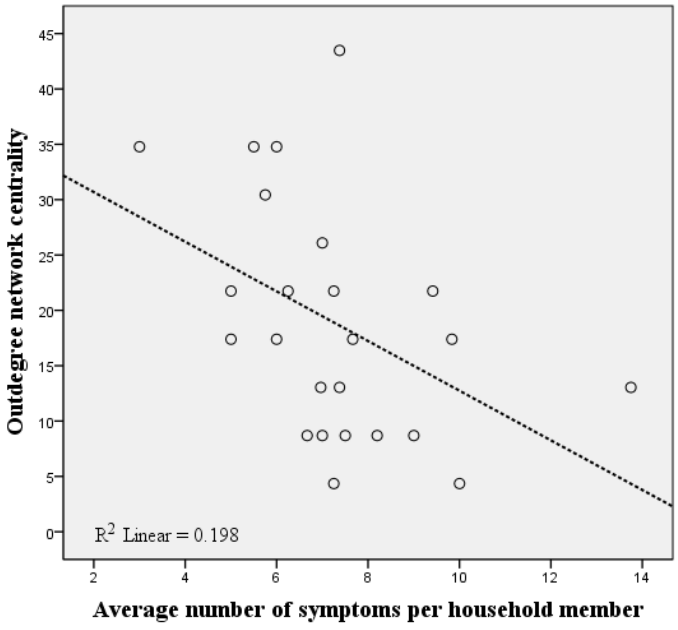


**Figure 7.2.** The relationship between outdegree network centrality (normalized) and per capita morbidity. The variables are negatively correlated (Pearson's *r*= -.445, 1-tailed p=.015, n=24).

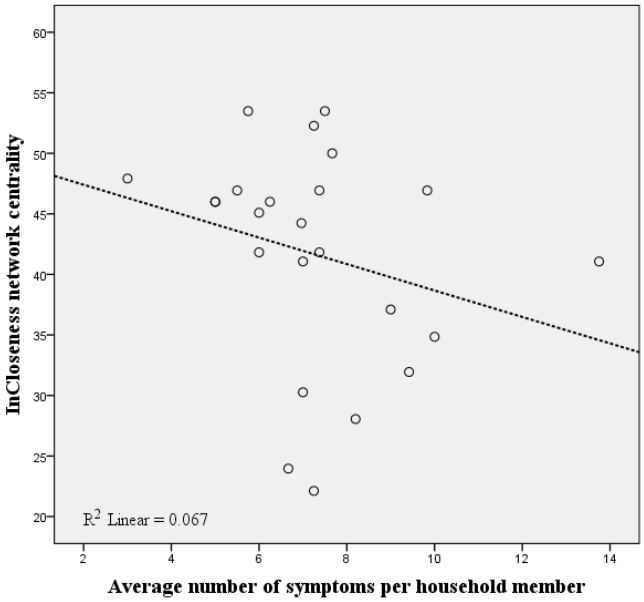


**Figure 7.3.** The relationship between inCloseness network centrality (normalized) and per capita morbidity (Pearson's *r*= -.260, 1-tailed p=.110, n=24).

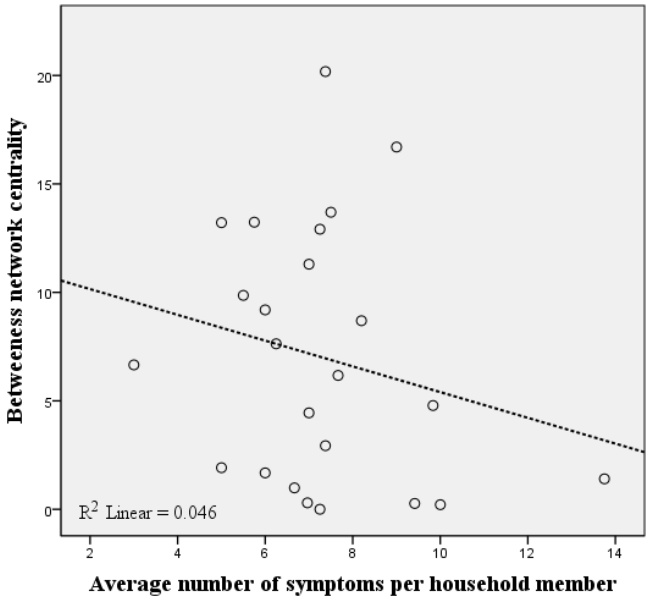


**Figure 7.4.** The relationship between betweenness network centrality (normalized) and per capita morbidity. (Pearson's *r*= -.214, 1-tailed p=.157, n=24).

***Hypothesis 6***

Results indicate that outdegree and betweeness network centrality are both correlated with non-CA reputation score (Figures 7.5 and 7.7). InCloseness centrality is marginally correlated with reputation (Figure 7.6).

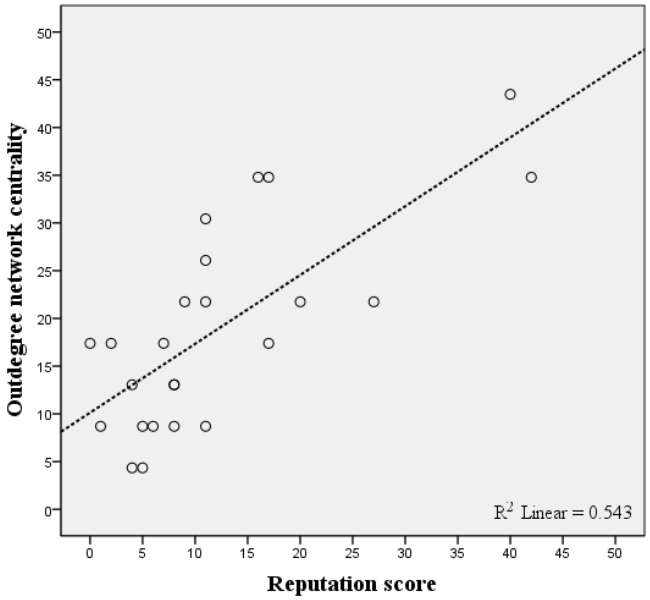


**Figure 7.5.** The relationship between outdegree network centrality (normalized) and reputation score. The variables are positively correlated (Pearson's *r* = .737, 1-tailed p=<.001, n=24).

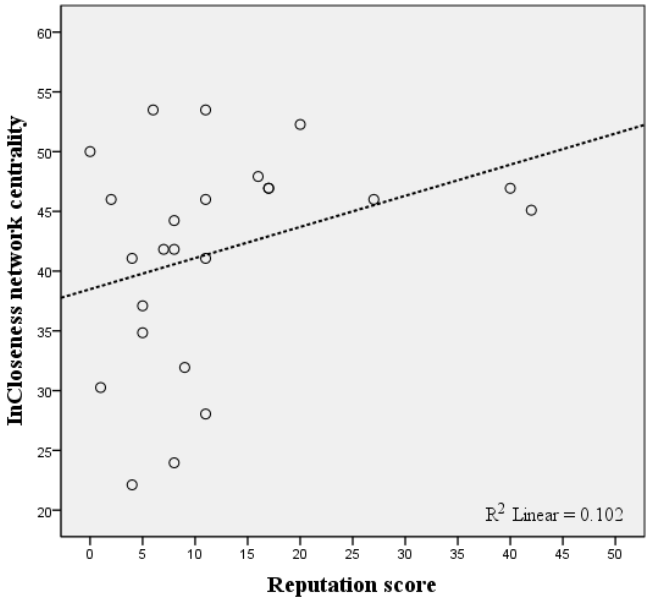


**Figure 7.6.** The relationship between inCloseness network centrality (normalized) and reputation score (Pearson's *r* = .319, 1-tailed p=.064, n=24).

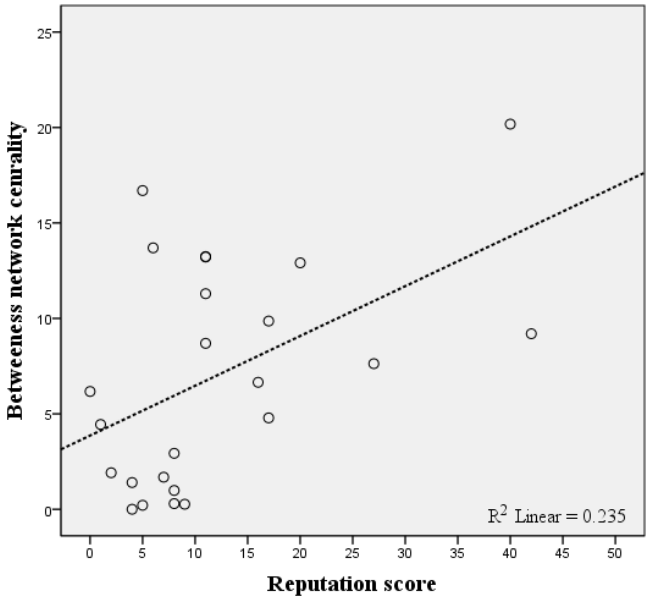


**Figure 7.7.** The relationship between reputation score and betweenness network centrality (normalized). The variables are positively correlated (Pearson's r= .485, 1-tailed p=.008, n=24).

### *Variable selection for testing Hypotheses 5 and 6*

Two analyses, partial and bivariate correlations, were conducted to determine which, if any, potential confounding variables impact the relationships predicted in H5 and H6. These tests were also run to determine potential confounders for the relationship between the network measures used in testing H6 and per capita HH health.

**Partial correlations – Hypothesis 5**

A partial correlation test analyzes the relationship between two continuous variables, including an additional variable as a control. It is a very useful analysis for identifying potential confounding variables that may in some way influence the relationship between the independent and dependent variable, and can thus offer insight into variable selection for the inferential tests of Hypothesis 5 & 6. Results from these tests show that no potential confounders have a major impact on the relationship between the network measures and morbidity (Table 7.1-7.4).

**Table 7.1.** Pearson coefficients and p-values from partial correlations of indegree network centrality and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Indegree network centrality and Morbidity | None | -.487 | .008 |
| | Wealth | -.495 | .008 |
| | Dependency | -.507 | .007 |
| | Kinship | -.474 | .011 |

**Table 7.2.** Pearson coefficients and p-values from partial correlations of outdegree network centrality and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Outdegree network centrality and Morbidity | None | -.445 | .015 |
| | Wealth | -.454 | .015 |
| | Dependency | -.449 | .016 |
| | Kinship | -.434 | .019 |

**Table 7.3.** Pearson coefficients and p-values from partial correlations of inCloseness network centrality and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| InCloseness network centrality and Morbidity | None | -.260 | .110 |
| | Wealth | -.263 | .113 |
| | Dependency | -.279 | .098 |
| | Kinship | -.242 | .133 |

**Table 7.4.** Pearson coefficients and p-values from partial correlations of betweenness network centrality and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Betweenness network centrality and Morbidity | None | -.214 | .157 |
| | Wealth | -.229 | .147 |
| | Dependency | -.213 | .164 |
| | Kinship | -.177 | .210 |

**Partial correlations – Hypothesis 6**

For the same reasons described above, partial correlation tests were used to explore the potential for confounding in the relationship predicted in Hypothesis 6. The results show that none of these covariates have a major impact on the relationship between the network measures and reputation (Tables 7.5-7.7).

**Table 7.5.** Pearson coefficients and p-values from partial correlations of outdegree network centrality and social reputation, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Outdegree network centrality and Social reputation | None | .737 | <.001 |
| | Wealth | .723 | <.001 |
| | Age | .725 | <.001 |
| | Years living in community | .726 | <.001 |
| | Kinship | .762 | <.001 |

**Table 7.6.** Pearson coefficients and p-values from partial correlations of inCloseness network centrality and social reputation, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| InCloseness network centrality and Social reputation | None | .319 | .064 |
| | Wealth | .288 | .091 |
| | Age | .478 | .012 |
| | Years living in community | .465 | .013 |
| | Kinship | .341 | .056 |

**Table 7.7.** Pearson coefficients and p-values from partial correlations of indegree network centrality and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Betweenness network centrality and Social reputation | None | .485 | .008 |
| | Wealth | .441 | .018 |
| | Age | .478 | .012 |
| | Years living in community | .465 | .013 |
| | Kinship | .538 | .004 |

**Bivariate correlations – Hypothesis 5 & 6**

Correlations between the potential confounding variables and the non-CA reputation were analyzed to provide insight into variable selection for the linear regression model. Results show that age and kinship were not significantly correlated with non-CA reputation; wealth and years in the community were considerably closer to reaching statistical significant (Table 7.8). Correlations between potential

confounding variables and HH morbidity can be found in Chapter 6 (Table 6.5). In brief, none of the confounders were associated with morbidity.

**Table 7.8.** Correlations between potential confounding variables and social reputation.

| | Age | Wealth | Kinship | Years in community |
|---|---|---|---|---|
| Pearson's *r* | -.023 | .230 | .124 | .201 |
| *P* | .458 | .139 | .283 | .173 |

### *Predictive analyses for Hypothesis 5 and 6*

This section uses a series of regression models to test Hypotheses 5 and 6. All regression tests are one-tailed. Non-network data were analyzed using SPSS (19.0) with alpha set at .05. Network data were analyzed in UCINET (6.0). Figures 7.8 and 7.9 were produced (via UCINET) with NetDraw 2.09.

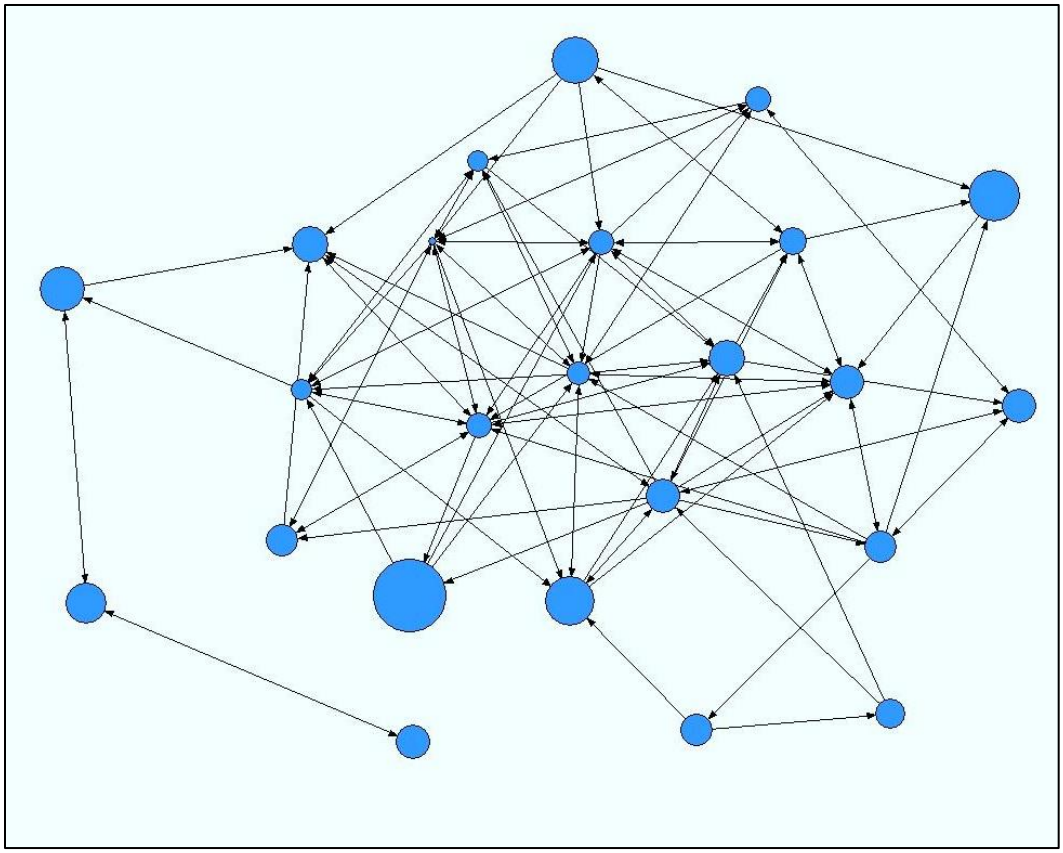

**Figure 7.8.** Health advice network in Pucucanchita. Node size in this graph is determined by the average number of symptoms each HH experienced; the larger the node, the greater number of symptoms experienced. Arrows indicate direction of aid. Reciprocity of the network in terms of proportion of dyads that are reciprocal is 0.41, and 0.58 in terms of the proportion of arcs (ties) that are reciprocated.

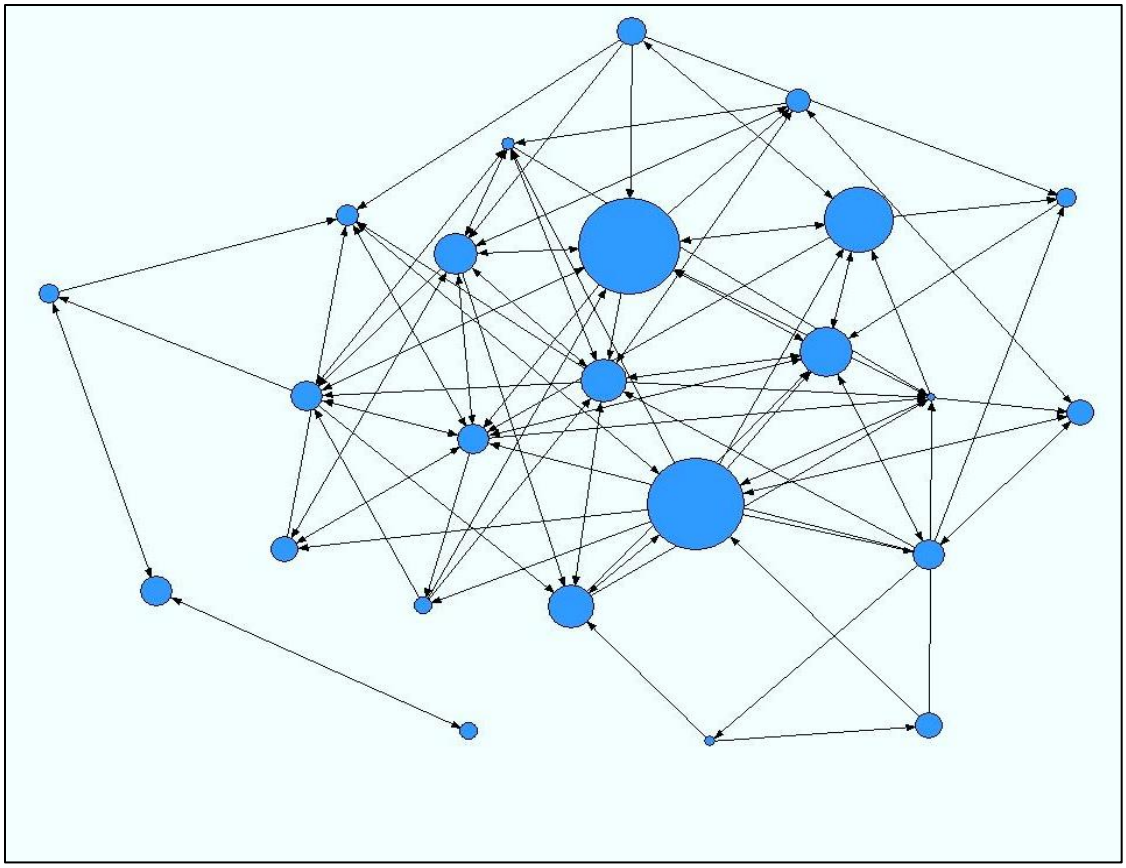

**Figure 7.9.** Health advice network in Pucucanchita. Node size in this graph is determined by the non-CA reputation score; the larger the reputation score, the larger the node. Arrows indicate direction of aid.

**Hypothesis 5**

Since there is no indication of confounding, it is not necessary to add any variables to the linear regression model. (Tables 7.1-7.4). Nevertheless, three variables—kinship, dependency, and wealth—were included to evaluated their effects when included together as covariates in the model. It is important to note that the probability of rejecting the null decreases as more covariates are included in the model, especially given the relatively small sample size used in this analysis.

Hypothesis 5a and 5b are supported. Indegree and outdegree network centrality are highly correlated with (Figure 7.1 and 7.2) and predictive of (Table 7.9 and 7.10) HH-level morbidity after controlling for the aforementioned covariates. Hypothesis 5c is provisionally supported, as inCloseness and morbidity were marginally correlated (p=.110; Figure 7.3). In addition to Pearson's *r*, Spearman's

*rho* (a non-parametric rank-order correlational analysis) was also used for the analysis of H5c. Spearman's *rho* is influenced less by outliers (compared with Pearson's *r*) which can greatly impact a predicted association when the sample size is small. The result from this analysis showed, again, that inCloseness and morbidity were marginally correlated, though slightly more so than Pearson's test (Spearman's *rho* = -.298, 1-tailed p=.079, n=24). The linear model that tested the predictive relationship in H5c shows similar results (Table 7.11). Hypothesis 5d is not supported. While there is a clear trend such that higher betweeness results in lower morbidity there is no statistically significant association, looking at Pearson's *r* (*r* = -.214, 1-tailed p=.157; Figure 7.4) and Spearman's *rho* (*rho* = -.186, 1-tailed p=.192, n=24). The linear model shows similar results (Table 7.12).

**Table 7.9.** Multiple linear regression model with *morbidity* as the dependent variable and indegree network centrality, kinship, dependency, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Indegree network centrality | -.513 | -2.52 | .011 |
| Kinship | .119 | .567 | .289 |
| Dependency | -.108 | -.521 | .305 |
| Wealth | .106 | .508 | .309 |

**Table 7.10.** Multiple linear regression model with *morbidity* as the dependent variable and outdegree network centrality, kinship, dependency, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Outdegree network centrality | -.457 | -2.21 | .020 |
| Kinship | .158 | .736 | .236 |
| Dependency | .027 | .127 | .451 |
| Wealth | .129 | .594 | .280 |

**Table 7.11.** Multiple linear regression model with *morbidity* as the dependent variable and inCloseness network centrality, kinship, dependency, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| InCloseness network centrality | -.270 | -1.18 | .127 |
| Kinship | .151 | .644 | .264 |
| Dependency | .072 | .307 | .381 |
| Wealth | .069 | .298 | .385 |

**Table 7.12.** Multiple linear regression model with *morbidity* as the dependent variable and betweenness network centrality, kinship, dependency, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Beetweeness network centrality | -.221 | -906 | .188 |
| Kinship | .158 | .665 | .257 |
| Dependency | -.007 | -.031 | .489 |
| Wealth | .119 | .475 | .320 |

**Hypothesis 6**

Similar to H5 there is no indication of confounding with the relationships predicted in H6, and it is thus not necessary to add any variables to the linear regression model (Tables 7.5-7.8). Nevertheless, three variables—years living in the community, kinship, and wealth—were included to evaluate their effects when included together as covariates.

Hypothesis 6a is supported. Outdegree centrality was highly correlated with and predictive of social reputation (Figure 7.5; Table 7.13). Hypothesis 6b is provisionally supported. InCloseness and reputation were marginally correlated using Pearson's *r* test (p=.064; Figure 7.6) and Spearman's test (*rho* = .370, 1-tailed p=.037, n=24). In the linear model inCloseness centrality was modestly predictive of social reputation (Table 7.14). Hypothesis 6c is also supported. Betweeness centrality was strongly

correlated with social reputation (Figure 7.7) and the inferential test showed similar results (Table 7.15). Kinship neared statistical significant as a covariate in two of the models (7.13 and 7.15).

**Table 7.13.** Multiple linear regression model with *non-CA reputation* as the dependent variable and outdegree network centrality, years living in the community, kinship, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Outdegree network centrality | .735 | 4.88 | <.001 |
| Years living in the community | .005 | .030 | .489 |
| Kinship | .239 | 1.58 | .066 |
| Wealth | .125 | .773 | .225 |

**Table 7.14.** Multiple linear regression model with *non-CA reputation* as the dependent variable and inCloseness network centrality, years living in the community, kinship, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| inCloseness network centrality | .296 | 1.39 | .090 |
| Years living in the community | .089 | .403 | .346 |
| Kinship | .209 | .963 | .174 |
| Wealth | .198 | .858 | .201 |

**Table 7.15.** Multiple linear regression model with *non-CA reputation* as the dependent variable and betweeness network centrality, years living in the community, kinship, and wealth as covariates.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Betweeness network centrality | .510 | 2.42 | .013 |
| Years living in the community | .071 | .346 | .367 |
| Kinship | .269 | 1.34 | .099 |
| Wealth | .075 | .341 | .369 |

## *Discussion*

Social network studies have provided valuable insight into how network access leads to better health, and how (and why) resources and information flow between HHs (Nolin 2010; Cohen and Syme 1985; Hadley 2004; Kawachi et al. 1996; Uchino et al. 1996). This study contributes to these research areas by exploring the social dynamics and health outcomes of health advice networks in a small community in the highlands of southern Peru.

This chapter addresses two questions about Pucucanchita's health advice network in relation to: (1) the health outcomes of *access to* and *position in* these networks and (2) the reputation outcomes of generosity and position in these networks. First, does greater access to health advice and knowledge of traditional medicine in fact lead to better health? Second, are certain network positions associated with high social reputation? To approach these questions, the following network measures are examined: support received (i.e., indegree), support given (i.e., outdegree) and network position (i.e., inCloseness and betweenness).

### Health advice and morbidity

The answer to the first question is, yes. HHs that receive advice from more HHs tend to experience fewer illness symptoms. Further, those who give the most aid (likely because they are sought out for their expertise in traditional medicine) also experience better health. The impact a HH's network position had on health was slightly less obvious. InCloseness, the measure of the shortest (network) distance a particular HH is from other HHs in the community, does improve health but not at the levels of indegree and outdegree network centrality. My reasoning regarding inCloseness enhancing health is that those who have broader, not-too-distant support have an adaptive advantage, and should thus experience fewer illnesses. Bivariate analyses show a modest negative association between inCloseness and morbidity as did the predictive tests. Clearly, those who have a shorter "distance" to other HHs through the advice network tend to be healthier, but the trend did not reach conventional standards of statistical significance. The same was true for betweenness centrality, a measure of how often a HH acts as a bridge between

other HHs in the network. My reasoning is that the ability to control the transfer of health information and its spread throughout the network can provide health benefits because of the special access to health advice it affords. Additionally, high betweenness may also allow a HH to use its favorable position to leverage services of a different nature. For example, I may provide a neighbor access to information (either by connecting them directly with the person or by obtaining the information and relaying it to them) with the expectation that when the time comes that I need a hand with, say, an agricultural task, I can ask the neighbor that I helped. There is a potential for those of high betweenness (or high outdgree) to have a bank of support to draw from, built through controlling (or providing) much-needed information. While the idea is compelling, findings from this research do not provide strong support. Those with higher betweenness centrality have, on average, healthier families, but again the trend is not statistically significant.

A few unanswered questions remain about the dynamics of these networks. First, clearly having access to health advice has its benefits, but how does one build this network of support? Although kinship is a likely candidate, it is not correlated with morbidity or any of the network centrality measures in this dataset. High investment in CA is another candidate. It is possible that those who have expert healing advice "repay" reliable contributors to CA by preferentially helping these HHs during their time of need. Simply, high contributors to CA are recognized as such and receive more advice from the best healers. Another plausible scenario is that those HHs that receive advice from the best healers repay the aid in other forms, such as help with agricultural tasks.

**Network attributes and social reputation**

As discussed in previous chapters, there are likely to be multiple fitness benefits that come with a good social reputation. Research in several small-scale societies indicates that those with greater reputations and/or status have more children (who are treated better by fellow community members), are more likely to receive aid in times of need, and have greater influence in community affairs (Gurven et al. 2000; Smith 2004; Gurven and von Rueden 2006; von Rueden et al. 2008). Chapter 5 discussed

reputation building through participation in CA. Here, I explore reputational differences that stem from disparities in knowledge about traditional medicines and positions in health advice networks.

Before discussing the potential for reputation building via network advice exchanges, it is important to readdress the necessity of having access to knowledge about traditional medicines. Access to professional health care is not an option for most *campesinos* due to a lack of mobility and money to pay for specialized services. Furthermore, rural health clinics are seldom open and do not provide trusted care in the eyes of locals. Instead, *campesinos* rely heavily on self-treatment, usually in the form of various combinations of herbs boiled in water and served as a tea. Not all *campesinos* have equal knowledge (or access to knowledge) about these medical solutions. In fact, a few members of Pucucanchita are part of a well-respected, widely-known guild of women who meet outside of the village and discuss traditional medicines. Expertise in traditional medicines (and/or access to this knowledge) is a desirable trait that, if possessed, may change how one is perceived by others.

Findings from this research provide some support for this proposition. HHs that gave more advice had a better reputation as generous, influential, and respected members of the community. It is unclear whether the reputation derives from the value the community places on *knowledge* about illness remedies or if the reputation is the result of the *generosity* of providing advice. Of course, these possibilities are not mutually exclusive and it very well may be that those who have knowledge about traditional medicine strategically provide this much-needed resource with some expectation of delayed reciprocity and/or "generosity" reputation building.

Just as having the expertise in traditional medicines leads to a better reputation, so too does having favorable access to and/or controlling health-related information. Findings indicate that a relatively shorter network distance (i.e., high closeness) to advice not only leads to better health, but also a better social reputation. Further, those who act as a bridge to advice (i.e., high betweeness) achieve a high reputation even if they don't directly possess the knowledge themselves. These HHs which act as gatekeepers to health advice have considerable influence with regard to the flow of information in a network (Everett and Borgatti 2005; Wasserman and Faust 1994; Hanneman and Riddle 2005).

Is it possible that having a good reputation leads to better social network position and access, rather than network position/access leading to a good reputation? This may be true with regard to indegree: those with a greater reputation receive more health advice. However, this research predicts that higher outdegree, closeness, and betweeness centrality lead to a greater reputation and, regarding outdegree, there is no reason to believe that having a reputation as a generous, influential, well respected community member will give a person greater knowledge about traditional medicines. Whether or not having a stronger reputation gives an individual better position within these networks is a little more difficult to answer. It is unlikely that having a good reputation places a person in a position of high betweeness. Why not use one's reputation to directly receive aid rather than dealing with the complexities and time costs of managing and distributing information. It seems more likely that high betweeness leads to a better reputation rather than the other way around. However, it is plausible that higher inCloseness, which is quantified based on indegree, is influenced by social reputation. These issues should be addressed in future research.

### *Conclusions*

Social network analysis provides an excellent framework for understanding highland advice networks and how they affect (and are affected by) social reputation and health. In Pucucanchita, those HHs that receive and give more aid, and those who have a more favorable network position in these fitness-enhancing networks, have members who experience fewer illnesses. This finding adds to the rich literature on the health benefits of larger networks, while also filling a gap by demonstrating the role position plays in promoting health in an indigenous advice network.

The role of healers in the evolutionary history of social behavior was likely an important one. In contemporary (and past) cultures that rely (have relied) on traditional medicines, healers not only play an important role in the social lives of their community, but are also afforded special privileges and higher social status (Fabrega 1997). Findings from this research support this supposition – HHs with greater

knowledge about traditional medicine (and access/control of this knowledge) have more reputable HH heads.

### *Limitations*

A major assumption of this research is that traditional medicines in fact lead to better health. This assumption is not directly testable with the data that I've collected. However, my finding that those who provide the most advice have the healthiest families provides indirect evidence in support of the assumption. Having expertise (or access to this expertise) in traditional medicines is likely adaptive even if these medicines have a modest *direct* impact on the actual symptoms. As pointed out earlier, psychoemotional benefits of access to health care/advice alone reduces stress, and can reduce illness susceptibility. Given the outcomes of self-treatment on healing and the long history of traditional medicine among the Quechua, there is some reason to suspect that there is an adaptive component to participation and access to health advice networks. Another limitation is that these analyses utilize correlational and regression tests of the hypotheses; the latter show the predictive relationship between the variables, but do not provide a complete picture of their causal relationship.

# Chapter 8: Total support network

This chapter explores the relationship between the household head's social reputation and his or her household's complete access to social support, defined as the sum of agricultural support, health advice, and nutritional support received. The relationship between the household's "total support network" and household morbidity is also explored. This total support network is evaluated in binary and summative forms. In addition to inferential statistical tests of the predicted relationships, descriptive statistics for variables not reported thus far are also included.

## *Statement of the problem*

As noted in previous chapters, life in the Andes of southern Peru presents severe challenges for human subsistence, due to the high elevation and resultant low oxygen pressure, aridity and severe climate. These factors, along with the difficulty of modifying the environment, result in low ecosystem productivity and marginal subsistence (Thomas and Winterhalder 1976; Orlove 1977). In the highland community of Pucucanchita residents rely on social support to alleviate some of these stressors. These networks are composed of kin, friends, allies and mates and their families, and have a long history in Andean Peru, going back at least to Incan times (Flores-Ochoa 1968; Allen 2002; Carey 1988; Mayer 2002). While the sharing of information, materials, and labor is dynamic and ever-changing in the *altiplano*, a household's (HH) dependency on social support continues to be vital. Social support networks that occur in the study community are discussed in detail in Chapters 3, 6, and 7. Below, I provide a brief overview of the three support networks explored in this dissertation: agricultural support, health advice, and food sharing.

As subsistence agropastoralists, access to social support in the form of help with agricultural tasks is crucial for *campesinos* living in Pucucanchita. Farming tasks, such as preparing and planting gardens can be more efficient and productive with help from outside of the HH. Help with animal husbandry tasks

and advice about vaccination and breeding programs are also vital. Rural health centers in the Nuñoa District are open sporadically, provide minimal care, and lack electricity and sterile working conditions. These limitations, coupled with a lack of money to pay for pharmaceuticals, make HHs depend greatly on advice about health-related issues from members of their community. Finally, food sharing is important for some HHs living in Pucucanchita. Seasonal variation in nutrient intake increases vulnerability to infections, and thus periodic food sharing can have a number of advantages, particularly for families who may be struggling due to, for instance, an illness-induced reduction in HH output.

Chapters 6 and 7 examined social relations strictly in terms of agricultural support and advice about traditional medicines, respectively. This method of analysis makes sense given the *ayni* tradition of task-specific exchange of aid, especially regarding agricultural aid. However, my observations and those of others point toward a changing landscape of reciprocity in the *altiplano* (see Chapter 3). It may be that modern reciprocity in the Andes is less task-specific than it once was, with increased instances of trading one type of aid for a different type. Consequently, it is possible that some HHs have low indegree centrality (number of HHs providing support to it) for the agricultural network simply because they are providing agricultural support to other HHs (outdegree) in order to receive a different type of support (e.g., advice about the use of traditional medicines) in return. This could lead to a HH that has a high investment in collective action (CA), a reputable HH head, and yet a small agricultural support network. To address this and similar issues, the analyses in this chapter take a holistic approach of social support in the study community, considering an amalgamation of the networks previously explored, including previously unreported food sharing data.

It is also important to consider that some HHs may have strong relationships with a few HHs, instead of a wider support network (i.e. weak relationships with several HHs). For example, a HH may receive all three types of aid from a single HH instead of receiving each type of aid from a different HH. In a binary network that considers a unification of aid, the former HH would have an indegree of 1, while the later has an indegree of 3, despite the fact that each HH receives each type of aid. While there are

certain benefits of studying a binary, directed network as discussed below, considering a summation of support will provide some insight into the effects the degree of aid a HH receives has on HH morbidity.

### *Hypotheses 7 and 8*

**Hypothesis 7** examines the relationship between the social reputation of the head of HH and the total support the HH receives from other HHs in the community. H7 states: HHs that have a reputable HH head in terms of CA reputation and general reputation will have greater indegree network centrality for the (a) total binary and (b) total summative network.

**Hypothesis 8** examines the relationship between indegree network centrality for a HH's complete network and the health of the HH. H8 states: HHs that (a) receive aid from more HHs or (b) receive a greatest amount of aid (summing agricultural support, health advice and nutritional support) will experience, on average, fewer illness episodes among their members.

### *Descriptive statistics*

In this section, descriptive statistics for the total support network are reported. Descriptive bivariate correlations between key variables and their associated scatterplots are also presented.

#### Network descriptives

Social network data were collected on three types of agricultural help: help with herds and gardens, watching animals, and animal husbandry advice. Participants were asked whom they had aided and whom they had received aid from for each of the three kinds of agricultural support. Food sharing network data were collected on the principal types of food that is shared in the area: potatoes, grains, and meat. The health support network data asked about the transfer of health-related advice. See Chapters 6

and 7 for detailed information about the agricultural and health advice networks, respectively, and Chapter 4 for more details on support network data collection.

Networks with *directed* ties specify the direction of the flow of resources or support to and from HHs. Networks with *valued* ties include data representing the amount of aid that was provided, while a *non-valued* tie simply recognizes that aid was given or received. Indegree network centrality is the measure of the number of HHs that a focal HH received support from. Outdegree network centrality is the measure of the number of HHs that a focal HH gave support to. Two types of indegree were considered in the analyses below. The first is a binary network in which a relationship was coded as existing if there was any one of the three types of aid given or received. For instance, if a HH received agricultural support and health advice the relationship was considered the same as if the HH had only received agricultural support. The second method gave a value to the ties between HHs. If a HH received any (and only) one of the three types of aid from a particular HH, it was coded as 1, if it received two of the three types, it was coded as 2, and if it received aid for all types of aid from another HH the tie was coded as 3. An assumption of this method is that the weight of each type of aid is similar (i.e., the benefit of each type of aid is equivalent). This network will not be referred to as a valued network, since a valued network typically measures the exact amount of aid received (e.g., 10 hours of agricultural support). Instead, I will refer to this network as a summative network. As with all network analyses herein, the network is directed.

Table 8.1 presents network descriptives for all networks considered in this dissertation, including the total support network. This paragraph provides definition for the network measures reported in Table 8.1 that haven't been discussed thus far. *Density* is the measure of the number of observed ties divided by the number of potential ties. *Arc-based reciprocity* is a measure that approaches the question: of the observed arcs (i.e., directed ties between HHs) what proportion are part of a reciprocal relationship? *Dyad-based reciprocity* approaches the question: of those dyads that have a relation, what proportion are reciprocal? *Symmetric* is the total number of reciprocated ties involving a HH divided by the number of ties to and from the HH. *Mean non-symmetric out-ties* is the number of non-symmetric outgoing ties

divided by the total number of outgoing ties, whereas mean *non-symmetric in-ties* refers to the number of non-symmetric incoming ties divided by the total number of incoming ties.

**Table 8.1.** Various network measures for the three support networks as well as the total support network.

| | Agricultural support | Health advice | Food sharing | Total network (binary) |
|---|---|---|---|---|
| Mean degree (S.D.) | 5.17 (3.93) | 6.17 (2.84) | 2.08 (2.16) | 9.33 (4.26) |
| Mean indegree (S.D.) | 3.92 (2.94) | 4.33 (2.38) | 1.17 (1.82) | 7.08 (3.97) |
| Mean outdegree (S.D.) | 3.92(3.42) | 4.33 (2.41) | 1.17 (1.34) | 7.08 (3.58) |
| Network density | .170 | .188 | .050 | .308 |
| Number of ties | 94 | 104 | 28 | 170 |
| Number of isolates | 2 | 0 | 6 | 0 |
| Arc-based reciprocity | .681 | .577 | .214 | .682 |
| Dyad-based reciprocity | .516 | .405 | .120 | .518 |
| Symmetric | .522 | .414 | .121 | .494 |
| Mean non-symmetric in-ties | .317 | .437 | .814 | .368 |
| Mean non-symmetric out-ties | .306 | .446 | .715 | .366 |

**Covariates**

Descriptive statistics for reputation, morbidity, age, years living in the community, and dependency ratio, and the rationale for considering these variables, can be found in Chapter 5. Descriptive statistics for geographic distance between HHs can be found in Chapter 6.

**Correlation between independent and dependent variables**

This section reports two sets of descriptive correlational analyses, one for each hypothesis. The predicted relationship between social reputation and total support network size was explored using Pearson's *r*, as was the relationship between support network size and HH-level morbidity; these tests are one-tailed. Results indicate that total reputation score of the HH head is highly positively correlated with the total support network size of his or her HH (Figure 8.1). There is also a negative relationship between indegree network centrality (total network size) and morbidity, although it doesn't reach conventional levels of statistical significance (Figure 8.2).

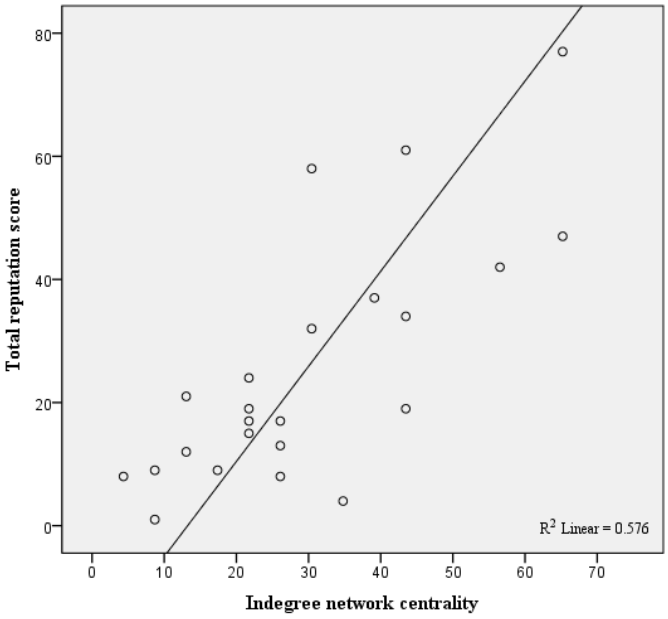


**Figure 8.1.** The relationship between total reputation score and normalized indegree network centrality for the total support network. The variables are positively correlated (Pearson's r = .759, 1-tailed p< .001, n = 24).

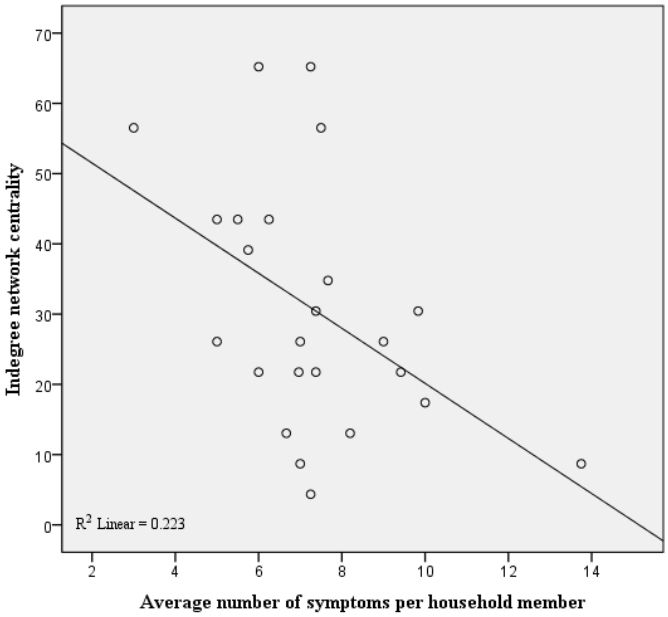


**Figure 8.2.** The relationship between a HH's network centrality (normalized) for its total support network and HH per capita morbidity. The variables are negatively correlated (Pearson's r = -.472, 1-tailed p=.010, n=24).

### *Variable selection for testing Hypotheses 7 and 8*

Two analyses, partial and bivariate correlations, were conducted to determine which, if any, potential confounding variables impact the predicted relationship between social reputation and network centrality (H7). These tests were also run to determine potential confounders for the relationship between network centrality and morbidity (H8). Partial correlation tests are two-tailed.

**Partial correlations – Hypothesis 7 and 8**

A partial correlation test is an analysis of the relationship between two continuous variables and includes an additional variable as a control. This test is used primarily as a tool for identifying potential confounding variables that may in some way influence the relationship between the independent and dependent variable. For H7, the results show that none of the control variables have a major impact on the relationship between reputation score and network centrality (Table 8.2). Similarly, the three control variables included in individual partial correlation analyses for H8—age, dependency, and kinship—had little impact on the total social support/morbidity relationship (Table 8.3).

**Table 8.2.** Pearson coefficients and p-values from partial correlations of the total reputation score and normalized indegree network centrality for the total support network, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Total reputation score and Network centrality | None | .659 | <.001 |
| | Age | .634 | .002 |
| | Morbidity | .612 | .002 |
| | Dependency | .643 | .001 |
| | Kinship | .688 | <.001 |

**Table 8.3.** Pearson coefficients and p-values from partial correlations of normalized indegree network centrality for the total support network and morbidity, controlling for possible confounders.

| Correlated variables | Control variable | *Pearson's r* | *P* |
|---|---|---|---|
| Network centrality and Morbidity | None | -.472 | 0.20 |
| | Age of HH head | -.509 | .015 |
| | Dependency | -.517 | .012 |
| | Kinship | -.461 | .027 |
| | Per capita herd size | -.494 | .017 |

**Bivariate correlations**

Correlations between the potential confounding variables and the dependent variable (social support), were analyzed, as these results can also provide insight into variable selection for the linear regression model. Results show that age and kinship were not correlated with network centrality (Table 8.4). Years living in the community and per-capita herd size were marginally (positively) correlated with network centrality, and distance was negatively correlated with network centrality (Table 8.4). None of the potential confounding variables—age, kinship, per capita herd size, and dependency—were correlated with average number of illness symptoms experienced (Table 8.5).

**Table 8.4.** Correlations between potential confounding variables and normalized total social network size.

| | Age | Kinship | Years in community | Per-capita herd size | Distance |
|---|---|---|---|---|---|
| Pearson's *r* | .006 | -.120 | .294 | .311 | -.440 |
| *P* | .489 | .289 | .081 | .069 | .018 |

**Table 8.5.** Correlations between potential confounding variables and the average number of symptoms experienced.

| | Age | Kinship | Per capita herd size | Dependency |
|---|---|---|---|---|
| Pearson's *r* | .198 | .245 | .086 | .049 |
| *P* | .365 | .248 | .702 | .820 |

### *Predictive analyses for Hypothesis 7 and 8*

This section uses a series of regression models to test H7 and H8. All regression tests are one-tailed. Non-network data were analyzed using SPSS (19.0) with alpha set at .05. Network data were analyzed in UCINET (6.0). Distances between HHs were calculated using ArcGIS 10.0. Figures 8.3 and 8.4 were produced (via UCINET) with NetDraw 2.09. Nodes are fixed in the two graphs to facilitate comparisons.

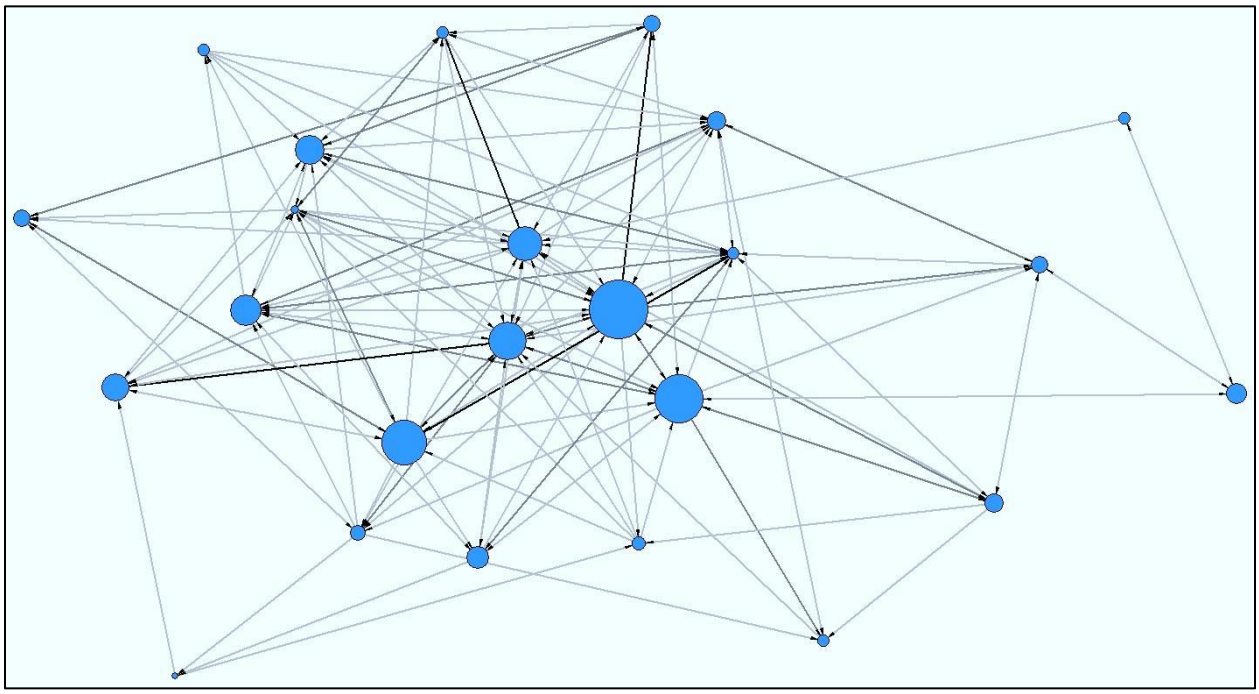

**Figure 8.3.** Total support network in Pucucanchita, including agricultural aid, health advice and food sharing. Arrows indicate direction of aid and the shade of the tie represents its strength. Node size is proportional to reputation score. HHs with the greatest degree network centrality are closer to the center of the graph. Distances between nodes are arbitrary.

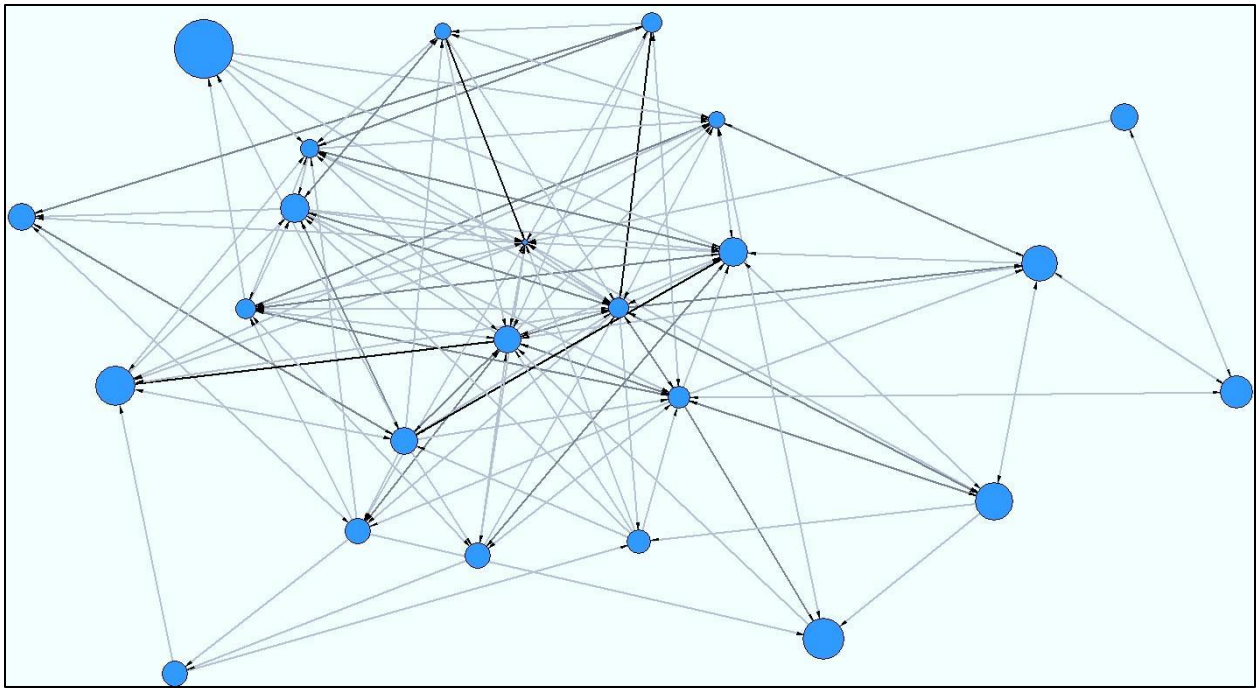

**Figure 8.4.** Total support network in Pucucanchita, including agricultural aid, health advice and food sharing. Arrows indicate direction of aid and the shade of the tie represents its strength. Node size is proportional to morbidity score. HHs with the greatest network centrality are closer to the center of the graph. Distances between nodes are arbitrary.

Hypothesis 7 was tested using a linear regression model with indegree centrality (normalized by dividing the number of observed relations by the total number possible) as the dependent variable and the total reputation score as the independent variable. Distance was included in the linear regression model as a covariate since it was negatively correlated with indegree centrality. Per capita herd size (or wealth) and years spent in the community were marginally correlated with indegree centrality and were also included. The covariates included in these analyses are the same as those that were considered in the analysis of the agricultural support network, which allows us to see if a change in coefficients results from adding ties from other support networks, and to comparing model fit.

Hypothesis 7 predicts that the most reputable HH heads in the community will have a larger and stronger total network size. This hypothesis is supported. The strong bivariate correlation between reputation and normalized indegree network centrality (Figure 8.1) was further supported using a multiple linear regression model. The total reputation score was highly predictive of indegree network centrality,

after controlling for other factors (Table 8.6). With the exception of distance (which was only marginally predictive), other covariates were not predictive of social support received. The same linear model was analyzed substituting the binary total support network with a summative one. The summative model shows a slightly stronger relationship between the covariates and social support and explains considerably more of the variance in support network size (Tables 8.6 and 8.7). Another notable difference is that morbidity is predictive of social support received in the summative model, but not the binary model.

**Table 8.6.** Multiple linear regression model with *total social support network size* (indegree network centrality) as the dependent variable and reputation, distance, morbidity, years living in community and per capita herd size as covariates. The model is significant ($F$=4.79, $df$=5, $p$<.005) and explains 59% of the variance in support network size.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Reputation | .534 | 3.06 | .003 |
| Distance | -.286 | -1.43 | .085 |
| Morbidity | -.227 | -1.24 | .116 |
| Years in community | -.055 | -.307 | .381 |
| Per capita herd size | .044 | .246 | .404 |

**Table 8.7.** Multiple linear regression model with *total social support network size* (summative indegree network centrality) as the dependent variable and reputation, distance, morbidity, years living in community, and per capita herd size as covariates. The model is significant ($F$=16.94, $df$=5, $p$<.001) and explains 83% of the variance in support network strength.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Reputation | .747 | 6.76 | <.001 |
| Distance | -.211 | -1.66 | .057 |
| Morbidity | -.213 | -1.84 | .042 |
| Years in community | -.094 | -.835 | .207 |
| Per capita herd size | .080 | .703 | .245 |

Hypothesis 8 predicts that HHs with a larger and stronger total support network will experience fewer per capita symptoms. This hypothesis is supported. A multiple regression test, including kinship,

dependency, and per capita herd size, reveals that total support network size is a powerful predictor of morbidity (measured as the average number of illness symptoms per HH) (Table 8.8). The linear model with the summative network as the dependent variable had similar results as the binary model. The only noteworthy differences are that social support is a somewhat better predictor in the summative model and that the summative model explains more variance in morbidity scores (Tables 8.8 and 8.9).

**Table 8.8.** Multiple linear regression model with *morbidity* as the dependent variable and network size, kinship, dependency, and per capita herd size as covariates. The model nears significance ($F$=2.03, $df$=4, $p$=.131) and explains 30% of the variance in morbidity.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Indegree network centrality | -.571 | -2.68 | .007 |
| Kinship | .121 | .587 | .282 |
| Dependency | .184 | .871 | .197 |
| Per capita herd size | .169 | .809 | .214 |

**Table 8.9.** Multiple linear regression model with *morbidity* as the dependent variable and summative network centrality, kinship, dependency, and per capita herd size as covariates. The model nears significance ($F$=2.79, $df$=4, $p$=.056) and explains 37% of the variance in morbidity.

| Independent variables | Standardized Beta Coefficient | *T* | *P* |
|---|---|---|---|
| Indegree network centrality | -.643 | -3.18 | .002 |
| Kinship | .237 | 1.22 | .119 |
| Dependency | .150 | .765 | .226 |
| Per capita herd size | .257 | 1.25 | .112 |

### *Tests of mediation*

A primary motivation of a mediation analysis is to identify underlying mechanisms that are influencing the relationship between an independent (x) and dependent variable (y) (see Chapter 6, Diagram 6.2) (Baron and Kenny 1986). Simply, the mediation model proposes that (x) influences a mediator (m), which subsequently influences (y) (MacKinnon 2008). The predicted causal relationship is (x)→(m)→(y). The mediator is said to govern the relationship between (x) and (y), in other words

providing the causal link between (x) and (y). Mediation models consider what is referred to as direct and indirect effects. The direct effect is a measure of the impact (x) has on the (y) when (x) is increased by one unit, holding (m) constant. The indirect effect is the reduction of (x) on (y) as a result of (m), and thus measures how much mediation is occurring. This analysis incorporates statistical bootstrapping with the Preacher-Hayes bias correction (Preacher and Hayes 2008). (See Chapter 6 for a discussion of the bootstrapping method incorporated here and more details on mediation testing).

Results from the linear regression models testing H1 and H2 (See Chapter 5 and 6 for comprehensive results) indicate that those HHs that contribute more to CA have more reputable HH heads, and that reputable heads receive agricultural support from more HHs. A test of mediation with reputation as the mediator, investment in CA as the independent variable, and agricultural support as a dependent variable found that reputation is only partially mediating the effects of CA investment on agricultural support. Here, I run the same mediation test substituting agricultural support with the total, summative support network to see if, by including all types of support, reputation becomes a stronger mediator.

In order to see if a mediation test is appropriate, three analyses were run. First, CA investment (x) should be a significant predictor of total social support (y); this criterion has been met (Standardized Beta = .667, 1-tailed $p < .001$, $n = 24$). Second, the CA investment should be a significant predictor of the mediator (reputation); this criterion has been met (Standardized Beta = .831, 1-tailed, $p < .001$, $n = 24$). Correlating reputation with social support is not sufficient when demonstrating a mediation effect since the reason they are correlated could be the result of (x) "causing" both (m) and (y). Consequently, reputation should be a significant predictor of total support network, controlling for CA investment; this criterion has been met (Standardized Beta = .995, 1-tailed, $p < .001$, $n = 24$).

Five-thousand bootstrap samples were generated and analyzed. The direct effect from CA investment to summative support network is not statistically significant (direct effect -.013; $p = .543$). As CA investment increases by one unit, summative support network decreases by .282 units. The indirect effect from CA investment to summative support network is significant (.082; $p < .001$). For the indirect

effect, as CA investment increases by one unit, summative support network increases indirectly via reputation by .082 units. The 95-percentile bootstrap confidence interval (bias corrected) is from .046 to .136. Zero is not in the confidence interval, and thus we can conclude that the indirect effect is different from zero. These results provide evidence for complete mediation of social reputation on the CA investment-total support relationship (Figure 8.5).

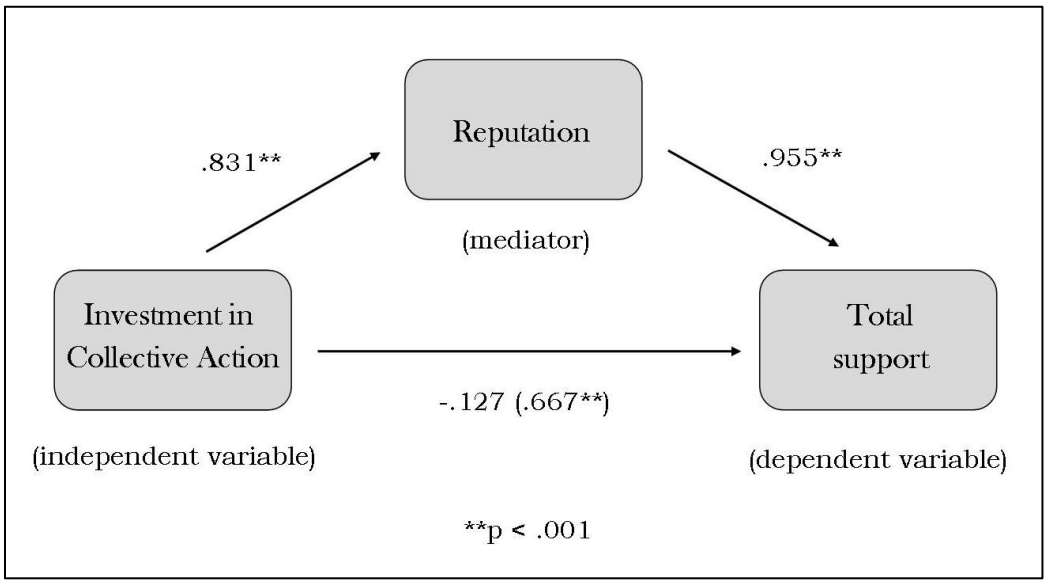


**Figure 8.5.** Standardized beta coefficients for the direct and indirect effects of the mediation model.

Linear models presented in this chapter (Tables 8.6-8.9) show a strong relationship between reputation and the total social support network, and that a HH's total support network is predictive of its per capita morbidity. Reputation is also marginally correlated with morbidity. Given these results it is possible that social support is mediating the relationship between reputation and morbidity, or it could be that reputation alone, or some factor strongly determining reputation, leads to better health regardless of support size or strength. A test of mediation with total social support (summative) as the mediator, reputation as the independent variable, and morbidity as a dependent variable could offer some insights into the indirect effects social support may or may not have on reputation and morbidity.

The criterion that reputation is a significant predictor of morbidity is met (Standardized Beta = -.307, 1-tailed, p=.072, n = 24) as is the relationship between reputation and summative support (Standardized Beta = .850, 1-tailed, p<.001, n = 24). Finally, total social support should be a significant predictor of morbidity, controlling for reputation (Standardized Beta = -.859, 1-tailed, p<.011, n = 24); this criterion is also met.

The same bootstrap protocol was used to investigate total social support as a mediator of the relationship between reputation and morbidity. The direct effect from reputation to morbidity is .045 and is not statistically significant (p=.236). As reputation increases by one unit, morbidity increases by .310 units. The indirect effect from reputation to morbidity is -.078 and is statistically significant (p<.001). For the indirect effect, as reputation increases by one unit, morbidity decreases indirectly via social support by .078 units. The 95 percent bias corrected bootstrap confidence interval (5000 trials) is from -.147 to -.030, and because zero is not in the confidence interval, we can conclude that the indirect effect is different from zero. This provides evidence for complete mediation (Figure 8.6).

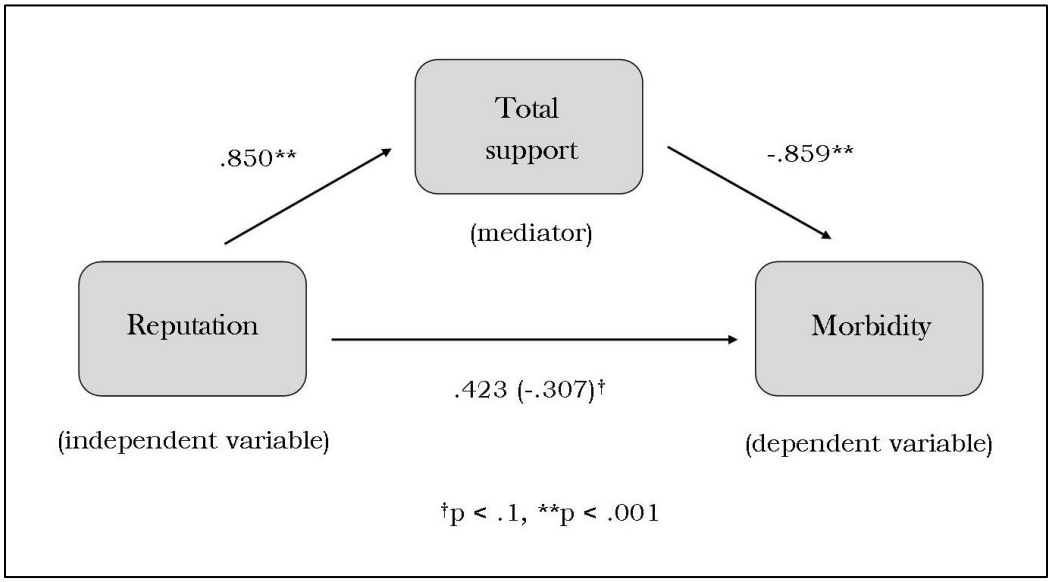


**Figure 8.6.** Standardized Beta coefficients for the direct and indirect effects of the mediation model.

## *Discussion*

### Total support network

This dissertation research has demonstrated in separate analyses the benefits of a larger agricultural support network (Chapter 6) and a larger health advice network (Chapter 7). Analyzing these networks independently is intuitive given the historical accounts of reciprocity in the area (i.e., aid-specific reciprocity as the norm). However, results from this method may not paint the most accurate picture of contemporary reciprocity in the area. Observations during my fieldwork (as discussed in Chapter 3) make one wonder how aid-specific reciprocity is in the study community. It is highly plausible that some HHs have a surplus of agricultural labor help (e.g., high ratio of workers in the HH to HH agricultural demands), and consequently do not need agricultural support from other HHs. Having a surplus of help from within the HH allows the HH head to strategically provide agricultural support to other HHs with the expectation of receiving aid in other forms, such as health advice or nutritional support. If this HH is active in CA and has a reputable HH head, the aid-specific analysis would leave one to believe that reputation, achieved through CA investment, does not enhance a HH's support network size. Thus, studying the agricultural network independent of other types of support may not truly capture the full social-network benefits of having a high reputation. The analysis employed in this chapter considers a unification of the three networks in hopes of providing a more accurate model of reputational benefits in the community.

How does including food sharing and health advice with agricultural support into a total support network change the predictive value of reputation on support network size? The two linear models with the same independent variable (reputation) and covariates, though with different dependent variables—one including indegree from the agricultural support network and the other including indegree for the total support network—are nearly identical (Tables 6.6 and 8.6). In sum, reputation does not seem to be a better predictor in the binary total support network, providing some assurance that looking only at agricultural support doesn't underestimate the benefits of having a good reputation.

**Network size and strength**

A second concern is that by looking only at a binary total network, we may be missing something regarding the importance of the strength of a particular social relationship. Consider the possibility that a HH has three other HHs in which it engages in a high level of sharing, receiving all three types of aid (i.e. indegree=3 in binary, indegree=9 in summative), and compare this HH with one that has six weak relationships, in which one type of aid is received from each relation (i.e. indegree=6 in binary, indegree=6 in summative). If looking only at the total binary network, the HH with a low-quantity, high-quality network may be perceived as receiving less support. Simply put, the summative network allows one to capture the strength of dyadic relationships.

There are certain benefits to measuring a binary network; for instance, it is a good measure of network width (i.e., number of HHs in which there is a relationship). Having a wide network of support has its benefits, such as the ability to call on immediate support if one's principal support partnerships are not available. Having a low-quantity, high-quality network can be problematic if one or two of these partners are ill or leave the community and the HH has no one to turn to. It could be argued that network width is more important than strength when it comes to agricultural networks, since need is short-term, sporadic, unpredictable, and by no means a daily affair. Similarly, having a wider rather than a stronger health advice network may be best given the urgency of need; health advice can't wait. On the other hand, having a relationship with another HH that includes multiple types of aid is indicative of a certain kind of relationship, one of commitment and obligation. Losing a relationship of this nature could have a major impact on a HH, and thus these relationships should be summative more and requests for help will likely be answered. There is also a level of assurance that comes with knowing you have a single HH (or more) that can provide a variety of assistance.

I can imagine several scenarios in which one or the other strategy is more advantageous, and I have no conclusive qualitative answers based on my experiences: in some situations a low-quantity, high-quality network is best and in others it is not. The quantitative results presented above may provide some clues. I presented two linear models with the same dependent variable (morbidity) and covariates, though

one included the indegree from the binary network as a predictor and the other included indegree from the summative network (Tables 8.8 and 8.9). The linear model that includes indegree from the summative network explains somewhat more of the variance in morbidity score, and support strength is a better predictor. Nevertheless, the end result is the same: a wide and/or strong network of support leads to better health.

If we are convinced that greater investment in CA is motivated, in part, by the opportunity to achieve a better reputation, then comparing the models in Tables 8.6 and 8.7 can provide insight into the type of social support that result from a high reputation. Do greater reputations lead to stronger network, wider network, or both? The answer is both, but reputation is a considerably stronger predictor of the summative network compared with the binary network. This implies that the strategy may lean toward building strong support relationships.

**The mediation effect**

Results from the linear models that approached the relationship between CA investment, reputation, and agricultural support are similar to those of the overall network. HHs that invest more in CA have reputable HH heads, and those with high reputations have larger support networks. Despite these results, the exact causal pathway can't be elucidated from the two linear models. Mediation tests of the agricultural support network data indicate that reputation is mediating the relationship between CA investment and social support, but the mediating effects are weak (Diagram 6.3). Interestingly, reputation is a strong mediator of the CA investment-total support relationship, and this is true for both the binary and summative results (Figure 8.5). The fact that the mediation effect of reputation increases as additional types of support are included in the model implies that reputation becomes a stronger path between CA investment and social support when multiple relations are included in the support network. This suggests that agricultural support alone may not be the motivating factor for CA investment.

Results from the linear models that investigated the relationship between reputation, agricultural support and health advice tell the same story as the models testing the overall network: those who have

greater reputations have larger and/or stronger support networks, and those with larger/stronger networks have healthier families. The same problem as stated above arises: the three variables are highly correlated and the linear models testing these relationships don't demonstrate causal flow. The results from the agricultural support network indicate that the mediating effects of social support on the relationship between reputation and morbidity are weak at best (Diagram 6.4). However, the mediation effect changed from nebulous to very strong when substituting the agricultural support network data with that of the binary or summative total support network (Figure 8.6). It may be that the total support network better captures inequalities in access to support that can influence health. That is, those who have high levels of agricultural support also receive higher levels of health advice and nutritional support, and the combined effects of social support work in concert to improve health.

# Chapter 9: Conclusions

This research was inspired by decades of research on collective action, reputation, reciprocity, social networks, and social organization in the Andes and elsewhere. Here, I outline the major findings of this dissertation research and briefly consider their contribution to ongoing research and debates in the aforementioned areas.

## *Major findings and contributions*

### Prosociality enhances social reputation

Findings show a strong relationship between investment in collective action (CA) and social reputation. A central paradox in the study of CA from an evolutionary perspective is: why do some individuals contribute to the good of the group when the greatest fitness-enhancing decision in most cases is to free ride and invest in personal or family interests? This research provides a clear answer to this conundrum: for many HHs it pays more to invest in CA than it does to free ride. These findings provide yet another example of how seemingly group-beneficial behavior is in fact self-interested.

### Reputation impacts support network size

I found that prosocial behavior is associated with a larger support networks and it is likely that reputation is mediating this relationship. In sum, results show that those who contributed more to CA achieved a greater reputation, and this reputation lead to fitness-related gains in social support. While the benefits of inclusion in support networks are well documented, there is a lack of research showing how network membership is established and maintained, how reputation within the network is assayed by other members, and whether or not some receive greater network benefits in relation to their reputation for generosity or other qualities. This research helps to fill these gaps, by illustrating a mechanism (reputation) for enhancing social support, and how that mechanism is evaluated (CA investment).

**Prosocial behavior demonstrates underlying qualities**

Findings indicate that the generosity displayed by HHs in CA is representative of their quality as generous, reciprocal HHs. Further, this research provides a convincing argument that only those HHs with members who can deal with grueling CA investment can consistently contribute over time. This study contributes to the growing scientific literature on honest signaling in humans.

**Greater social support and certain support network positions lead to better health**

In Pucucanchita, having an advantageous position in health advice networks leads to better health, as does a greater knowledge and access to knowledge about traditional medicines. This is one of the few studies that have explored the health outcomes of access to health advice using complete network data from an indigenous community. These network data, similarly to the agricultural support network data, illustrates how social dynamics can lead to health disparities even when differences in wealth are trivial. Access to health advice, a relatively ignored form of social support, should be taken into consideration by those interested in the cause of health disparities in communities that have limited access to professional health care.

## *Conclusions*

While there are several noteworthy conclusions that can be drawn from this research, there are two that I feel deserve special mention.

**Reputation solves the tragedy of the commons**

The problem of CA has been tackled by researchers in a number of disciplines, but important questions remain, particularly regarding the presence of free riders even in incidences of successful CA. Put another way, what factors act to stabilize CA in the face of incentives that could unravel it? Undoubtedly the most intriguing aspect of CA in Pucucanchita is the fact that free riding not only occurs, it goes unpunished. My findings support the argument that costly contributions to CA can be profitable if

they serve as a reliable signal in partner choice, resulting in social benefits extending beyond the CA context itself, in this case a larger support network. CA in Pucucanchita is a venue in which qualities that are valued in social network members (e.g., animal husbandry knowledge, work ethic) are efficiently broadcast community-wide. Most CA tasks are subsistence-related, and observations indicate that individuals differ in skills such as shearing animals, physically demanding work, or knowledge of the latest vaccination and/or breeding programs. Thus, CA provides an ideal social environment in which contributors can honestly broadcast adaptive information about their value as social network partners. Free riding (lower CA contribution) is an expected outcome of this signaling dynamic, and unlikely to unravel group cooperation as long as the benefits to signalers and signal receivers outweigh the costs of lower collective output that results from free riding.

These findings contribute to ongoing efforts to understand the forces shaping the evolution (cultural or genetic) of cooperation, particularly those related to group cooperation between non-kin. Indeed, it appears that CA can be maintained via direct fitness benefits, given the low relatedness between HHs in this community and the fact that kinship was not correlated with our key variables.

**The rules of reciprocity have changed in the *altiplano***

This work shows that reciprocal relations continue to be an important aspect of Andean culture. However, the frequency, expectations, and practices of reciprocity have changed considerably in recent decades. The ethnographic story that continues to dominate discussions of Andean reciprocity explains one type of reciprocity, *ayni*, as being a very rigid form of reciprocity in which one task is returned in the exact same form and amount. Observations early on in this fieldwork made me wonder how aid-specific reciprocity is in the study community. Quantitative findings show that sharing is more dynamic in Pucucanchita than one would expect given past accounts of reciprocity in the area; that is, HHs often exchange one type of aid (e.g., agricultural support) with the other (e.g., health advice). It is also important to note that the systems of reciprocity described in the literature (e.g., *ayni*, *mink'a*) are remembered only vaguely by locals and/or have different meanings than those detailed in ethnographies.

This is true even in remote areas where these cultural practices should have been affected less by the expanding market economy in South America.

The rich ethnographic literature on Andean reciprocity that predates the fall of the *hacienda* system should be considered a historical account instead of indicative of current practices. There is a changing landscape of reciprocity in the *altiplano* of southern Peru, in both terminology and practice, and this is especially apparent in Pucucanchita.

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