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Labor Complementarities and Health in the Agricultural Household

Achyuta Adhvaryu* and Anant Nyshadham**

Abstract

Models of the agricultural household have traditionally relied on assumptions regarding the complementarity or substitutability of family labor inputs. We show how data on time allocations, health shocks and corresponding treatment choices can be used to test these assumptions. Data from Tanzania provide evidence that complementarities exist and can explain the pattern of labor supply adjustments across household members and productive activities following acute sickness. In particular, we find that sick and healthy household members both shift labor away from self-employment and into farming when the sick recover more quickly. Infra-marginal adjustments within farming activity types provide further evidence of farm-specific complementarities.

Keywords: Intra-household allocation, health shocks, complementarity

JEL Codes: I10, J22, J43, O12

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1 Introduction

The agricultural household model forms the foundation of our understanding of household decision-making in agricultural societies, particularly in the developing world. [1] One common feature of models of this type is that household production may involve labor inputs from varied sources. For example, in the presence of labor markets, the farm production function may take hired as well as family labor as inputs; when labor markets are imperfect or altogether absent, the distinction may be made between male and female labor or adult and child labor within the family.

The way in which multiple labor inputs interact in the farm and off-farm production functions can be an important determinant of the predictions made by these model for the behavior of household members. The complementarity or substitutability of family labor in production affects the household's optimal allocation of resources (notably time allocations) as well as the way household members adjust to shocks. Complementarities may arise, for example, if adults can monitor children on the farm when they work together, or if males and females specialize in different aspects of the production process. The extent of substitutability of labor across subgroups of family members may depend on their physical endowments; their traditional roles in household production; or their farm- or home-specific human capital.

Despite this central role, however, there is little theoretical or empirical consensus on the nature of this interaction. For example, it has often been assumed that male and female labor inputs within the family are (imperfect) substitutes (Mark Rosenzweig 1980; Hanan Jacoby 1993; Michael Baker and Dwayne Benjamin 1997). As regards adult and child labor, some studies have assumed complementarity (e.g. Rosenzweig and Kenneth Wolpin 1985), while others have assumed separability of the two inputs (e.g. Jean-Marie Baland and James Robinson 2000). Still others have restricted the properties of the family production function in a way which implies either substitutability or complementarity (e.g. Pierre-Andre Chiappori 1997).[2]

The purpose of our study is to derive a test of the complementarity or substitutability of family labor in household production. To our knowledge, the only other study which has attempted to do this is by Thomas Kniesner (1976), whose test is important as a first attempt but is methodologically flawed.[3] The present study is different in several ways. First, it studies

[1]See Inderjit Singh, Lyn Squire and John Strauss (1986) for a survey of the classic models, and J. Edward Taylor and Irma Adelman (2003) for a synthesis of the more recent literature.

[2]A large literature has examined the related issue of the substitutability of family and hired labor (a classic example is Benjamin (1992)). We do not address this literature here because the distinction between hired and family labor is only relevant to contexts in which labor markets are complete, whereas in our data labor markets are largely nonexistent.

[3]Knieser's (1976) test is based on comparing estimates of the effect of the wife's wage on the husband's market labor time for two sub-samples of the National Longitudinal Survey: husband-wife pairs in which the wife works, and pairs in which the wife does not work. He instruments for the wife's wage using a vector of the wife's demographic characteristics. The study's methods are flawed in at least two aspects. First, in order to derive the cross-price elastic-

agricultural households in a developing country context, for whom the question of complementarity or substitutability of labor has not, to our knowledge, been tested. Second, we need not rely on any assumptions on the cross-price elasticities of labor across family members. Third, since the effective nonexistence of labor markets in our setting renders moot the issue of shifting household member-specific wages, we rely instead on shifting the closest analogs, i.e., the marginal productivities of farm and non-farm labor.

In particular, we focus on introducing health (and acute shocks to health) into a model of intra-household allocations. In our model, two household members provide labor inputs in two sectors of production - farm and off-farm work. Health enters directly into each individual's utility, and also affects the marginal productivity of labor in both sectors. Under minimal assumptions on the household decision-making process, we are able to derive a test of the complementarity or substitutability of family labor in the farm and non-farm production functions. The test exploits the empirically observed patterns of labor adjustment within the household in response to health shocks.

We estimate the pattern of labor adjustment using an instrument for the healthcare choices of sick individuals in the household. We propose that the choice of higher quality healthcare in response to acute illness results in a faster recovery, generating shifts in individuals' health. Accordingly, we first verify that using formal-sector care does indeed improve health outcomes for acutely sick individuals (akin to the results in Achyuta Adhvaryu and Anant Nyshadham (2010a, 2010b)).

We then estimate the labor supply responses of sick and non-sick household members. Our estimates reject the substitutability of family labor in farm and non-farm production, and instead imply that complementarities must exist in *at least one sector* of production. In particular, we find that sick and non-sick household members *both* shift labor away from non-farm and towards farm labor when the sick recover more quickly. The bulk of the adjustment takes place in labor on the household's own farm and in self-employment. Infra-marginal adjustments across types of farming activities provide further evidence of farm-specific complementarities: we find that when sick individuals recover, both sick and non-sick household members shift away from crop maintenance (weeding, pruning, etc.) and into land preparation and harvesting activities. In the appendix, we examine heterogeneous effects across gender and ages (children versus adults) in the household.

Understanding the way that labor inputs interact in household production may inform a diverse set of economic questions, from household adjustments following productivity or production technology shocks (Anjini Kochar 1995, 1999; Kathleen Beegle, Rajeev Dehejia and Roberta

ity of male market time with respect to the female wage, the test relies critically on assuming the sign of the opposite cross-price elasticity (female market time with respect to the male wage). Second, the validity of the exclusion restrictions for the instruments for wife's wages is tenuous: the wife's schooling, race and number of children are all likely related to the husband's labor supply through channels outside of the wife's wage.

Gatti 2006); to schooling-child labor decisions (Mette Ejrnæs and Claus Pörtner 2004; Eric Edmonds 2006); to the relationship between family labor supply and fertility (especially concerning pregnancy and childcare) (T. Paul Schultz 1990); to labor market effects of household health shocks (Dercon and Krishnan 2000; Adam Wagstaff 2007); to optimal sorting in the marriage market (Jere Behrman et al. 1994).

Our study also contributes to a large body of literature examining the role of health in intra-household resource allocations. Our results, building on work by Mark Pitt et. al (1990), Schultz (1990) and others, suggest that the health of household members–in addition to affecting bargaining power (Schultz 2001), consumption demand (Pitt and Rosenzweig 1985; Pitt et al. 2006) and household income (Schultz and Aysit Tansel 1997)–can have large effects on the time allocation decisions of sick *as well as* healthy household members through production complementarities.

Finally, the findings of this study may be relevant in setting labor-market and health-related policies, as well. First, we estimate the intra-household spillover effects of treatment for acute illness; recent studies have focused in general on the spillovers of treatment for longer-term health conditions (e.g. Giovanna d'Adda et al. 2009; Joshua Graff Zivin et al. 2009). Our results suggest that making transport to health facilities cheaper, or investing in health infrastructure in remote areas, improves not only health outcomes, but also has effects on the time allocations of the sick individual as well as the other members of his household. Second, our results on production complementarities are not contingent on this health-related context; thus, the insights gained here regarding intra-household adjustments may be applied to any policy which affects the labor supply or underlying productivity of particular household members.

The remainder of the paper is organized as follows. Section 2 presents the model and derives our main test of labor complementarities. Section 3 describes our data set and construction of important variables. Section 4 presents our empirical strategy and discusses its validity. Section 5 presents the main results of our test. Section 6 discusses the validity of alternative explanations to the results. Finally, section 7 concludes.

2 Model

We study a collective household model in which two household members divide their time between leisure and two types of productive activity: farm and non-farm labor. We use the model to characterize household behavior in the face of health shocks, focusing in particular on labor allocations within the household. We show that the pattern of adjustment of labor allocations across sectors and household members depends crucially on the complementarity or substitutability of household labor in the farm and non-farm production functions. Finally, we show how data on labor allocations, health shocks and corresponding treatment choices can be used to formulate an empirical test for the presence of labor complementarities in production.

2.1 Setup

Consider a household with two members $i \in \{1, 2\}$. Let Ω be the individual time endowment; each household member's time is allocated toward leisure L_i; labor on one's own farm (l_i^f); outside agricultural wage labor (l_i^w) at wage rate w; and non-farm labor (t_i). The time constraint for each i is therefore $\Omega = L_i + l_i^f + l_i^w + t_i$. Individuals value their own consumption of the two market goods ($\mathbf{c}_i = (c_i^f, c_i^n)$), own leisure ($L_i$), own health h_i, and the health and leisure of the other family member, h_{-i} and L_{-i} respectively. Each member's preferences are represented by a utility function $u_i(\mathbf{c}_i, L_i, L_{-i}, h_i, h_{-i})$.[4] Goods are produced via the production functions for farm and non-farm labor, $f(l_1^f, l_2^f, l^h, h_1, h_2)$ and $n(t_1, t_2, h_1, h_2)$, respectively, where l^h is the total hired labor on the household's farm. The market prices of the two goods are $\mathbf{p} = (p^f, p^n)$.

We assume that wage labor exists in the farm sector, but that non-farm labor time is non-marketable. Suppose further that the amount of outside agricultural wage labor (l_i^w) is constrained such that for each i the quantity of such labor cannot exceed M_i. These assumptions are in keeping with our empirical context, as well as other agricultural settings in the developing world (Udry 1996; Fafchamps 1993). In our sample, though the average number of hours spent farming per week by a member of a household with at least one sick and one non-sick member is roughly 14.5, less than .5 of these hours is spent working on someone else's farm for a wage. This evidence confirms that, while a market for farm labor exists, participation in this market is constrained to low levels.

Health enters the household allocation problem in two ways. First, it directly provides utility, as described above. Second, it affects each household member's productivity. We make only one restriction on the way in which h_i enters f and n: we assume that the health of person i does not *directly* affect the marginal productivity of person $-i$. That is, $\frac{\partial^2 f}{\partial l_{-i}^f \partial h_i} = 0$ and $\frac{\partial^2 n}{\partial t_{-i} \partial h_i} = 0$.[5] Of course, the marginal productivity of $-i$ in each sector is still free to shift as a result of labor adjustments to an acute health shock to i.

Our focus in this paper is on acute health shocks and corresponding (acute) investments in treatment for these shocks. Accordingly, we define the health production function as $h_i = h(\sigma_i Q_i, \varepsilon_i)$, where $\sigma_i \in \{0, 1\}$ is an acute health shock indicator, Q_i is the corresponding intensity of treatment (which we think of as the quality of healthcare for individual i), and ε_i is a vector of other inputs into health, such as endowments, long-term care, chronic illness etc. The price

[4]Note that we allow explicitly for non-separability of leisure and health across household members. The results of the model are also robust to considering a fully non-separable utility function within a unitary representation of the household's problem. We choose to focus on the collective model in keeping with the recent literature on intra-household decision-making in developing countries.

[5]One way in which this assumption may be violated is through disease contagion; we address this possibility in section 6.

of one unit of Q_i is p^Q. Note that as we have defined the health production function above, Q_i only improves health in the event of a health shock (i.e. when $\sigma_i = 1$). We restrict Q_i in this way to underscore its role as *curative care*, rather than long-term health investment, preventative care or the like. We return to this restriction in our discussion of the empirical strategy in section 4.

2.2 Utility maximization

An efficient allocation of resources within the household is characterized as a solution to the following problem:[6]

$$\max_{\mathbf{c}_i, L_i, l_i^f, l_i^w, l^h, t_i, Q_i:\, i \in \{1,2\}} \quad u_1(\mathbf{c}_1, L_1, L_2, h_1, h_2) + \Phi u_2(\mathbf{c}_2, L_1, L_2, h_1, h_2) \qquad \text{subject to}$$

$$\mathbf{p} \cdot (\mathbf{c}_1 + \mathbf{c}_2) + p^Q(Q_1 + Q_2) \leq p^f f(l_1^f, l_2^f, l^h, h_1, h_2) + w(l_1^w + l_2^w - l^h) + p^n n(t_1, t_2, h_1, h_2) \quad (1)$$

$$L_i + l_i^f + l_i^w + t_i = \Omega_i, \quad i \in \{1,2\} \quad (2)$$

$$l_i^w \leq M_i, \quad i \in \{1,2\} \quad (3)$$

$$h_i = h(\sigma_i Q_i, \varepsilon_i), \quad i \in \{1,2\} \quad (4)$$

We make the following standard assumptions about the shapes of the utilities and production functions:

1. Utility is increasing and concave in own consumption: $\frac{\partial u_i}{\partial c_i^f}, \frac{\partial u_i}{\partial c_i^h} > 0$ and $\frac{\partial^2 u_i}{\partial {c_i^f}^2}, \frac{\partial^2 u_i}{\partial {c_i^h}^2} < 0$, for $i = 1, 2$.

2. Consumption goods are normal.

3. The production functions are increasing and concave in their labor inputs: $\frac{\partial n}{\partial t_i}, \frac{\partial f}{\partial l_i^f} > 0$ and $\frac{\partial^2 n}{\partial t_i^2}, \frac{\partial^2 f}{\partial {l_i^f}^2} < 0$ for $i = 1, 2$; and $\frac{\partial f}{\partial l^h} > 0$ and $\frac{\partial^2 f}{\partial {l^h}^2} < 0$.

Under the above assumptions, in the unconstrained case (in which the agricultural wage labor constraints do not bind), we obtain interior solutions for consumption demand, labor supply and healthcare quality choice as functions of the model's parameters.[7] However, as noted above, frictions do exist in the agricultural labor market in our context, and thus the salient case is the one in which the constraint binds, i.e. when $l_i^w = M_i$ and $l^h = 0$. In this case,

[6] Ours is a simple variant of the basic constrained optimization problem of the agricultural household, described, for example, in Bardhan and Udry (1999). We modify the model to include multiple sectors, multiple household members and a role for health. For similar characterizations of the collective household as they apply to the developing country context, see, e.g, Chiappori (1992, 1997), Udry (1996), Duflo and Udry (2004).

[7] We show in appendix section A.1 that in the unconstrained case, in which the agricultural wage labor constraints do not bind, we are able to derive the same test of complementarities as in the constrained case.

the budget constraint becomes:

$$\mathbf{p} \cdot (\mathbf{c}_1 + \mathbf{c}_2) + p^Q(Q_1 + Q_2) \leq p^f f(l_1^f, l_2^f, 0, h_1, h_2) + w(M_1 + M_2) + p^n n(t_1, t_2, h_1, h_2) \tag{5}$$

We focus on two of the necessary first order conditions–those with respect to l_2^f and t_2, the own farm and non-farm labor contributions of the second household member. We do this to draw attention to the intra-household consequences of health shocks and their corresponding treatment, as below, we examine the case in which household member 1 experiences a health shock but household member 2 does not. The first order conditions for these two choice variables are as follows (letting λ and δ denote the Lagrange multipliers for the budget constraint and the time constraint, respectively):

$$(l_2^f): \qquad -\lambda\left(-p^f \frac{\partial f}{\partial l_2^f}\right) - \delta = 0 \tag{6}$$

$$(t_2): \qquad -\lambda\left(-p^n \frac{\partial n}{\partial t_2}\right) - \delta = 0 \tag{7}$$

Combining, we get

$$p^n \frac{\partial n}{\partial t_2} = p^f \frac{\partial f}{\partial l_2^f}. \tag{8}$$

An analogous condition holds for household member 1. Intuitively, at an optimum, each household member must equate the ratio of marginal productivities across sectors to the inverse price ratio.

2.3 Using labor adjustments to shocks to test for complementarities in production

Our first goal is to study the pattern of labor adjustments after a health shock. In the model, variation in individual i's acute sickness may derive from variation in the health shock σ_i and/or the variation in healthcare investment Q_i. In empirical settings, σ_i is very difficult to measure, and exogenous variation in σ_i is difficult to observe because health shocks are likely jointly determined with health endowments and health preferences, which are unobserved to the econometrician. Though Q_i is by construction an endogenous choice of the household, variations in the exogenous price of healthcare quality p_Q may be used as an exogenous shifter of sickness in order to explore its effects on the household's reallocation of resources.

Differentiating equation 8 with respect to p^Q, we obtain:

$$p^n \left(\frac{\partial^2 n}{\partial t_2 \partial t_1}\frac{\partial t_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2^2}\frac{\partial t_2}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_1}\frac{\partial h_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_2}\frac{\partial h_2}{\partial p^Q}\right)$$

$$= \quad p^f \left(\frac{\partial^2 f}{\partial l_2^f \partial l_1^f} \frac{\partial l_1^f}{\partial p^Q} + \frac{\partial^2 f}{\partial {l_2^f}^2} \frac{\partial l_2^f}{\partial p^Q} + \frac{\partial^2 f}{\partial l_2^f \partial h_1} \frac{\partial h_1}{\partial p^Q} + \frac{\partial^2 f}{\partial l_2^f \partial h_2} \frac{\partial h_2}{\partial p^Q} \right) \tag{9}$$

The above equation indicates that the way in which household members adjust labor allocations following an acute health shock (or, as expressed above, a shift in the price of curative care) depends crucially on the shapes of the production functions for farm and non-farm labor. We use this equation to formulate a test for the complementarity of household labor in these production functions.

We are interested in particular in the labor responses of households with both sick and non-sick members. Thus, let us examine equation 9 for the case in which $\sigma_1 = 1$ and $\sigma_2 = 0$ (that is, only household member 1 is acutely ill). The fourth terms within parentheses ($\frac{\partial^2 n}{\partial t_2 \partial h_2} \frac{\partial h_2}{\partial p^Q}$ and $\frac{\partial^2 f}{\partial l_2^f \partial h_2} \frac{\partial h_2}{\partial p^Q}$) on both sides of the equation equal 0 in this case, since $\frac{\partial h_2}{\partial p^Q} = 0$ when $\sigma_2 = 0$. Further, the third terms within parentheses ($\frac{\partial^2 n}{\partial t_2 \partial h_1} \frac{\partial h_1}{\partial p^Q}$ and $\frac{\partial^2 f}{\partial l_2^f \partial h_1} \frac{\partial h_1}{\partial p^Q}$) are also 0, since we have imposed that the health of i does not *directly* affect the marginal productivity of $-i$ (i.e. $\frac{\partial^2 n}{\partial t_2 \partial h_1} = \frac{\partial^2 f}{\partial l_2^f \partial h_1} = 0$). Equation 9 can thus be written as

$$p^n \left(\frac{\partial^2 n}{\partial t_2 \partial t_1} \frac{\partial t_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2^2} \frac{\partial t_2}{\partial p^Q} \right) = p^f \left(\frac{\partial^2 f}{\partial l_2^f \partial l_1^f} \frac{\partial l_1^f}{\partial p^Q} + \frac{\partial^2 f}{\partial {l_2^f}^2} \frac{\partial l_2^f}{\partial p^Q} \right) \tag{10}$$

The above equation forms the basis of our joint test of household labor complementarities. The objects of interest are the cross-partials $\frac{\partial^2 n}{\partial t_2 \partial t_1}$ and $\frac{\partial^2 f}{\partial l_2 \partial l_1}$. Note that $\frac{\partial^2 n}{\partial t_2^2} < 0$ and $\frac{\partial^2 f}{\partial l_2^2} < 0$ by the assumption of concavity of the production functions. The remaining four derivatives constitute the extent of labor adjustments to shock across household members and activities (i.e., $\frac{\partial k_j}{\partial p^Q}$ for $k \in \{t, l^f\}$ and $j \in \{1, 2\}$).

Assuming complementarity or substitutability of farm and non-farm labor would yield predictions on the signs of these labor adjustments. Conversely, estimating these adjustment terms and signing them imposes restrictions on the signs of $\frac{\partial^2 n}{\partial t_2 \partial t_1}$ and $\frac{\partial^2 f}{\partial l_2 \partial l_1}$. Thus, estimating the labor adjustments to health shocks across sectors allows us to test indirectly for the complementarity of substitutability of household labor. In the results section, we return to equation 10 to use the estimated values of the adjustment terms to draw conclusions about the signs of the cross-partials.

3 Data

3.1 Overview

This study uses survey data from the Kagera region of Tanzania, an area west of Lake Victoria, and bordering Rwanda, Burundi and Uganda. Kagera is mostly rural and primarily engaged in producing bananas and coffee in the north, and rain-fed annual crops (maize, sorghum, and cotton) in the south. The Kagera Health and Development Survey (KHDS) was conducted by the World Bank and Muhimbili University College of Health Sciences (MUCHS). The sample consists of 816 households from 51 "clusters" (or communities) located in 49 villages covering all five districts of Kagera, interviewed up to four times, from Fall 1991 to January 1994, at 6 to 7 month intervals. The randomized sampling frame was based on the 1988 Tanzanian Census.[8] KHDS is a socio-economic survey following the model of previous World Bank Living Standards Measurement Surveys. The survey covers individual-, household-, and cluster-level data related to the economic livelihoods and health of individuals, and the characteristics of households and communities. In the following paragraphs, we outline the variables we use in our analyses.

3.2 Health variables

In the health module of the KHDS, all household members are asked about chronic illnesses and acute illness episodes; care sought for these episodes; and current illness (at the time of survey).[9] As our main sample restriction, we use information on whether households contained at least one sick member (i.e. a member who reported having been sick in the last 14 days with an *acute illness*) and one non-sick member. We collapse our observations to the household-year level, by constructing within-household-year means for important health and labor supply variables. Our means are constructed using the number of *productive* household members, which is defined as the number of household members who answered the time use survey (all individuals above the age of 7). We restrict the sample in this way so that the labor means do not erroneously take into account household members for whom the time use survey was not asked.

Table I shows summary statistics for the Kagera sample. The number of household-year observations with at least one sick and one non-sick household member is 2146; this comprises 75% of the household sample reported having at least one sick and one non-sick member. Within these households, 42% of sick individuals report still being ill at the time of survey.

[8]A two-stage, randomized stratified sampling procedure was employed. In the first stage, Census clusters (or communities) were stratified based on agro-climactic zone and mortality rates and then were randomly sampled. In the second stage, households within the clusters were stratified into "high-risk" and "low-risk" groups based on illness and death of household members in the 12 months before enumeration, and then were randomly sampled.

[9]In the case of individuals below the age of 15, the primary caretaker of the child is asked to answer on the child's behalf.

Our main independent variable is the proportion of sick household members who visited formal-sector healthcare, defined as care at a hospital, health center or dispensary (which includes government, NGO, and private facilities). We normalize this variable by its standard deviation for ease of interpretation. The mean for this normalized proportion is reported in table 1. Without normalization, about 25% of sick household members sought formal sector healthcare for their illness episode.

3.3 Labor variables

The time use module of the KHDS collects detailed information on various types of labor supply for all individuals seven years of age and older. Individuals are asked how many hours in the past 7 days they spent in each of a variety of activities. We construct a composite variable for the total labor hours of household members above 7 years old. We then divide the total hours by the number of productive household members to obtain a per-capita measure of hours across 1) all household members; 2) sick members; and 3) non-sick members. Finally, we break these various per-capita measures in activity in different sectors.

In particular, we first split total labor hours into farm hours and non-farm hours. Then, we further split each category into subcategories. We subdivide the farm hours into employment hours, field and herd hours, and processing hours. Employment hours include hours spent working on a neighbor's farm, fishing, and working as a merchant. Other wage employment outside of the home is included here as well; however, hired farm work makes up the largest component of wage labor, hence its inclusion here. Field and herd hours include time spent on the individual's own farm, on a community farm and time spent herding livestock. Processing hours include time spent making farm produce and animal products into marketable goods.

We subdivide non-farm hours into self-employment hours and home hours (which is then further divided to display number of hours spent caring for an ill individual). Self-employment includes any non-farm activities the profit from which accrues to the individual (as opposed to working for someone else's business); this may include household enterprise, production or sale of market goods, or owning another type of small business (restaurant, hotel, etc.). Home hours include time spent in household chores, and time spent collecting water and firewood. For further details on the definitions of the labor supply variables and the method we used to aggregate them into totals, please refer to the data appendix.

In table 1, we compare means in these labor variables for sick versus non-sick members in households with at least 1 sick and 1 non-sick member; and for non-sick members of households with no sick members (i.e. households in which all members are not acutely ill). Several interesting features of the labor data are revealed. First, within "sick" households, sick and non-sick members appear to be spending nearly the same amount of time in each sector and sub-sector. For example, both types of individuals report working a total of about 30 hours last week. Of this time, a little less than half (13.5 hours) is spent on the farm, while the rest is spent in non-farm labor, which is mostly comprised of home labor. t-tests confirm the statistical equality of per-capita labor amounts across all sectoral categories.

On the other hand, we see significant differences (as again confirmed by t-tests) between the amount worked by members in "sick" versus "non-sick" *households*. In households with no sick members, total labor is significantly greater, and that difference is reflected in both sectors. In percentage terms, farm labor is about 18% greater in "non-sick" households, while non-farm labor is 14% greater.

The differences in these per-capita time use variables across "sick" and "non-sick" households, but *not* across sick and non-sick individuals within the same household, suggest that sick and non-sick household members may adjust to illness shocks in the same way. In particular, at least from the mean differences, it appears as though following illness, both sick and non-sick individuals draw down farm labor relative to off-farm labor, while total labor hours declines slightly. Clearly, we must not interpret these differences as causal estimates of sickness on the intra-household allocation of labor. In subsequent sections, we test more rigorously that this pattern of labor adjustments holds in a causal sense.

3.4 Other household- and cluster-level variables

We use a variety of household- and community-level demographic and socioeconomic characteristics in our regressions. The most important for the purposes of our analysis is the existence (or, to be precise, the lack of existence) of a formal healthcare facility in the cluster. As Table I reports, about 50% of households were located in communities without a formal-sector healthcare facility. As we describe in Section 4, we control for a variety of other variables related to the existence of other resources in one's community; these are existence of a daily market, periodic market, motorable road, public transportation, secondary school, bank, and post office/telephone. We also control for the distance to various types of formal-sector care options if they are not in the household's community; in particular, we include the distances to the nearest dispensary, health facility, and hospital (*n.b.*: if these options are in the individual's cluster, this variable equals 0).[10] Table 1 reports the means for these variables.

We control for various household characteristics. In particular, specifications include the maximum years of completed schooling across all household members (quintiles); mean age of household members (cubic polynomial); and household demographic composition, including the number of females, adults (age 15 or older), children (younger than age 15), males, females, men (adult males), women (adult females), boys (male children), and girls (female children). We also include household size (cubic polynomial); total assets owned by the household (quintiles

[10]We control for a cubic polynomial in the distance to nearest formal-sector care facility (which could be any one of the three types mentioned above), as well as quintiles of the distance to each option separately.

of an asset index generated using principal components analysis); and year of survey (fixed effects). Finally, we include district fixed effects.

3.5 Rainfall data

We obtained monthly rainfall data from the Tanzania Meteorological Agency spanning from 1980 to 2004.[11] The data set includes the amount of rainfall (in millimeters) per month and total days with rainfall per month for 21 weather stations in Kagera region. The data set provides a matching file which report the closest and second closest weather station to each cluster in the KHDS sample. Two measures of "closest" have been used: a straight-line distance between each cluster and each rainfall station, and a distance measure which takes into account the location topology of the area. We use the straight-line measure definition of "closest," and use the number of days of rainfall in the month the individual was sick as the primary measure of rainfall in our regressions. Further, we match the rainfall observation to the households with sick members by taking the rainfall value in the month the household was surveyed, in the cluster in which the household is located. If the rainfall value for this cluster-by-month observation is missing, we use the value at the second closest rainfall station to the cluster.

We also control for the number of days of rainfall in the month *prior to* the illness episodes reported by household members (discussed further in Section 4); the historical mean and historical standard deviation of the distribution of rainfall in the given month, computed over all the years of available data for the month in question (quadratic terms of these variables are included as well); fixed effects for the closest rainfall station; deciles for the number of days of rainfall; deciles for the amount of rainfall (in millimeters) in the month the individual fell sick; and interactions of days of rainfall with the existence of resources variables defined in the previous sub-section. For further details on the construction of rainfall variables, please see the data appendix.

4 Empirical strategy

Our goal in this section is to propose and discuss the validity of an instrument for healthcare choice, and to discuss how we use the variation induced by the instrument to first verify the effects of healthcare choices on health outcomes and then to explore effects on intra-household labor allocations. The observed patterns in labor supply responses within the household enable us to test for labor complementarities among family members using the predictions of the model of household behavior described in Section 2.

[11] The data set is downloadable from the EDI-Africa website: http://www.edi-africa.com/research/khds/introduction.htm.

4.1 An instrument for healthcare choice

Let O_{ij} denote an outcome for household i in cluster j, let h_{ij} denote the household's composite healthcare choice (calculated as the proportion of sick individuals in the household sent to formal sector care), and let $\mathbf{X}_{ij}$ denote a vector of household- and community-level characteristics. Consider the following empirical model:

$$O_{ij} = \beta h_{ij} + \mathbf{X}'_{ij}\gamma + \epsilon_{ij}. \tag{11}$$

As discussed extensively in Adhvaryu and Nyshadham (2010a), measuring the relationship between healthcare choice and health outcomes using OLS, as shown above in equation 11, likely results in a biased estimate of the effect of h on O, due to unobserved determinants of outcomes in the error term ϵ that are correlated with healthcare choice. In particular, the severity of the health shock likely influences the care option chosen as well as the outcome. That is, household members with higher-severity illnesses are more likely to be sent to higher quality healthcare options; and higher-severity illnesses will generate worse health and labor outcomes.

To address these endogeneity concerns, we use an instrument for healthcare choice which exploits exogenous variation in the costs of formal-sector healthcare. The instrument builds on the methodology introduced in Adhvaryu and Nyshadham (2010a) and applied in Adhvaryu and Nyshadham (2010b) at the individual level to the same data used in this study. A major point discussed in those papers is the fact that the largest costs of formal-sector care in developing countries are often those associated with the opportunity cost (or the direct costs) of travel to the care facility. Distance to the nearest facility (or alternatively, the presence of a formal care facility in one's community) is thus a large determinant of healthcare choice in developing countries, through its effects on costs (Gertler et al. 1987, Mwabu et al. 1995, Mwabu 2009).

Following Adhvaryu and Nyshadham (2010a), we propose an interaction instrument: specifically, we interact a dummy variable for the absence of a formal-sector health facility in a household's community with the number of days of rainfall in the month in which the household reported having at least one ill member, and exclude only this interaction from the second stage, while controlling for the main effects of facility "existence" and days of rainfall in the first and second stages of a two-stage instrumental variables estimator. In doing so, we use as our instrument only the temporary, random amplification caused by rainfall of the opportunity cost of time represented in the facility existence dummy, thereby avoiding issues of unobserved systematic variation in long-term access to resources that accompany the use of facility existence alone.

The two stages of analysis are specified as follows. Define $NoFac_j$ to be a dummy variable which equals 1 if *no* formal-sector health facility exists in cluster j, and R_{ij} to be the number of days of rainfall in cluster j in the month in which household i reported having at least one sick member (and one non-sick member, to allow for analysis on intrahousehold labor effects of sickness).[12] The two-step estimator is written as follows:

$$\text{1st stage:} \quad h_{ij} = \alpha_1 \left(NoFac_{ij} \times R_{ij}\right) + \alpha_2 NoFac_{ij} + \alpha_3 R_{ij} + \mathbf{X}'_{ij}\alpha_4 + \zeta_{ij} \tag{12}$$

$$\text{2nd stage:} \quad O_{ij} = \beta_1 h_{ij} + \beta_2 NoFac_{ij} + \beta_3 R_{ij} + \mathbf{X}'_{ij}\beta_4 + \epsilon_{ij} \tag{13}$$

The intuition behind the instrument is simple. The main effects of facility non-existence and rainfall are likely both negative; that is, not having a facility in a household's community and being exposed to more rainfall should, for the purposes of travel costs, discourage the household from sending sick members to formal-sector health facilities. Moreover, heavier rains should discourage households that are farther away *more* than households located in a community with a health facility.

Imagine one household located directly next to a facility, while another is located many villages away. In times of dry weather, clearly the household in the community with a health facility will be more likely to choose formal-sector care than the one farther away. However, in times of heavy rains, the rain should incrementally deter the farther household *more* than the one just next door.

4.2 Instrument validity

Ideally, we would like variation in the instrument to be equivalent to experimental variation in the price of formal-sector care. That is, we would like to answer the question, "Holding all other prices constant, if we shift only the price of formal-sector care, how does the demand for this care change, and subsequently, how do these shifts affect health and labor supply outcomes?" One crucial element of our argument is thus that the interaction instrument must induce price changes solely in the costs of formal-sector care, as opposed to shifting other prices which determine access to other resources, as well as directly influence consumption and labor allocations.

4.2.1 Controlling for general remoteness

It is plausible that fluctuations in rainfall induce differential price shifts in communities with health facilities as compared with communities without. For example, suppose non-existence of a formal care facility was correlated with a community's general remoteness; that is, communities lacking health facilities lacked access to other important resources (commodity and labor markets, roads, irrigation, etc.). In controlling for the main effect of the existence of a health

[12] We define the facility "existence" variable in the negative in order to make interpretation of the interaction coefficient easier; of course, changing this variable to reflect the existence of a health facility as opposed to the lack of existence has no effect on the estimation procedure or the results (barring changing the sign of the coefficients on the interaction term and the main effect of facility existence).

facility in the community, and excluding only its interaction with days of rainfall, we control for the long-term, baseline effects of access to various resources, as mentioned above. However, since rainfall, through the interaction instrument, acts as a randomized amplifier of the costs of access to formal-sector care, rainfall could amplify the costs of access to these other resources as well. If this were true, the instrument would not be excludable. To address this problem, borrowing the strategy used in Adhvaryu and Nyshadham (2010b), we control for the existence and distance to a variety of important resources, as well as the interactions of these variables with days of rainfall.[13] Controlling for the main effects of this rich set of variables and its interaction with rainfall ensures that the variation induced by the instrument is specific to the costs of formal-sector care.

4.2.2 Selection into sickness

One desirable feature of the instrument for healthcare choice must be that it does not predict selection into sickness, but rather only the choice of care conditional on acute sickness. To check that this is indeed the case, we regress a dummy for having at least one sick member and one non-sick member in the household of at least 7 years of age on the interaction instrument, the main effects, and the full set of controls. The results, reported in column 1 of Table A.1, verify that the instrument does not predict selection into acute sickness: the coefficient on the interaction instrument is a precisely estimated zero. In columns 2-4 of Table A.1, we report results from similar regressions which check that the instrument does not predict selection into the other samples used in our analysis: households with one sick member and one non-sick male, households with one sick member and one non-sick female, and households with no sick members.

4.2.3 Instrument does not shift labor supply for non-sick households

We posit that the interaction instrument shifts the costs of access to formal-sector care, and thus generates exogenous shifts in the healthcare choices–and ultimately the health and labor outcomes–of sick individuals. If this is the dominant mechanism through which our instrument works, we should not observe that this variable shifts labor allocations for households with *no sick members*. To test this hypothesis, we regress per-capita labor outcomes (hours of non-sick members aggregated to the household level, divided by number of non-sick household members) on the instrument and the full set of controls using the sample of households which had no sick members. The results, reported in Table A.3, verify that the instrument does not predict fluctuations in labor hours for all categories of labor included in our analysis; in each case, the

[13]For example, we include existence of a daily market, motorable road, public transport, and secondary school; for a full listing of the variables included, please refer to the note at the bottom of Table II.

coefficient is quite small and insignificantly different from zero. This falsification provides further evidence that the instrument affects labor outcomes purely through its effect on healthcare choice, and therefore, evidence of the validity of the instrument's exclusion from second stage regressions.

4.2.4 Nonlinear effects of endogenous distance

Finally, we allow for the possibility that distance enters the first and second stages nonlinearly. We do this to further preclude the possibility that the interaction instrument is only capturing a nonlinear effect of distance (or extreme remoteness), rather than the interaction of distance with a randomized, transitory source of variation. To account for this concern, we include quintiles of the distribution of distance to the nearest health facility, hospital and dispensary in all regressions.

5 Results

5.1 First Stage Results

Results from the first stage regressions are presented in Table II. In the first stage specification in column 1, we regress the proportion of sick individuals in the household who visited a healthcare facility (normalized by its standard deviation) on the proposed instrument of the interaction of days of rainfall in month of survey and a dummy for the lack of a formal-sector healthcare facility in the individual's community. The results in column 1 of Table II show a significant reduction in the proportion of sick individuals choosing formal-sector care when the interaction instrument increases. The F-stat on the instrument coefficient is nearly 16 ($p = 0.000135$).

As a robustness check to a different set of controls, we run the same specification as reported in column 1 excluding, first, all demographic controls and then interactions of days of rainfall and resource existence dummies as well (see section 3 for details). The results, reported in columns 2 and 3 of Table II, respectively, are qualitatively similar to the original specification, though the coefficient on the instrument and the F-stat are reduced in column 3.

In column 4 of Table II, we report the results of a specification with the full set of controls but excluding the interaction instrument. Here, as expected, we see a strongly negative correlation between choosing formal-sector care and the non-existence of a health facility in the household's village. The coefficient on days of rainfall in the month of survey is small and insignificant. This result is also in line with our expectations, as the composite effect of rainfall on healthcare choice is conceptually ambiguous: as discussed in section 4, rainfall affects not only the cost of travel to a facility but also many other economic and health-related outcomes for households in agricultural societies.

5.2 Health Outcomes

Column 1 of Table III presents results from the second stage IV regression of the proportion of household sick who were still ill at the time of survey on the normalized proportion of household sick who visited formal-sector care. The results show a large and significant reduction in the proportion of individuals still ill when these individuals are driven exogenously to formal-sector care.

The magnitude of these results corresponds to the results in Adhvaryu and Nyshadham (2010b), which applies a similar analysis at an individual level to the same data, and in Adhvaryu and Nyshadham (2010a), which applies a similar analysis to nationally representative data on children under five in Tanzania. Note that the marked attenuation in the OLS estimates reported in column 2 of Table III is also consistent with estimates from previous studies and corresponds to bias due to self-selection into formal-sector care on the basis of severity.

5.3 Intra-Household Labor Responses

Now that we have verified the power of the interaction instrument to predict the use of formal-sector care and the effects of formal-sector care on health outcomes, we next investigate the effects of formal healthcare on the labor supply of sick and non-sick members of the household. We noted in the summary statistics that both household sick and non-sick members (in households with at least one of each) seem to have the same allocations of labor across farm and non-farm activities. In order to identify the causal effect of formal-sector acute care on the labor supply of household members, we run the same IV specification reported in column 1 of Table III with per capita labor supplies as outcomes. In Table IV, we present results on total labor supply and on allocations of total labor to farm and non-farm activities for sick individuals. Each outcome is calculated by summing across sick members of the household and dividing by the number of sick members.

The results in Table IV show that when sick household members are exogenously driven to formal-sector care, they reallocate their time away from non-farm labor and back towards farm labor. When the proportion of sick household members who visited formal-sector care is increased by a standard deviation, non-farm labor of each of the sick household members is decreased by more than 10 hours on average and farm labor is increased by nearly 9 hours on average during the week prior to survey. Both effects are significant at the 5 percent level.

In Table V, we report the same regressions conducted on household non-sick labor supplies. The results show the same pattern among non-sick members of the household as was reported in Table IV among sick household members. That is, when sick members of the household are driven exogenously to formal-sector care, the non-sick members of the household also draw down their non-farm labor and increase their farm labor. The estimates show that when the proportion of sick members who visited formal-sector care is increased by one standard deviation, each non-sick member of the household decreases their non-farm labor by an average of more than 9 hours and increases their farm labor by roughly 4 hours on average. The effect on the non-farm labor of non-sick members is significant at the 5 percent level, while the effect on farm labor is not significant at conventional levels.

Table VI shows results from the same regressions for labor supplies of all members of the households. The dependent variables in the regressions reported in Table VI are calculated by summing across all productive members of the household, both sick and non-sick, and dividing by the number of productive members. The pattern of results is as expected given the results on the subsamples of sick and non-sick household members: non-farm labor decreases and farm labor increases as a result of an increase in the proportion of sick household members visiting formal health facilities.

Exploring further these effects on farm and non-farm labor, in Tables VII-IX, we break down the effects of formal sector care on labor supplies into effects on subsets of farm and non-farm activities. We show employment hours, hours spent in the field and herding, hours spent processing farm and animal products as subsets of farm labor; and self-employment and home chores as subsets of non-farm labor.

In Table VII, we see that the positive effects of formal sector care on the farm labor hours of sick household members are concentrated in hours spent in the field and herding livestock. These results correspond to the idea that the productivity of sick household members is most affected in activities which require much physical effort, and that participation in these high effort activities is restored when sick members receive high quality care. We also find that negative effects on non-farm labor hours of sick household members are concentrated in hours spent in self-employment. That is, it would appear that when household members fall acutely ill and are made consequently less productive on the farm, they substitute away from farm activities and towards self-enterprise activities which are more able to be completed at home.

In Table VIII, we find similar patterns of results on subsets of farm and non-farm labor hours amongst non-sick members of the household. In particular, effects on non-farm labor hours are concentrated on self-employment hours. Effects on farm labor hours are split between employment hours and hours spent in the field and herding livestock. The largest effects seem to be on employment hours (which are in large part made up of working on neighbors' farms, fishing, and wage labor for educational and health institutions); however, these results lack precision and should be interrupted with caution. Table IX shows results from the same regressions on the whole household. The pattern of results is as expected given the results on sick and non-sick subsamples reported in Tables VII and VIII.

5.4 Labor Complementarities

In section 2, it was demonstrated how estimates of the labor adjustments of sick and non-sick household members could be used to test for the presence of complementarities in farm and non-farm labor. Using the estimates described above, we return to equation 10, and examine the case in which $\frac{\partial l_1^f}{\partial p^Q}, \frac{\partial l_2^f}{\partial p^Q} < 0$ (decrease in farm labor) and $\frac{\partial t_1}{\partial p^Q}, \frac{\partial t_2}{\partial p^Q} > 0$ (increase in non-farm labor):

$$p^n \left(\frac{\partial^2 n}{\partial t_2 \partial t_1} \underbrace{\frac{\partial \hat{t}_1}{\partial p^Q}}_{>0} + \underbrace{\frac{\partial^2 n}{\partial t_2^2}}_{<0} \underbrace{\frac{\partial \hat{t}_2}{\partial p^Q}}_{>0} \right) = p^f \left(\frac{\partial^2 f}{\partial l_2^f \partial l_1^f} \underbrace{\frac{\partial \hat{l}_1^f}{\partial p^Q}}_{<0} + \underbrace{\frac{\partial^2 f}{\partial {l_2^f}^2}}_{<0} \underbrace{\frac{\partial \hat{l}_2^f}{\partial p^Q}}_{<0} \right) \tag{14}$$

Plugging these signs into equation 10, we obtain the following inequality:

$$\frac{\partial^2 n}{\partial t_2 \partial t_1} + \gamma \frac{\partial^2 f}{\partial l_2^f \partial l_1^f} > 0, \tag{15}$$

where $\gamma \equiv \left(-p^f \frac{\partial \hat{l}_1^f}{\partial p^Q} \right) / \left(p^n \frac{\partial \hat{t}_1}{\partial p^Q} \right)$ is a positive constant. We conclude that $\frac{\partial^2 n}{\partial t_2 \partial t_1}$ and $\frac{\partial^2 f}{\partial l_2 \partial l_1}$ cannot both be negative; that is, production in *at least one sector* must exhibit complementarities in household labor.

Thus our results suggest that at least one, and perhaps all, of the productive activities in which members of the agricultural households in our sample engage must exhibit complementarities among the labor inputs of various members of the household. This is potentially an important result, given the frequency with which previous studies of the agricultural household have assumed that family labor inputs are at least imperfectly substitutable. The pattern of empirical results in this study suggests that the substitutability of family labor inputs in the agricultural household model is not necessarily an appropriate assumption in all settings.

5.5 Farm-specific Complementarities

As discussed, our test is a composite one for complementarities in *at least one sector* of production. Therefore, we have so far provided empirical evidence of the existence of labor complementarities in farm and/or home production. However, though we might hypothesize that certain farm activities likely exhibit labor complementarities, we must provide additional evidence to support such a hypothesis.

In Tables X-XII, we report results from second stage regressions of the proportion of household members participating in certain farm activities on healthcare choice of sick household members. The specifications are identical to those reported in previous tables, however the outcomes are proportions of sick, non-sick, and all household members participating in activities as opposed to per capita hours spent in these activities because data on hours spent in specific farm-related activities was not collected.

In Table X, we find that a one standard deviation increase in the proportion of sick household members visiting formal-sector care induces nearly a 20 percentage point decrease in the percentage of sick household members who participated in crop maintenance (weeding, pruning, fertilizing, etc.). Correspondingly, a one standard deviation increase in formal-sector care use induces roughly a 21 percentage point increase in the percentage of sick household members participating in the harvesting and bringing to market of crops.

These results, once again, correspond to a larger reduction in the productivity of sick household members in high effort activities (such as harvesting and carrying crops to market), as compared to lower effort activities (such as weeding and pruning), as a result of an acute health shock. Consequently, we find evidence of a substitution away from harvesting and toward crop maintenance when ill, and back toward harvesting when recovered.

Of particular interest is the parallel pattern of results for farm activity of non-sick household members reported in Table XI. We find effects on farm activity of non-sick household members in the same direction and of similar magnitude as those on farm activity of sick members. That is, a one standard deviation increase in the proportion of sick household members visiting formal-sector care induces nearly a 19 percentage point reduction in the percentage of non-sick household members participating in crop maintenance and a more than 18 percentage point increase in the percentage of non-sick household members participating in harvesting and marketing activities. Table XII shows a nearly identical pattern amongst the household as a whole, as expected. This is fairly strong evidence of the existence of labor complementarities specifically in farm production. That is, we have evidence that at least one of these farm-related activities exhibits labor complementarities.

6 Alternative Explanations

6.1 Externality to Non-Farm Labor

Previous literature has emphasized hours spent caring for ill household members as a component of intra-household labor reallocations in response to health shocks (Pitt and Rosenzweig 1990). It is possible that an added return to time spent off the farm by non-sick household members (that is, an ability to simultaneously care for sick household members while engaging in non-farm labor), might masquerade as an observed complementarity between sick and non-sick labor without the existence of true complementarities in either production technology. However, it should be noted that the additional evidence presented above in favor of labor complementarities specifically in farm-related activities mitigates this concern.

Nevertheless, we are able to test directly for effects of formal healthcare on care hours of non-sick household members in order to evaluate the validity in our empirical context of this alternative explanation. If an externality to home labor in the presence of health shocks is in fact a primary explanation for the pattern of empirical results discussed above, we should expect to find that an increase in the proportion of sick household members who visited formal-sector care reduces the number of hours spent by non-sick members of the household caring for sick household members.

The results from this regression are reported in column 1 of Table XIII. We find a small and weakly significant *positive* effect of an increase in the proportion of household sick who visited a health facility on care hours of non-sick household members. A one standard deviation increase in the proportion of sick household members visiting formal health facilities generates only a 1 hour *increase* in care hours per non-sick. This likely cannot explain the shift from non-farm to farm labor among non-sick members, given that care hours are likely not spent on the farm. Furthermore, compared to the roughly 10 hour reallocation from non-farm to farm labor among non-sick household members shown in Table V, this 1 hour increase in care hours is quite small.

Columns 3 and 5 report results from these same regressions conducted on male and female subsamples of non-sick household members, respectively. If time spent caring for sick household members is in fact a primary explanation for the labor reallocation pattern observed in the data, we would expect that female care hours might respond more to formal care. We find no significant effects on care hours, even among females who are thought to be more likely to provide care to sick members of the household.

Lastly, we would expect that the care hours explanation would likely be most appropriate when children make up most of the sick members of the household. Columns 2, 4, and 6 of Table XIII report results from regressions of the care hours of all non-sick, male non-sick, and female non-sick members, respectively, on both the proportion of sick members visiting formal care facilities and its interaction with the proportion of sick members in the household that are children. We instrument for the interaction with the interaction of our usual instrument and the proportion of sick members who are children. Again, we find that, even when all the sick members of the household are children, a one standard deviation increase in the proportion of sick members visiting formal health facilities generates a small and weakly significant positive effect on the care hours of all non-sick members, and smaller insignificant effects on the subsamples of non-sick male and females.

6.2 Health Spillovers

Another candidate explanation which might give the appearance of complementarities is the presence health spillovers between acutely ill members and reportedly non-sick members of the household. Several types of spillovers must be considered. First, household members may value each other's health; second, health shocks to one household member may affect another member's health directly through disease contagion; third, individuals seeking treatment for acute health shocks may enable easier access to medicines or information for other (non-acutely ill) members of the household (treatment spillovers). We address these in succession below.

6.2.1 Utility spillovers

As relates to the first concern, our model explicitly allows for utility spillovers of health. Each individual's utility function is allowed to depend (non-separably) on both own health and the health of the other household member. As shown in section 2, our test of complementarities goes through when allowing for utility spillovers of health.

6.2.2 Contagion

The second possibility–that health shocks spill over across household members due to contagion–is one that until now we have explicitly disallowed from the model. To understand what problems contagion-based health spillovers would generate for our test of complementarities, suppose that each household member's health were a function of own health shock and the health shocks of the other household member. Thus for $i \in \{1, 2\}$ we now have

$$h_i = h(\sigma_i Q_i, \sigma_{-i} Q_{-i}, \varepsilon_i, \varepsilon_{-i}). \tag{16}$$

Clearly, in this case, $\frac{\partial h_{-i}}{\partial p^Q}$ is in general non-zero, even when $\sigma_{-i} = 0$; that is, non-sick individuals' health stocks are directly affected by health shocks to other members in the household. Indeed, we may expect that $\frac{\partial h_{-i}}{\partial p^Q} < 0$, since, in the case when contagion matters, increases in the price of acute healthcare will worsen the effects of health shocks for both sick and healthy individuals. Equation 10, from which we derive our test of complementarities, now becomes

$$p^n \left(\frac{\partial^2 n}{\partial t_2 \partial t_1} \frac{\partial t_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2^2} \frac{\partial t_2}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_2} \frac{\partial h_2}{\partial p^Q} \right) = p^f \left(\frac{\partial^2 f}{\partial l_2^f \partial l_1^f} \frac{\partial l_1^f}{\partial p^Q} + \frac{\partial^2 f}{\partial {l_2^f}^2} \frac{\partial l_2^f}{\partial p^Q} + \frac{\partial^2 f}{\partial l_2^f \partial h_2} \frac{\partial h_2}{\partial p^Q} \right) \tag{17}$$

From the equation above, we can see that the validity of our test for complementarities in household labor depends on the signs of the additional terms on either side of equation 17. Maintaining the signs of the estimated labor adjustment terms (as well as the assumptions on the concavity of production with respect to labor), it is easy to see that inequality **??** still holds if

$$\frac{\partial^2 f}{\partial l_2^f \partial h_2} > \frac{\partial^2 n}{\partial t_2 \partial h_2}. \tag{18}$$

That is, even in the presence of contagion effects, our test for complementarities will be valid if complementarities between health and labor are greater for farm vis-a-vis non-farm production.[14] This statement would be consistent with the fact that farm labor requires more physicality (e.g. more physical effort, more calories expended) than non-farm labor. However, if the above inequality *does not* hold, we cannot in general determine the validity of the test; validity will depend in this case on the relative magnitudes of the various terms above.

We cannot determine empirically whether the inequality above actually holds. However, it does seem implausible in our context that health spillovers through contagion can entirely explain the pattern of adjustments we observe. Since we divide the household into individuals who reported being acutely sick and those who did not, the contagion effect would need to be small enough that though non-sick individuals (as we classify them) are affected, they are not affected *enough to report being sick*, but large enough that it drives changes in the labor allocations of the non-sick that are commensurate, both in absolute magnitude and as a percentage of total hours, with the changes observed for sick household members. We find (subjectively of course) the likelihood to be small that the contagion effect achieves this balance perfectly.

6.2.3 Treatment spillovers

The third concern regarding to spillover effects relates to the idea that *treatment* sought by acutely ill members of the household has spillover effects on the health of non-sick members. One might imagine that household members who are chronically ill, but not acutely so, accompany acutely ill members to treatment, or that acutely ill individuals bring back medication or treatment-related information to other members of the household. These examples can be explained by the same extension to the model as shown above.

In this case, we would expect to see that increases in the proportion of sick members of the household visiting formal care generates improvements in the health status of reportedly non-acutely-ill members of the household (either through reduced contagion brought about by improved health outcomes of sick members or through healthcare spillovers from sick members visiting formal care). In columns 1-3 of Table XIV, we report results from second stage IV regressions of the proportion of non-sick members who reported chronic illness on the proportion of sick members who visited formal healthcare in our usual specification. We find no significant effects of the formal healthcare of sick members on chronic fever, weight loss, and rash among non-sick members.

In columns 4-6 of Table XIV, we check the reduced form of the same regressions we reported in columns 1-3, in case the instrument affects non-sick health outcomes directly by other channels than the formal care of sick household members. Again, we find no significant ef-

[14]Of course, the reverse statement holds if health and labor are substitutes in the production processes.

fects. Lastly, in columns 7-9, we check that the instrument has no effect on the chronic illness of members of households with no sick members. A significant coefficient would suggest that the exclusion restriction might be violated. We find precisely estimated zeros across all chronic illnesses.

7 Conclusion

Previous studies of intra-household decision-making in the agricultural household have generally resorted to assumptions on the complementarity or substitutability of family labor. We develop a model of health and intra-household allocations in which both sick and non-sick members allocate their time across farm labor, non-farm labor, and leisure. Our simple test of complementarities relies on the observation that acute sickness, and corresponding treatment choices, generate variation in the productivities of both sick and non-sick individuals in the household. The model predicts that sick and non-sick household members will adjust their labor allocations in parallel fashion only if their labor is complementary in at least one sector of production.

We then use plausibly exogenous variation in the cost of formal-sector health care to show that, in fact, an increase in the proportion of sick members visiting formal health facilities generates a decrease in non-farm labor and an increase in farm labor among both sick and non-sick members. These results provide strong evidence that within family labor is complementary in farm and/or non-farm production. Note, however, that this is an indirect test for labor complementarities. That is, the predictions from the model require only that at least one of the production technologies exhibit complementarities in labor for sick and non-sick labor supplies to adjust in parallel fashion across farm and non-farm activities.

We then provide additional evidence of parallel shifts among sick and non-sick household members away from lower effort farm activities back towards higher effort farm activities when sick household members are made well through formal-sector care. These results suggest that at least some of these farm-specific activities exhibit labor complementarities. We further show evidence that neither an externality to non-farm labor in the form of caring for sick household members nor health spillovers can explain the observed pattern in labor responses to formal healthcare in our context.

Our findings on the complementarity of labor in production activities of the agricultural household are not specific to the effects of health shocks on labor allocations, but rather can hopefully inform the modeling of time and resource allocations within the agricultural household more generally. Our results suggest that we must take care when modeling shocks and/or policy interventions which affect the relative marginal productivities of labor or the opportunity cost of time for members of agricultural households, to account for the various production activities across which each member allocates his time and the ways in which family labor inputs interact in these production technologies.

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A Model Appendix

A.1 When Agricultural Wage Labor Constraints Do Not Bind

In the unconstrained case of the model, in which agricultural wage labor constraints do not bind, we arrive at the same two first order conditions as in equations 6 and 7. We combine these with the first order condition with respect to l^h, hired labor on the farm, which is as follows (using the same notation as in section 2):

$$-\lambda(-w) - \delta = 0. \tag{19}$$

Combining, we get

$$p^f \frac{\partial f}{\partial l_2^f} = w = p^n \frac{\partial n}{\partial t_2}. \tag{20}$$

We begin with the second equality in equation 20: $w = p^n \frac{\partial n}{\partial t_2}$. Differentiating with respect to p^Q, we get:

$$\frac{\partial^2 n}{\partial t_2 \partial t_1}\frac{\partial t_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2^2}\frac{\partial t_2}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_1}\frac{\partial h_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_2}\frac{\partial h_2}{\partial p^Q} = 0. \tag{21}$$

Note that farm production does not play a role in the equation above, meaning that the implications we derive from above will solely be related to non-farm labor. As before, $\frac{\partial^2 n}{\partial t_2 \partial h_1} = 0$, and $\frac{\partial h_2}{\partial p^Q} = 0$ when $\sigma_2 = 0$, and thus

$$\frac{\partial^2 n}{\partial t_2 \partial t_1}\frac{\partial t_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2^2}\frac{\partial t_2}{\partial p^Q} = 0 \tag{22}$$

Plugging in the estimated signs of the labor adjustments and making use of the concavity assumption as before ($\frac{\hat{\partial t_1}}{\partial p^Q} > 0$, $\frac{\hat{\partial t_1}}{\partial p^Q} > 0$, $\frac{\partial^2 n}{\partial t_2^2} < 0$), we find that $\frac{\partial^2 n}{\partial t_2 \partial t_1} > 0$, i.e. that household labor in non-farm production must exhibit complementarities.

Using the first equality in equation 20 ($p^f \frac{\partial f}{\partial l_2^f} = w$), and plugging in the estimated signs of the farm labor adjustments as well as the concavity assumption on farm labor in production, we get a similar implication for farm labor: $\frac{\partial^2 f}{\partial l_2^f \partial l_1^f} > 0$, i.e. that household labor in farm production must exhibit complementarities as well. Thus a stronger conclusion than the one in the constrained case holds when agricultural wage labor is not constrained: here, labor in *both* sectors must exhibit complementarities.

A.2 Land as an Input Into Farm Production

Here we consider the case in which farm production takes land as an input. Let the farm production function be $f(l_1^f, l_2^f, l^h, h_1, h_2; A)$, where A is the total plot area. Differentiating equation 8 with respect to p^Q as before, we obtain the same equality as in equation 9, but with an added term on the right-hand side, corresponding to the addition of A to the production function. Equation 9 therefore becomes

$$\begin{aligned} & p^n\left(\frac{\partial^2 n}{\partial t_2 \partial t_1}\frac{\partial t_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2^2}\frac{\partial t_2}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_1}\frac{\partial h_1}{\partial p^Q} + \frac{\partial^2 n}{\partial t_2 \partial h_2}\frac{\partial h_2}{\partial p^Q}\right) \\ = \quad & p^f\left(\frac{\partial^2 f}{\partial l_2^f \partial l_1^f}\frac{\partial l_1^f}{\partial p^Q} + \frac{\partial^2 f}{\partial {l_2^f}^2}\frac{\partial l_2^f}{\partial p^Q} + \frac{\partial^2 f}{\partial l_2^f \partial h_1}\frac{\partial h_1}{\partial p^Q} + \frac{\partial^2 f}{\partial l_2^f \partial h_2}\frac{\partial h_2}{\partial p^Q} + \frac{\partial^2 f}{\partial l_2^f \partial A}\frac{\partial A}{\partial p^Q}\right). \end{aligned} \tag{23}$$

When $\frac{\partial A}{\partial p^Q}$ is 0, the above equation is the same as equation 9. In fact, we find that in our context land is most often inherited and less frequently bought and sold on spot markets. That is, a household would likely find it very difficult to make short-term changes to their stock of land, and we do not see such high-frequency variation in the data. Specifically, amongst our main sample of household with at least one sick member and one non-sick member, roughly 48 percent of land owned by the household was inherited, while only 23 percent was bought at some point. Most importantly, only .4 percent of land currently owned was bought in the 6 months prior to survey.

B Additional Results

B.1 Sample Selection

In Table A.1, we report results from sample selection regressions of dummies for inclusion in the various samples used in the analysis on the interaction instrument, the main effects of the facility non-existence dummy and days of rainfall in the month of survey, and the full set of controls used in the preferred first and second stage regressions. Column 1 reports results from the specification checking for selection into the sample of households with one sick and one non-sick member above the age of 7 on the basis of the instrument. Columns 2 and 3 report results from checks for selection into the samples of households with one sick member and one non-sick member who is male and female, respectively. Column 4 reports results from the check for selection into the sample of households with no sick members. Across all checks, we find no evidence that the instrument predicts selection into the sample.

B.2 Collinearity Between Instrument and Resource Access Controls

To the degree that general remoteness strongly predicts both the presence of all resources in the community, including health facilities, we might be worried about collinearity between the health facility non-existence dummy and the dummies for the presence of other resources in the community such as daily market, motorable road, post office or telephone, etc. Table A.2 reports results from the regression of the No Facility dummy on the resource dummies included in set of controls of the preferred specifications from the analysis. The results show significant correlations, but sufficient residual variation in the No Facility dummy. The R-squared is only .324, indicating that nearly two-thirds of the variation in the No Facility dummy is orthogonal to the various resource access controls. Therefore, collinearity is not an issue.

B.3 Falsification on Non-Sick Households

A crucial assumption for the validity of the empirical strategy used in the analysis is the excludability of the interaction instrument from second stage regressions. In order for this assumption to hold, we must believe that the instrument affects second stage outcomes only through its effects on formal healthcare use.

As a falsification exercise to check the appropriateness of this assumption, we run our usual labor supply regressions in reduced form on households with no sick members. If in fact the instrument has no effect on labor supply except through its effects on the formal care use of sick members of the households, we should expect to find no effects of the instrument on labor outcomes of members of households with no sick members. In Table A.3, results from these reduced form regressions confirm that the instrument does not predict total labor supply nor labor allocations across productive activities of members of entirely non-sick households.

B.4 Heterogeneity

B.4.1 Sick and Non-Sick Labor Responses By Gender and Age

In Tables A.4 and A.5, we investigate heterogeneity in the sick and non-sick labor responses to formal care use across gender and age. In Table A.4, we regress the usual per capita labor supply variables for sick and non-sick members on both the proportion of sick members visiting formal care and its interaction with the proportion of sick members who are male in the usual specification. We again instrument for the interaction with the product of our usual interaction instrument and the proportion of sick members who are male.

The results in the top panel of Table A.4 show that when all the sick members in the household are male, a one standard deviation increase in the proportion of sick members visiting formal care generates the same 9 hours increase in farm labor seen among all non-sick members in Table V but a significantly larger 15 hour decrease in non-farm labor. This larger decrease in non-farm labor among sick males (as compared to females) is made up entirely of home chores, and generates a statistically significant 7 hour decrease in total labor hours. In contrast, when all the sick members of the household are female, while a one standard deviation increase in the proportion visiting formal care still generates a 9 hour increase in farm labor it causes a large (more than 9 hour) decrease in self-employment hours and a small, insignificant *increase* of 4 hours in home chores. The result is an insignificant reduction of 5 hours in non-farm labor among sick females.

In the bottom panel of Table A.4, we report the results for the same regressions as in the top panel, but with non-sick labor hours as outcomes. The results show that when all the sick members of the household are male, non-sick members of the household reallocate their labor much less than in response to sick females. A one standard deviation increase in the proportion of sick visiting formal healthcare, when all sick members are male, generates a small 1 hour decrease in total non-sick labor hours, a small insignificant 3 hour increase in farm labor, and a 4 hour decrease in non-farm labor. This small decrease in non-farm labor in response to the use of formal-healthcare amongst sick males is made up of a 6 hour decrease in self-employment and a 2 hour increase in home chores. Again, we find a contrasting response in non-sick labor hours to formal care among sick females. Total labor hours of non-sick members decrease by an average of 9 hours when the proportion visiting healthcare increases by one standard deviation and all sick members are female. Farm hours increase insignificantly by 4 hours, and non-farm hours decrease by 14 hours. The decrease in non-farm hours is significant at the 1 percent level and is made up of a 6 hour decrease in self-employment and an 8 hour decrease in home chores.

In summary, it seems that the labor hours of sick males respond more to formal healthcare than that of sick females, with comparable increases in farm labor but larger decreases in home chores. On the other hand, non-sick labor supply responds more to formal healthcare use among sick females, with larger decreases in home chores as well.

Table A.5 reports results from regressions exploring heterogeneity across age. The specifications are identical to those reported in Table A.4, but we interact the proportion visiting formal care with the proportion of sick members who are children instead of the proportion of sick who are male. The results in the top panel show that when all sick household members are children a one standard deviation increase in the proportion visiting formal care causes only a 3 hour increase in farm labor of sick members and a decrease of more than 8 hours in non-farm labor, made up largely of a decrease in self-employment. On the other hand, when all sick household members are adults, an increase in the proportion visiting formal care brings about a 10 hour increase in farm labor and a 9 hour decrease in non-farm labor (mostly, self-employment).

Effects on household non-sick labor, reported in the bottom panel of Table A.5, seem to be less heterogeneous across the age of household members who fall ill. That is, non-sick non-farm labor decreases significantly by nearly 10 hours (mostly, in self-employment) with a one standard deviation increase in the proportion of sick members visiting formal care irrespective of whether the sick members of the household are adults or children, and farm labor increases insignificantly.

Overall, it seems sick children do not adjust their farm hours much following formal healthcare but significantly reduce their non-farm labor, particularly their hours spent in self-employment; while adults also significantly reduce their self-employment hours, but significantly increase their farm labor in exchange. Non-sick labor supply in the household responds the same to sickness and healthcare among children and adults: self-employment hours decrease significantly, farm labor increases insignificantly.

B.4.2 Degree of Complementarity Across Gender and Age

In Tables A.6 and A.7, we explore the degree of complementarity across gender and age. To do so, we run regressions identical to those reported in Tables A.4 and A.5, but with gender-specific per capita labor hours as outcomes. In the top panel of Table A.6, the results suggest that male non-sick labor hours respond more to the proportion of household sick visiting formal care when all sick members are female than when all sick members are male. That is, non-sick male non-farm labor decreases significantly by nearly 12 hours and farm hours increase weakly by 5 hours when all sick members are female, but non-farm labor decreases weakly by only 6 hours and farm labor is virtually unaffected when all sick members are male (differences are significant for farm labor and home chores at the 10 percent level). In the bottom panel of Table A.6, results suggest that female non-sick labor hours also respond more to formal healthcare use by sick household members when those members are female as compared to when sick household members are all male.

The results reported in the top panel of Table A.7 show little evidence of heterogeneity across the age of sick household members in labor supply responses by non-sick children. Non-sick child non-farm labor decreases by roughly 9 hours (self-employment decreases by 2 hours and home time decreases by nearly 7 hours) with a one standard deviation increase in proportion of household sick visiting a formal health facility, regardless of the proportion of sick who are children, and farm labor appears unaffected. Similarly, in the bottom panel we find no significant differences in non-sick adult labor supply responses across age of household sick; however, the point estimates suggest that farm labor increases and non-farm labor reductions in non-sick adult labor might be slightly larger when all sick household members are children.

Overall, the results suggest that female labor is complementary to other female labor and to male labor, but that male labor is less complementary to other male labor. Also, it seems that child labor is complementary to other child labor, and perhaps that adult and child labor are slightly stronger complements.

C Construction of variables

The following list describes the construction of variables used in analysis:

- $sick = 1$ if the household reported having at least one member who was sick with an illness that began 14 days or less prior to the date of survey, $sick = 0$ otherwise.

- $h = 1$ if sick individual visited hospital, health center or dispensary (government, NGO or private); $h = 0$ otherwise; then these binaries are averaged to create a proportion of the sick members of the household who visited a formal-sector care facility

- $raindays$ equals the number of days of rainfall at the rainfall station closest to the household's sample cluster, in the month and year that the household was surveyed

- $histmean$ of rainfall is the number of days of rainfall in the month of survey averaged over all years in which rainfall data are recorded for that cluster in the particular month

- $histsd$ is calculated as the standard deviation of the historical distribution of days of rainfall in the month of survey, across all years in which rainfall data are recorded for that cluster in the particular month

- $histmeansq$ and $histsdsq$ are smooth polynomials to the second degree in historical mean days of rainfall and historical standard deviation of days of rainfall, respectively

- $raindayslast$ equals the number of days of rainfall at the rainfall station closest to the household's sample cluster, in the month *before* that in which the household was surveyed of the same year

- $decraindays$ and $decrainfall$ are categorical variables reporting which decile of the rain days and rainfall distributions, respectively, the rain in the survey month falls; fixed effects for each decile are included in all specifications

- $noexist$ is a binary variable which takes value $noexist = 1$ if neither hospital, health center, nor dispensary of (government, NGO or private) exists in the community, and $noexist = 0$ otherwise (Note: for waves in which these data were missing, the values were filled first using the minimum from the waves in which the data were not missing for that cluster, and second using the minimum of non-missing values from clusters matched to the same rain station in the same wave; that is, if a facility of these types ever existed in that cluster or in very proximate clusters before or after the year in which the data are missing, we assumed it existed during this wave as well)

- For the following facilities/attributes (x), we calculate distances as $dist(x) = 0$ if the facility/attribute exists in the same village as the household; $dist(x)$ equals the distance to the nearest such facility/attribute outside the household's village if one does not exist in the village (Note: for waves in which these data were missing, the values were filled first using the mean from the waves in which the data were not missing, and second using non-missing data from clusters matched to the same rain station in the same wave)
  - Hospital
  - Health center
  - Dispensary
  - Daily market
  - Periodic market
  - Motorable road
  - Public transportation
  - Secondary school
  - Bank
  - Post office/telephone booth
- Categorical variables for the quintiles of the distributions of the above defined distances to hospital, health center, and dispensary were created and included in all specifications
- $dist$, $distsq$, and $distcub$ are smooth polynomials up to the third degree in the minimum distance to either a hospital, health center, or dispensary
- $hhsize$, $hhsizesq$, and $hhsizecub$ are smooth polynomials up to the third degree in the number of members of the household
- $age1$, $age2$, and $age3$ are smooth polynomials up to the third degree in the mean age of the respondents in the household
- $assets$ is a categorical variable measuring the value of all assets of the household; fixed effects for these categorical values are included in all specifications
- $adult$, kid, $male$, $female$, man, $woman$, boy, and $girl$ reflect the number of members of the household of each gender, age, and gender/age combination; where $adult$ is defined $age > 15$ and $kid \ = adult$
- $hhadultsick$, $hhkidsick$, $hhmalesick$, $hhfemalesick$, $hhmansick$, $hhwomansick$, $hhboysick$, and $hhgirlsick$ reflect the number of members of the household of each gender, age, and

gender/age combination who qualified as $sick == 1$, by the above definition, at the time of survey

- $hhadultnosick$, $hhkidnosick$, $hhmalenosick$, $hhfemalenosick$, $hhmannosick$, $hhwomannosick$, $hhboynosick$, and $hhgirlnosick$ reflect the number of members of the household of each gender, age, and gender/age combination who qualified as $sick == 0$, by the above definition, at the time of survey

- $hhsick$, $hhsicksq$, and $hhsickcub$ are smooth polynomials up to the third degree in the number of members of the household who qualified as $sick == 1$

- $educ$ is the maximum value within the household of a categorical variable for how much education the respondents have completed; fixed effects for each of these values are included in all specifications

Table I: Summary Statistics

Summary Statistics of Variables of Interest in Sick and Non-Sick Samples

Household-Year Observations:		
with at least one sick and one non-sick member	2146	
with no sick members	1049	
Proportion of Sick Household Members Still Ill	0.416	0.430
Proportion of Sick Household Members Visited Formal Healthcare (normalized)	0.615	0.999

	Sick Members		Non-Sick Members		No Sick Members	
	(households with at least one sick and one non-sick member)				*(households with no sick members)*	
	Mean	SD	Mean	SD	Mean	SD
Time use per member of household (hours in week before survey)						
Total Labor	29.567	20.922	29.037	18.361	34.246	18.611
Farm	13.597	12.663	13.465	10.956	15.991	12.014
Employment	2.481	8.259	2.637	7.538	4.073	10.004
Field and Herd	10.925	10.222	10.670	9.165	11.727	8.787
Processing	0.191	1.113	0.159	0.797	0.191	0.960
Non-farm	15.970	16.033	15.572	14.780	18.255	14.203
Self-employment	3.114	12.385	3.376	12.376	3.504	11.863
Home	12.857	10.535	12.196	8.751	14.751	8.279
Care	0.803	3.291	0.866	2.903	0.855	3.958

	Mean	SD	Mean	SD
Costs of Healthcare				
# of days of rain in month of survey	7.998	5.298	8.249	5.125
No health facility in community	0.627	0.484	0.651	0.477
Resources in Community				
Daily market	0.605	0.489	0.564	0.496
Periodic market	0.339	0.474	0.369	0.483
Motorable road	0.956	0.205	0.972	0.164
Public transport	0.275	0.447	0.326	0.469
Secondary school	0.119	0.324	0.117	0.322
Bank	0.112	0.315	0.112	0.315
Post office/telephone booth	0.130	0.337	0.143	0.350
Demographic Characteristics				
Age	28.022	9.202	33.442	14.858
Household size	5.134	2.334	3.561	1.996
No. of Female Members	2.702	1.623	1.867	1.304
Household assets (Deciles)	5.141	2.833	4.427	2.833

Notes: Sample used in analysis is made up of households with at least one member with illness that began in the two weeks prior to survey.

Table II: First Stage and Robustness Checks

Interaction of Rain and Distance to Health Facility on Proportion Visiting Formal Healthcare

	First Stage			Main Effects
	All Controls	Interactions of Resource Dummies and Days of Rainfall	No Controls	No Rain Interactions
Days of Rainfall x No Facility	**-0.0579*** (0.0147)**	**-0.0566*** (0.0139)**	**-0.0288*** (0.00965)**	
No Facility	-0.0872 (0.271)	-0.137 (0.281)	-0.0557 (0.280)	-0.507*** (0.0806)
Days of Rainfall	0.0960* (0.0532)	0.0846 (0.0513)	0.0524 (0.0501)	0.00294 (0.0115)
Observations	1932	1995	1995	1932
Mean of Dependent Variable	0.615	0.615	0.615	0.615
F-test: Rain x Distance=0	**15.56**	**16.50**	**8.903**	
Prob>F	**0.000135**	**8.73e-05**	**0.00345**	

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Standard errors are clustered at the sampling cluster by year level. All specifications inlcude main effects of days of rainfall and "No Facility," assets, highest eduction in household, district, rain station, and year of survey group effects; as well as polynomials up to a third degree in average age in household, third degree polynomials of no. of household sick and household size, and distance to nearest health facility if one does not exist in community. Specifications also include decilies of days of rainfall and levels of rainfall as well as for how long ago the illness started; and quintiles for distance to nearest hospital, healthcare facility, and dispensary. Dummies for the existence of a daily market, periodic market, motorable road, public transport, secondary school, bank and post office/telephone are included; along with interactions of these dummies with days of rainfall. Other controls include historical means and standard deviations of both rainfall and quadratic terms of these; days of rainfall in month prior to survey and its interaction with "No Facility;" and gender/age composition of the household. All samples in the analyses, unless otherwise stated, are restricted to households with at least one member with an illness that began in the two weeks prior to survey and at least one member that did not report such an illness.

Table III: Health Outcomes

Effects of Healthcare Choice on Proportion of Household Still Ill

	Second Stage IV	OLS
Formal Healthcare	**-0.200****	**-0.0330*****
	(0.0992)	**(0.0122)**
Observations	1932	1932
Mean of Dependent Variable	0.416	0.416

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table IV: Labor Supply of Houshold Sick

Second Stage IV: Effects of Healthcare Choice on Labor Per Capita of Household Sick

(Households with at least one sick member and one non-sick member)

	Total Labor Hours	Farm Labor	Non-Farm Labor
Formal Healthcare	**-1.726**	**8.675****	**-10.40****
	(5.095)	**(4.240)**	**(4.215)**
Observations	1932	1932	1932
Mean of Dependent Variable	29.57	13.60	15.97

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table V: Labor Supply of Houshold Non-Sick

Second Stage IV: Effects of Healthcare Choice on Labor Per Capita of Household Non-Sick

(Households with at least one sick member and one non-sick member)

	Total Labor Hours	Farm Labor	Non-Farm Labor
Formal Healthcare	**-5.286**	**4.082**	**-9.368****
	(3.883)	**(2.938)**	**(4.093)**
Observations	1932	1932	1932
Mean of Dependent Variable	29.04	13.47	15.57

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table VI: Household Labor Supply

Second Stage IV: Effects of Healthcare Choice on Household Labor Supply Per Capita

(Households with at least one sick member and one non-sick member)

	Total Labor Hours	Farm Labor	Non-Farm Labor
Formal Healthcare	**-2.747**	**4.962***	**-7.709****
	(3.261)	**(2.641)**	**(3.008)**
Observations	1932	1932	1932
Mean of Dependent Variable	29.42	13.53	15.89

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table VII: Components of Labor Supply of Houshold Sick

Second Stage IV: Effects of Healthcare Choice on Labor Per Capita of Household Sick

(Households with at least one sick member and one non-sick member)

	Farm Labor			Non-Farm Labor	
	Employment	Field and Herd	Processing	Self-Employment	Home
Formal Healthcare	**2.802**	**5.712****	**0.161**	**-8.211****	**-2.190**
	(3.100)	**(2.745)**	**(0.231)**	**(3.616)**	**(2.733)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	2.481	10.92	0.191	3.114	12.86

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table VIII: Components of Labor Supply of Houshold Non-Sick

Second Stage IV: Effects of Healthcare Choice on Labor Per Capita of Household Non-Sick

(Households with at least one sick member and one non-sick member)

	Farm Labor			Non-Farm Labor	
	Employment	Field and Herd	Processing	Self-Employment	Home
Formal Healthcare	**2.502**	**1.647**	**-0.0676**	**-6.479***	**-2.889**
	(1.666)	**(2.727)**	**(0.176)**	**(3.642)**	**(1.969)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	2.637	10.67	0.159	3.376	12.20

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table IX: Components of Household Labor Supply

Second Stage IV: Effects of Healthcare Choice on Household Labor Supply Per Capita

(Households with at least one sick member and one non-sick member)

	Farm Labor			Non-Farm Labor	
	Employment	Field and Herd	Processing	Self-Employment	Home
Formal Healthcare	**2.021**	**2.906**	**0.0352**	**-6.615****	**-1.094**
	(1.276)	**(2.470)**	**(0.160)**	**(2.575)**	**(1.318)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	2.577	10.78	0.170	3.354	12.54

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table X: Farm Activity of Household Sick

Second Stage IV: Effects of Healthcare Choice on Proportion of Household Sick in Farm Activities

(Households with at least one sick member and one non-sick member)

	Crop Maintenance (Weeding, Pruning, etc.)	Land Preperation & Planting	Harvesting & Marketing
Formal Healthcare	**-0.216**	**0.183**	**0.224***
	(0.135)	**(0.122)**	**(0.135)**
Observations	1932	1932	1932
Mean of Dependent Variable	0.535	0.278	0.169

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table XI: Farm Activity of Household Non-Sick

Second Stage IV: Effects of Healthcare Choice on Proportion of Household Non-Sick in Farm Activities

(Households with at least one sick member and one non-sick member)

	Crop Maintenance (Weeding, Pruning, etc.)	Land Preperation & Planting	Harvesting & Marketing
Formal Healthcare	**-0.189***	**0.0215**	**0.184**
	(0.113)	**(0.0904)**	**(0.112)**
Observations	1932	1932	1932
Mean of Dependent Variable	0.502	0.256	0.162

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table XII: Household Farm Activity

Second Stage IV: Effects of Healthcare Choice on Proportion of Household in Farm Activities

(Households with at least one sick member and one non-sick member)

	Crop Maintenance (Weeding, Pruning, etc.)	Land Preperation & Planting	Harvesting & Marketing
Formal Healthcare	**-0.198***	**0.123**	**0.209***
	(0.107)	**(0.0953)**	**(0.115)**
Observations	1932	1932	1932
Mean of Dependent Variable	0.514	0.265	0.164

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table XIII: Care Hours of Household Non-Sick Males and Females

Second Stage IV: Effects of Healthcare Choice on Hours Per Capita Spent Caring for Ill

	Total		Male		Female	
	(at least one sick and one non-sick member)		*(at least one sick member and one non-sick male)*		*(at least one sick member and one non-sick female)*	
Child x Formal Healthcare		**-0.0880**		**-0.304**		**0.716**
		(0.791)		**(0.565)**		**(1.261)**
Formal Healthcare	**1.035***	**1.100***	**0.772**	**0.887**	**0.528**	**0.394**
	(0.564)	**(0.611)**	**(0.558)**	**(0.644)**	**(0.708)**	**(0.693)**
Observations	1932	1932	1599	1599	1598	1598
Mean of Dependent Variable	0.866	0.866	0.568	0.568	1.144	1.144

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments. Samples are restricted as noted.

Table XIV: Health Spillovers

Effects of Healthcare Choice on Proportion of Non-Sick Members Reporting Chronic Illness

	Second Stage IV			Reduced Form			Reduced Form Falsification		
	Chronic Fever	Chronic Weight Loss	Chronic Rash	Chronic Fever	Chronic Weight Loss	Chronic Rash	Chronic Fever	Chronic Weight Loss	Chronic Rash
	(Households with at least one sick member and one non-sick member)						*(Households with no sick members)*		
Formal Healthcare	**0.0522**	**-0.101**	**0.0464**						
	(0.0346)	**(0.0688)**	**(0.0493)**						
Days of Rainfall x No Facility				**-0.00302**	**0.00584**	**-0.00269**	**-0.00424**	**0.00265**	**-0.00518**
				(0.00195)	**(0.00376)**	**(0.00263)**	**(0.00285)**	**(0.00388)**	**(0.00408)**
Observations	1932	1932	1932	1932	1932	1932	906	906	906
Mean of Dependent Variable	0.208	0.107	0.0478	0.0435	0.116	0.0515	0.0435	0.116	0.0515

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table A.1: Selection Checks

Relationship Between Instrument and Selection into Various Samples

	1 Sick, 1 Non-Sick Productive Member	1 Sick, 1 Non-Sick Productive Male	1 Sick, 1 Non-Sick Productive Female	No Sick
Days of Rainfall x No Facility	-0.00238	-0.00349	-0.00174	0.00341
	(0.00491)	(0.00488)	(0.00497)	(0.00504)
No Facility	0.169	0.0818	0.124	-0.111
	(0.137)	(0.117)	(0.134)	(0.135)
Days of Rainfall	-0.0163	-0.0352**	-0.0283	0.0168
	(0.0202)	(0.0168)	(0.0192)	(0.0227)
Observations	2960	2960	2960	2960
Mean of Dependent Variable	0.641	0.529	0.529	0.311
F-test: Instrument = 0	0.236	0.511	0.123	0.458
Prob>F	0.628	0.476	0.726	0.500

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Dependent variables are binaries for whether the household is included in each sample. See Table II for other notes.

Table A.2: Partial Correlations of Access Variables

Regression of No Health Facility in Community on Presence of Other Resources

	No Facility
Daily Market	-0.126***
	(0.0147)
Periodic Market	0.0753***
	(0.0153)
Motorable Road	-0.196***
	(0.0365)
Public Transportation	-0.0418**
	(0.0188)
Secondary School	-0.179***
	(0.0229)
Bank	-0.0534**
	(0.0254)
Post or Public Telephone	-0.618***
	(0.0241)
Observations	3383
R-Squared	0.324

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table A.3: Labor Supply of Households with No Sick Members

Reduced Form Effects of Intrument on Labor of Households with No Sick Members

	Total Labor Hours	Farm Labor	Non-Farm Labor		
			Total	Self-Employment Total	Home Total
Days of Rainfall x No Facility	**-0.0624**	**-0.00712**	**-0.0552**	**-0.176**	**0.121**
	(0.394)	**(0.265)**	**(0.314)**	**(0.298)**	**(0.124)**
Observations	906	906	906	906	906
Mean of Dependent Variable	34.25	15.99	18.26	3.504	14.75

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments. Sample is restricted to households with no

Table A.4: Heterogeneous Labor Supply Responses to Sickness Across Genders

Second Stage IV: Effects of Healthcare Choice Amongst Sick Males and Females on Labor Per Capita of Household

	Total Labor Hours	Farm Labor	Non-Farm Labor		
			Total	Self-Employment Total	Home Total
Effects on Labor Supply of Sick Household Members					
Male x Formal Healthcare	**-10.53****	**-0.747**	**-9.785*****	**2.576**	**-12.36*****
	(5.277)	**(3.784)**	**(3.751)**	**(2.687)**	**(2.814)**
Formal Healthcare	**3.488**	**8.834****	**-5.346**	**-9.377****	**4.031**
	(6.391)	**(4.225)**	**(4.773)**	**(3.813)**	**(3.025)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	29.57	13.60	15.97	3.114	12.86
Effects on Labor Supply of Non-Sick Household Members					
Male x Formal Healthcare	**8.052****	**-1.774**	**9.826*****	**-0.511**	**10.34*****
	(3.474)	**(2.375)**	**(3.034)**	**(2.120)**	**(2.189)**
Formal Healthcare	**-9.186****	**4.894**	**-14.08*****	**-6.081***	**-7.999*****
	(3.955)	**(3.174)**	**(4.431)**	**(3.659)**	**(2.114)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	29.04	13.47	15.57	3.376	12.20

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table A.5: Heterogeneous Labor Supply Responses to Sickness Across Age

Second Stage IV: Effects of Healthcare Choice Amongst Sick Children and Adults on Labor Per Capita of Household

	Total Labor Hours	Farm Labor	Non-Farm Labor		
			Total	Self-Employment Total	Home Total
Effects on Labor Supply of Sick Household Members					
Child x Formal Healthcare	**-14.05****	**-6.321****	**-7.728**	**-6.310**	**-1.418**
	(5.741)	**(2.866)**	**(5.248)**	**(4.491)**	**(2.614)**
Formal Healthcare	**0.951**	**9.680****	**-8.730****	**-6.783***	**-1.947**
	(5.429)	**(4.439)**	**(4.252)**	**(3.483)**	**(2.853)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	29.57	13.60	15.97	3.114	12.86
Effects on Labor Supply of Non-Sick Household Members					
Child x Formal Healthcare	**4.383**	**3.639**	**0.744**	**1.667**	**-0.923**
	(4.141)	**(3.010)**	**(3.314)**	**(2.876)**	**(2.125)**
Formal Healthcare	**-6.172**	**3.252**	**-9.423****	**-6.828***	**-2.596**
	(3.964)	**(2.760)**	**(4.152)**	**(3.587)**	**(1.977)**
Observations	1932	1932	1932	1932	1932
Mean of Dependent Variable	29.04	13.47	15.57	3.376	12.20

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table A.6: Heterogeneous Labor Supply Responses of Non-Sick Males and Females

Second Stage IV: Effects of Healthcare Choice Amongst Sick Males and Females on Non-Sick Male and Female Labor

	Total Labor Hours	Farm Labor	Non-Farm Labor		
			Total	Self-Employment Total	Home Total
Effects on Labor Supply of Non-Sick Male Household Members					
Male x Formal Healthcare	**0.0164**	**-5.504***	**5.520**	**1.988**	**3.533***
	(4.369)	**(3.322)**	**(3.635)**	**(3.321)**	**(1.944)**
Formal Healthcare	**-6.376**	**5.295**	**-11.67****	**-7.806**	**-3.865****
	(5.617)	**(3.926)**	**(5.506)**	**(5.229)**	**(1.802)**
Observations	1599	1599	1599	1599	1599
Mean of Dependent Variable	26.75	15.02	11.73	4.631	7.097
Effects on Labor Supply of Non-Sick Female Household Members					
Male x Formal Healthcare	**5.333**	**0.982**	**4.351**	**0.427**	**3.924***
	(4.203)	**(2.513)**	**(2.681)**	**(1.527)**	**(2.237)**
Formal Healthcare	**-5.117**	**2.806**	**-7.922***	**-4.745**	**-3.177**
	(5.208)	**(2.960)**	**(4.451)**	**(3.360)**	**(2.748)**
Observations	1598	1598	1598	1598	1598
Mean of Dependent Variable	30.67	12.05	18.62	1.878	16.74

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.

Table A.7: Heterogeneous Labor Supply Responses of Non-Sick Children and Adults

Second Stage IV: Effects of Healthcare Choice Amongst Sick Children and Adults on Non-Sick Child and Adult Labor

	Total Labor Hours	Farm Labor	Non-Farm Labor		
			Total	Self-Employment Total	Home Total
Effects on Labor Supply of Non-Sick Child Household Members					
Child x Formal Healthcare	**-0.823**	**-1.510**	**0.687**	**-0.376**	**1.064**
	(4.563)	**(2.584)**	**(3.726)**	**(0.939)**	**(3.223)**
Formal Healthcare	**-7.925**	**1.251**	**-9.176***	**-2.209***	**-6.967***
	(5.892)	**(3.462)**	**(4.963)**	**(1.335)**	**(4.171)**
Observations	1244	1244	1244	1244	1244
Mean of Dependent Variable	17.67	6.834	10.83	0.123	10.71
Effects on Labor Supply of Non-Sick Adult Household Members					
Child x Formal Healthcare	**-1.895**	**1.719**	**-3.614**	**-2.181**	**-1.433**
	(4.826)	**(3.429)**	**(4.392)**	**(4.166)**	**(2.329)**
Formal Healthcare	**-4.452**	**4.732***	**-9.184****	**-8.374***	**-0.810**
	(4.485)	**(2.861)**	**(4.538)**	**(4.287)**	**(1.910)**
Observations	1818	1818	1818	1818	1818
Mean of Dependent Variable	34.10	16.61	17.49	4.791	12.70

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). See Table II for additional comments.