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Original Research Paper

The effect of health shocks on agricultural productivity: Evidence from Ghana

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While agriculture remains the major source of livelihood for rural households in many countries in the developing world, agriculture output continues to depend on the availability and quality of the labour force which unfortunately is hampered by health shocks and diseases. Reviewing the empirical literature, it appears however, that both micro- and macro-level studies have not provided clear evidence to show the linkage, due largely to methodological issues. The purpose of this study is to estimate the impact of idiosyncratic health shocks on farm labour use at all the stages of farming activities, use of non-labour inputs and on the end value of agricultural output. Using a two-wave panel data, our results show that family labour used in land preparation and farm management are very sensitive to ill-health. Households are only able to substitute lost family labour at the farm management stage. Substituted labour however does not completely replace the lost family labour. The effect on agricultural investments is also negative. We argue that preventive healthcare interventions intended to reduce the consequences of ill-health on agriculture must target the different stages of the agriculture process. More lasting health policies such as health insurance that reduces out-of-pocket payments would be an authentic option in reducing the effect of healthcare expenditures on agriculture investment.

Key words: Ill-health, labour market imperfections, farm management, health insurance, farmer-based organisation

INTRODUCTION

Agriculture is the predominant economic activity in most countries in Africa with more than half of their populations engaged directly or indirectly. In Ghana agriculture employs more than 60 per cent of the economically active labour force and contributes nearly 40 per cent to total productivity in the economy. Growth in agricultural productivity is essential for improving welfare especially among rural households (by increasing incomes and living conditions) and achieving sustained economic growth for poverty reduction. It is noted that no country has been able to sustain a rapid transition out of hunger and poverty without raising productivity in its agricultural sector (Timmer, 2005). Growth in agricultural productivity is not only associated with an increase in farm incomes, it also stimulates linkages with the non-farm economy, causing economic growth and rapid poverty reduction. In countries where agricultural productivity has failed or lagged behind other sectors, hunger has been inescapable. Incidentally, this has been the bane of most African economies.

In Africa, agriculture is labour-dependent and rely substantially on less skilled labour force with low investment in information and technology. Consequently, productivity is usually far less than the size of human engagement and land use as compared to developed economies. Low labour productivity thus continues to be a distinguishing characteristic of agriculture in Africa. Attempts to stimulate agricultural productivity have witnessed increased investment in innovation, training, increasing access to credit, information and improved technology. While these investments may yield positive returns, unanticipated health shocks have a tendency of dissipating anticipated benefits.

Africa is customary with human diseases such as malaria, Onchocerciasis, Buruli ulcer, guinea worm, and HIV/AIDS.

These diseases are probably the most critical impediment to agricultural productivity, growth and poverty reduction in Africa. Parasitological infestations and common transitory health shocks have both a direct and indirect effect on agriculture labour and consequently on productivity.

Directly, ill-health affects physical strength and work days/hours available for farm work. Since agricultural productivity is dependent on physical strength and stamina, and therefore good health, it is more probable that health shocks directly affects worker productivity. Indirectly, ill-health involving high medical expenditures tends to deprive farming households of resources to invest in experimentations on improved practices and adoption of new technology. Poor health reduces farmer's ability to innovate, experiment, and operationalise changes in agricultural systems (Asenso-Okyere et al. 2010). Serious health conditions resulting in catastrophic expenditures may also result in depletion of productive assets such as sale of draught animals and sale of cultivable land (Slater and Wiggins, 2005). The consequence of these actions include reduction of farm sizes, cultivation of less-intensive crops, and reduction in livestock numbers resulting in poor livelihoods.

Some empirical studies have confirmed that there is a relation between health and economic growth, even though the direction of interaction appears complex. There is also a strong agreement among public health professionals and economists that health shocks can impose substantial economic costs on individuals and households, and that cumulatively these costs represent a major burden on society. The economic burden of a single health shock in a household on labour productivity and welfare outcomes is well acknowledged. A number of studies have provided quantitative evidence on the impact of a person's health on productivity, farm profits and wage rates at the household and the individual level (Gertler and Gruber 2002; Dercon and Krishnan 2000; Schultz and Tansel, 1997; O'Donnell 1995; Deolalikar 1988; Strauss 1986).

There is general consensus in the literature on two common roles for health in a typical household utility maximization problem: the direct disutility of sickness and the negative effect of sickness on time endowment (e.g. O'Donnell 1995; Dercon and Krishnan 2000; Gertler and Gruber 2002). In agricultural societies, as in Africa, health may affect an individual's ability to perform strenuous tasks like farming (Adhvaryu and Beegle, 2012). Especially at key times of the year (e.g. during harvest), acute health shocks could entail significant time and earning losses for the household. Sickness in young children or aged could also change the returns to an adult's (e.g. a mother in the case of children) labour inputs on the farm versus the home (Pitt and Rosenzweig, 1986) as labour may be completely or partially diverted from farm work to full time caretaker role for the chronically ill or temporarily for the transiently sick. Asenso-Okyere and others (2010) also noted that in the extreme event of the death of a sick adult, knowledge acquired through learning and experience is no longer available for others to use and considerable agricultural knowledge would have been lost.

Notwithstanding the theoretical consensus on the effect of health shocks on productivity, due to conceptual and methodological reasons, the empirical evidence available so far, has been less obvious or at best contradictory. A review of the empirical literature shows that investigations on the effect of health shocks usually estimate either agricultural productivity directly (Baldwin and Weisbrod, 1974; Weisbrod and Helminiak, 1977; Audibert, 1986), allocation of labour and land (Conly, 1975; Larochelle and Dalton, 2006), or effect on physical ability (Brohult et al., 1981). Baldwin and Weisbrod (1974) for example examined the effects of five diseases (schistosomiasis, ascariasis, trichuriasis, strongyloidiasis and hookworm infection) on productivity in Santa Lucia using earnings per week as a measure of productivity. These parasitic infections were found to cause few statistically significant adverse effects on agricultural labour productivity, as they affected much more significantly the quality and quantity of leisure time and relationships within the household. Years later, Weisbrod and Helminiak (1977) found to the contrary that while schistosomiasis exerted a lower effect on earnings (14 percent of the daily earnings of male workers against 30 percent previously) ascariasis exerted a much higher effect.

Audibert (1986) using two ill-health scenarios in a household production model: one capturing the impact of malaria and the other, the impact of schistosomiasis, estimated the impact on rice production in North Cameron. While finding that a 10 per cent increase in schistosomiasis prevalence reduces agricultural output by 4.9%, malaria did not appear to have any significant effect. In a similar analysis in Mali, Audibert and Etard (1998, 2003) estimated the impact of schistosomiasis on rice production using a quasi-experimental design including health treatment. Their results showed that health improvement has no direct effect on rice production, but affects the household's use of its labour resources and its ability to utilize other resources. They noted that, relative to the untreated group, the number of family workers-days available increased by 69 per hectare and the size of cultivated land by 0.47 hectare in the treated group.

The first concern in all these contradictory string of analyses lies in the methods used in the estimations. Taking that what theory suggests that there is an endogenous relationship between health and productivity is true, the use of ordinary least squares (OLS) estimation strategy as in most of the studies, most likely produced biased and inconsistent estimates of the structural parameters. The few studies that used more refined methodologies in later analysis found evidence that were indeed contrary to earlier findings. Audibert et al. (2003 & 2009) for example revisited the effect of malaria this time using field data collected between March 1997 and February 1998 in the savannah zone of Korhogo and in the 1999 year in the forest zone of Danane, all in Cote d'Ivoire. Two malaria morbidity indicators were used: Plasmodium falciparum infection rate and high parasite density infection rate.

In their first analyses which assessed the effect of malaria on the cotton-crop development in the savannah zone using a production frontier model, they hypothesised that unhealthy (due to malaria infection) cotton-grower households should be less efficient than healthy ones (Audibert et al., 2003). The results confirmed the assumption and showed a critical threshold above which malaria had a negative effect on technical efficiency in the cotton crop. They found that a farm household in which the proportion of active Plasmodium falciparum was higher or equal to 25 per cent, were less efficient than farm households in which this proportion is lower. Later, they assessed the effect of malaria on coffee and cocoa production or yield, this time controlling for malaria endogeneity and village heterogeneity and also used a two-stage least squares regression analysis (Audibert et al., 2009). In that instance, they found, contrary to the earlier results on the cotton-crop that malaria infection seems to have no effect (neither directly nor indirectly) on coffee and cocoa crops. Even though they speculated that the lack of effect is perhaps due to the fact that coffee and cocoa crops are less labour-consuming as compared to rice or cotton crops, the different statistical tool used and the use of panel data may have contributed to the different results obtained.

Clearly, even though on the broader level, there are evidence of an association between measures of household economic status and a variety of health outcomes, the empirical literature on the topic has been very less confirmative. The normative verdict however remains generally accepted and strong. The need for broader studies to provide this empirical evidence is an imperative for an informed policy intervention in agriculture. The aim of this study is to empirically examine the effect of common illness conditions in a household on agricultural productivity. This study is particularly important in a setting where health shocks are rampant and agricultural productivity is correspondingly low.

MATERIAL AND METHODS

The Data

The data come from the second batch (Phase II farmers) of a two-phased randomized control experiment used to evaluate the impact of credit and training programme given to farmers in six selected regions in Ghana referred to as intervention zones of the Millennium Development Authority (MiDA). The government of Ghana, through MiDA, implemented a 5-year US$547 million Compact signed with the Millennium Challenge Corporation (MCC) of the United States of America. The Compact's overarching goal was to reduce poverty through economic growth and agricultural transformation. The key projects of the intervention programme were implemented across the three (3) ecological zones (Northern Agricultural Zone, Southern Horticulture Belt and Afram Basin) of Ghana, covering originally 23 districts, but currently 30 districts due to redistricting.

As part of the programme a credit facility and training programme for farmers was organised around a randomized half (treatment group) of 1,200 Farmer Based Organisations (FBOs) and the other half (control group) covered in the second batch of the training programme. By the design of the programme two distinct set of farmers – one group given early training and credit and the second receiving late training. FBO surveys were therefore undertaken to evaluate the impact of the credit facility and the training on agricultural productivity and crop incomes among the farmers. The surveys were conducted over three (3) years during the life of the Compact, starting November 2008 through to January 2011.

Under the evaluation design each farmer was interviewed twice – round one (baseline) and round two (follow-up). The follow-up survey for the second batch was done eight to ten months after the baseline survey. Whilst the baseline coincided with land preparation and farm management, the follow up coincided with the harvesting period especially of the major farming season. This design of the survey allows an analysis of the effects of illness on labour at the different stages of the agricultural production process (land preparation, farm management and harvesting). The paper uses only the major season of the production cycle to allow for comparative analysis to be made across the three ecological zones which have different agricultural seasons. A total of 2,842 households consisting of 16,419 persons were surveyed in batch 2. A total of 2,569 households were however used for the estimation due to incomplete data for some variables.

Econometric estimations

A Cobb-Douglas type of specification is used to analyse the relationship between ill-health in a household and farm labour use. Other relationships were jointly estimated with the farm labour use model. They include the linkage between health shocks, labour and agriculture investments (investments in tools, seeds, and chemicals), farm size cultivated (hectares), and the resultant effect on total household agriculture output. The estimation was based on a three-stage least squares (3SLS) approach. Both family and casual labour supply for various agricultural activities (labour allocation in land preparation, farm management and harvesting) were analysed.

The production relationship between output and factors of production is first written as:

$$Y = f(L(H_{t-1}^{s}, H_{t}^{s}), I(H_{t-1}^{s}), H_{t-1}^{s}, H_{t}^{s})$$

$$\text{llab\_f1} = \beta_0 + \beta_1 \text{numill}_{t-1} + X\beta_I + \varepsilon_1 \qquad \textit{Family labour: land preparation}$$
$$\text{llab\_c1} = \beta_0 + \beta_2 \text{numill}_{t-1} + X\beta_{II} + \varepsilon_{II} \qquad \textit{Casual labour: land preparation}$$
$$\text{llab\_f2} = \beta_0 + \beta_3 \text{numill}_{t-1} + X\beta_{III} + \varepsilon_{III} \qquad \textit{Family labour: farm management}$$
$$\text{llab\_c2} = \beta_0 + \beta_4 \text{numill}_{t-1} + X\beta_{IV} + \varepsilon_{IV} \qquad \textit{Casual labour: farm management}$$
$$\text{llab\_f3} = \beta_0 + \beta_5 \text{numill}_{t} + X\beta_{V} + \varepsilon_{V} \qquad \textit{Family labour: harvesting}$$
$$\text{llab\_f3} = \beta_0 + \beta_6 \text{numill}_{t} + X\beta_{VI} + \varepsilon_{VI} \qquad \textit{Casual labour: harvesting}$$
$$\text{ltool\_val} = \beta_0 + \beta_7 \text{numill}_{t-1} + X\beta_{VII} + \varepsilon_{VII} \qquad \textit{Value of tools}$$
$$\text{lseed\_val} = \beta_0 + \beta_8 \text{numill}_{t-1} + X\beta_{VIII} + \varepsilon_{VIII} \qquad \textit{Value of seeds}$$
$$\text{lchem\_val} = \beta_0 + \beta_9 \text{numill}_{t-1} + X\beta_{IX} + \varepsilon_{IX} \qquad \textit{Value of chemicals}$$
$$\text{lsize\_ha2} = \beta_0 + \beta_{10} \text{numill}_{t-1} + \alpha_1 llab\_f1 + \alpha_2 llab\_c1 + X\beta_X + \varepsilon_X \qquad \textit{Farm size}$$
$$\text{lprod\_val} = \beta_0 + \beta_{10} \text{numill}_{t-1} + \beta_{11} \text{numill}_{t} + \sum_j \alpha_j llab\_fj + \sum_j \alpha_j llab\_cj + \sum_k \delta_k INVk + X\beta_{XI} + \varepsilon_{XI} \qquad \textit{Output}$$

Figure 1. Modelling variables used in the regression analysis.

Where L(.) represent labour (both family and hired man-hours) used for the farming season and I(.) represents agricultural investments (value of tools, seeds, chemicals and land) made during the season. Health shocks (H) are captured at different stages of production and since previous transient health shocks do affect current labour allocation, we specify the inputs function using the baseline health shocks to explain land preparation, farm management and farm investments. Health shocks, measured at the time of the follow-up survey explain labour used for harvesting. In addition to the estimation of indirect effects on production, captured through the inputs, we also estimate the effects of illness on innate capabilities, which can affect output directly.

Eleven equations involving endogenous factors on the right-hand side are estimated (see Appendix; Table 1 for a description of all the variables used in Figure 1).

The system excludes joint estimation of production and consumption because the survey did not capture consumption data. We assumed the absence of separability between consumption and production decisions based on earlier establishment that the absence of separability has no consequence on the estimation of agricultural production in which labour input is instrumented (Croppenstedt and Muller, 2000). Number of days of illness is also endogenised in the system. The estimation technique is quite different from the traditional seemingly unrelated regression specification as we used different exogenous and instrumental variables for different equations.

RESULTS

Descriptive results

The data shows close reflection of the characteristics of farmers in Ghana (GLSS, 2007; GLSS+, 2009). Total land holdings for crop farming were small ranging from a minimum of 0.02 to a maximum of 177.78 hectares. On average farmers used about 3.84 hectares of land for various crops production. About a quarter of the farmers grew rice or yam, three in ten grew groundnuts, over four in ten grew cassava and 92.5 per cent grew maize in the major farming season. Households spent about GH¢114 to hire and use farm tools (mostly tractor), about GH¢155 spent on seeds and about GH¢197 spent on chemicals such as fertilizer, herbicides, insecticides and others. The average total monetary value of output of the farmers for the major season was about GH¢1,514. Variation in community or district prices of the produce was accounted for at the estimation stage using a combination of per-kilogramme price of 23 major crops in the sample.

Health shocks refer to common transient illness conditions such as malaria, fever, diarrhoea, cold, etc. reported in a household. We do not include chronic health conditions and congenital disorders. The data shows that in nearly four out of every ten households, a health shock condition was reported, and there is no significant difference across ecological zones, except that the northern agriculture zone had a slightly higher proportion of reported incidences than the other two zones (Table 1). There is also no significant difference between the proportion of households in treatment group who reported health shock conditions and households in the control group who reported illness conditions.

imilarly, the number of days lost due to a health shock condition was not significantly different across zones, nor between treated and control groups (Table 2). This implies that whether a household had somebody who benefitted from the MiDA training or the credit scheme or not the effect of illness in terms of limiting labour supply was not different. Certainly the slight difference noticed between the treated

Table 1: Proportion of households that reported short illness (%)

MiDA zone	Treated group	Control group	All
Southern Horticulture Belt	36	35	36
Afram Basin	37	39	38
Northern Agriculture Zone	41	41	41
Total	38	39	38

Table 2: Number of days lost in a week by economically active people who reported illness

MiDA zone	Treated group	Control group	All
Southern Horticulture Belt	7.0	6.8	6.9
Afram Basin	6.1	6.7	6.4
Northern Agriculture Zone	5.4	6.1	5.7
Total	6.2	6.6	6.4

Table 3a: Effects of ill-health on labour for land preparation (3SLS Simultaneous Regression)

Variable	Log(Fam. labour)		Log(Casual labour)	
Log(No. of days ill by household member during land preparation)	-3.3276	***	-2.4595	***
No. of economically active males in household during land preparation	0.1632	***	-0.1070	**
No. of economically active females in household during land preparation	0.0771	**	0.0128	
Highest level of education completed by a household member	-0.1757	**	0.0378	
Number of literate adults (15+ years)	0.0558	**	0.0131	
Household receives MiDA credit and training	0.0775		0.2479	***
MiDA Zone - Southern horticultural zone	-1.4238	***	1.2216	***
MiDA Zone - Afram Plains	-0.6263	***	1.8199	***
No. of draught animals household owns at land preparation stage	-0.0049		0.0544	
No. of cattle household owns at land preparation stage	0.0002		0.0013	
Value of household assets at land preparation stage	-0.0008		0.0101	***
Constant	6.8111	***	0.7871	**

Significance level: *** 1%; ** 5%; and * 10%

group in the southern horticulture belt and the northern agriculture zone could not be attributed to the impact of the training programme, but more to labour supply irregularities in the two zones. Whereas in the southern zone it is relatively easier, no less cheap though, to hire casual labour to replace lost family labour, in the northern zone labour supply constraints are enormous due to pronounced north-south migration. Invariably, households with reported illness are compelled to continue working even when sick, hence the less number of reported days lost associated with farm households in the northern zone.

At the various stages of the agriculture circle we found reported illness and days lost following the same trend; no significant difference across zones and between treatment and control groups. The average number of days of illness per household during the land preparation and harvesting stages was about 2.4 and 2.6 respectively. All illness days refer to the two weeks reference period used in this survey and also used in several other household surveys.

In terms of labour allocation, we found that the allocation of labour for farm use mostly came from family sources, which ranged from an average of 253 hours for land preparation to about 551 hours for farm management. Farm management received the largest share of man hours from family sources whilst land preparation received the largest share of casual labour hired during this season (all other descriptive statistics are summarised in the Appendix; Table 2a and 2b).

Results of estimations

Health shock and labour use in farming activities (family and casual labour)

The results are presented in three stages. The first regressions are presented in the first three tables below (Table 3a; Table 3b; and Table 3c). These results show the relationships between illness and labour (family and casual) use at land preparation, land management and farm harvesting stages of production. In all the tables, the family labour use model is the number of family labour hours

Table 3b: Effects of ill-health on labour for farm management (3SLS Simultaneous Regression)

Variable	Log(Fam. labour)		Log(Casual labour)	
Log(No. of days ill by household members during land preparation)	-10.3159	***	9.1230	***
No. of economically active males in household during farm management	0.2325	***	-0.1473	***
No. of economically active females in household during farm management	0.1427	***	-0.0390	
Highest level of education completed by a household member	-0.1901	**	-0.0363	
No. of literate adults (15+ years)	0.0557		0.0447	
Household receives MiDA credit and training	0.0327		0.2324	**
MiDA Zone - Southern horticultural zone	-1.8524	***	0.3254	*
MiDA Zone - Afram Plains	-0.8052	***	0.5162	***
No. of draught animals household owns at land preparation stage	0.0103		0.0769	
No. of cattle household owns at land preparation stage	-0.0032		0.0074	***
Value of household assets at land preparation stage	-0.0032		0.0119	***
Constant	8.2488	***	-0.0904	

Significance level: *** 1%; ** 5%; and * 10%

allocated to manual labour during land preparation, farm management and harvesting, whilst the casual labour use model is the number of casual labour hours hired during each of these stages in the agricultural production process.

As expected the relationship between ill health and hours worked is more sensitive to current values of health stock than lagged health status. The effects of one day of illness on family labour are strong on the amount of hours family members make available for land preparation. On average a percentage increase in the days of illness reported in a household reduces family labour use for land preparation by about 3 percentage points (Table 3a). This implies that illness generally reduces family labour use quite significantly. The negative sign for casual labour use indicates that, on the average families at this stage do not or are not able to buy extra labour. The fact that households are not able to significantly purchase labour from outside, points to possible labour supply and demand constraints at certain stages of the production process.

An important variable that may also help to explain the negative sign associated with number of days a household member is ill and the amount of casual labour use is the presence of economically active members in the household. The model shows that an additional member in the household who is economically active is not only positive and significantly associated with an increase in family labour use, but it is also negatively associated with casual labour use. The effect is particularly higher if the increase is in the number of economically active males as a one man increase, increases the percentage of family labour use by about 16 per cent, which is more than two times higher if there was an increase in the economically active female population.

It is important to establish that, in the short run it is not expected that family labour supply can be increased. What can be increased with increased access to credit and possible expansion of farm size is the use of casual labour. The treatment (treatdum) effect is thus, not significant on the use of family labour, but significant in increasing the use of casual labour. Households that received the training and the starter-pack are significantly more likely to increase purchase of casual labour by about 24.8 per cent.

At the second stage of the agriculture production process (farm management) there is a significant amount of use of casual labour (Table 3b). During this stage the effect of illness on family labour availability is severely affected. Illness reported reduces family labour use by more than a day of family labour hours available for land management. This leads to a corresponding increase in casual labour purchased to replace the lost family labour. A percentage increase in the number of days of illness in a household decreases by as much as 10 percentage points the number of hours of family labour used on farm management.

Since this appears to be a very crucial phase of the season households try to replace or hire casual labour. The model shows a significant amount of casual labour use (i.e. a 9% increase) with a percentage increase in the number of days of illness reported in the household. Even though this increase is slightly less than the percentage of family labour loss, it is an indication of a positive labour substitution, albeit not as productive as the lost family member's labour supply. There is also a significant stretch of all household resources as shown by the increase in the percentage of family labour relative to a unit increase in the number of economically active males and females. An increase in the number of economically active persons for example, increases family labour use by about 23 per cent and about 14 per cent if the increase is in the number of males or females respectively.

During the harvesting stage of the agriculture production process there is normally an increase in demand for labour to avoid loses at the farm gate level. The coefficient of the illness variable, even though negative and significant, the effect size is not so strong in terms of reduction of family labour use during this period as compared to those at the earlier stages of production (Table 3c). This is an indication that some intra-family labour substitution or labour reallocation takes place at this stage to prevent extremely

Table 3c: Effects of ill-health on labour for harvesting (3SLS Simultaneous Regression)

Variable	Log(Fam. labour 3)		Log(Casual labour 3)	
Log(No. of days ill by household member during harvesting)	-1.8678	***	-1.3914	*
No. of economically active males in household during harvesting	0.1035	***	0.0040	
No. of economically active females in household during harvesting	0.0798	**	0.0037	
Highest level of education completed by a household member	-0.1085	**	0.1204	*
Number of literate adults (15+ years)	0.1131	***	0.0199	
Household receives MiDA credit and training	0.0866		0.0115	
MiDA Zone - Southern horticultural zone	-1.7043	***	0.8037	***
MiDA Zone - Afram Plains	-1.2252	***	0.6789	***
No. of draught animals household owns during land preparation	0.0407		0.0694	
No. of cattle household owns during land preparation	-0.0001		0.0044	**
Value of household assets at land preparation stage	0.0008		0.0086	***
Constant	5.7381	***	1.9198	***

Significance level: *** 1%; ** 5%; and * 10%

avoidable losses. A one per cent increase in the number of days ill in a household leads to only 1.9% decrease in family labour employed. The effect on casual labour use at this stage is negative, reflecting the possible difficulties households face in effectively replacing lost family labour. Even at this stage the treated group are unable to buy casual labour.

Health shock and investment in agriculture inputs

The estimated effects of ill health on agricultural investments are presented in Table 4. The agricultural investments considered in this case are the value of investments made on seeds, chemicals, and tools (mostly tractor use). Severe illness affects agriculture investments due to expenditures on healthcare leading to depletion of "investible" capital. Considering that financial capital is fungible, the occurrence of transient health shock can derail the course of capital from use in agriculture investment to payment for healthcare. Even though the survey did not collect data on cost of healthcare, days lost due to illness are used to reflect the severity of the health shock condition in the household. As would be expected therefore the relationship between ill-health and investments made is negative. For land size cultivated, illness has a negative effect through unavailability of labour (both family and casual).

All the results confirm expectations showing that illness has a negative impact on the value of investments made in hiring or using tools, purchasing seeds, and purchasing chemicals. A percentage increase in the number of illness days reported in a household decreases the amount of money spent on hiring a tractor and the amount spent on chemicals by as much as 2.2 percent. The effect is even slightly higher for seeds as compared to the other inputs used. A percentage increase in the number of illness days reported in a household decreases the amount of money spent on improved seeds by about 3.4 percent.

The model does not show that there is any significant difference between households that received the MiDA training and credit and the control group in the crucial investments expected. Households in the treated group did not increase investment in the use of tools, use of chemicals nor did they increase their farm sizes. Households in the treated group are however associated with an increase in the value of investments made in seeds. The parameter estimate associated with farm size may however not be that meaningful since the sub-data used for this analysis only coincided between land preparations and harvesting. Land size increase can only be measured in the subsequent cropping seasons. The results for the other inputs are however surprising since the credit was given on purpose for use in purchasing chemicals and for hiring of tractors.

Health shock and value of agriculture output

The final model estimates the effect of illness on value of total agriculture output (Table 5). The main variables we look out for in this model are the behaviour of the ill-health variable, value of investments on inputs (seeds, chemicals, and tools) and how they relate with total production controlling for community prices for various crops. In this model the illness variable is treated as exogenous. Whilst a significant number of the variables show behaviour that is in consonance with a priori expectations, some appear in contrast, raising questions for further investigations.

Apart from the indirect effects of ill-health on production, captured through the inputs, the model also estimates the direct effect of illness on management capabilities of the farmer which has a direct negative effect on output. Treating the illness variable as exogenous, the coefficient is negative and significant confirming both theoretical and conceptual discussions that illness can have a direct effect on the total value of productivity (Table 5). The effect could particularly be severe if it happens during crop harvesting. A percentage increase in the number of days ill during crop harvesting phase decreases the value of total agricultural production by about 2%. This is higher than the gains made

Table 4: Effects of ill-health on agricultural investments (3SLS Simultaneous Regression)

	Log(Val. of tools)		Log(Val. of seeds)		Log(Val. of chemicals)		Log(Farm size)	
Log(No. of days ill by household member during land preparation)	-2.1774	***	-3.3538	***	-2.2218	***		
Log(Family labour supply during land preparation (hours))							0.4941	***
Log(Casual labour supply during land preparation (hours))							0.2655	***
No. of economically active males in household during harvesting	0.0861	**	0.1091	***	0.0637	**		
No. of economically active females in household at the time of harvesting	0.0903	***	0.0727	***	0.1401	***		
Highest level of education completed by a household member	0.0027		0.0505		0.1639	***	0.0525	**
Number of literate adults (15+ years)							0.0088	
Household receives MiDA credit and training	-0.1256		0.1491	***	-0.1877	**	0.0212	
MiDA Zone - Southern horticultural zone	-2.2147	***	-0.7639	***	-0.5327	***	-0.0962	
MiDA Zone - Afram Plains	-2.5778	***	-0.5053	***	-0.7587	***	-0.5481	***
No. of draught animals household owns during land preparation	-0.0037						0.0003	
Value of household assets during land preparation	0.0077	***	0.0027	**	0.0062	***	0.0008	
Household cultivates rice	0.1064						0.0864	*
Household cultivates cassava	-0.8051	***					-0.1139	**
Household cultivates maize	0.8299	***					-0.0261	
Household cultivates yam	0.1222						0.1194	***
Household cultivates groundnuts	0.5292	***					0.0283	
Constant	3.9533	***	5.2097	***	4.6702	***	-2.2159	***

Significance level: *** 1%; ** 5%; and * 10%

Table 5: Effects of ill-health on agricultural output (3SLS Simultaneous Regression)

Variable	Log(Market Value of Output(GHS))	
Log(No. of days ill by household members during land preparation)	-1.9067	***
Log(No. of days ill by household members during the harvesting)	-2.0379	***
Log(Family labour supply during land preparation (hours))	0.5604	**
Log(Family labour supply during farm management (hours))	-0.0218	
Log(Family labour supply during harvesting (hours))	-0.0824	
Log(Casual labour supply during land preparation (hours))	-0.9369	***
Log(Casual labour supply during farm management (hours))	1.3286	***
Log(Casual labour supply during harvesting (hours))	-0.1833	**
Log(Plot size measured in hectares owned by household members)	0.1699	
Log(Value of tools used during one agriculture season)	-0.1277	
Log(Value of seed used)	0.4429	***
Log(Value of chemicals used)	0.7634	***
Highest level of education completed by a household member	0.1536	**
Average district price of major food crops	0.0223	***
No. of cattle household owns at land preparation stage	-0.0071	***
Value of household assets at land preparation stage	-0.0029	
Household receives MiDA credit and training	0.1175	
MiDA Zone - Southern horticultural zone	1.3729	***
MiDA Zone - Afram Plains	1.4815	***
Constant	-1.0473	

in relation to a percentage increase in family labour supply during the harvesting stage. If the illness occurs during the land preparation stage it also reduces the value of agriculture production by close to the same percentage points (1.9%). Even though the differential impact is not great, it is noted that poor management of harvest as a result of illness could lead to abandonment or loss of farm produce.

As expected, the signs of the coefficients for two of the input variables (value of chemicals use and value of seeds) were all positive and significant at 1% level. The coefficient for farm size is also positive but not significant. There are possibly characteristics such as quality of land and issues of diminishing returns to scale. A percent increase in the value of seeds and chemicals invested leads to a 0.44 percent and 0.76 percent increase in the value of agriculture output made respectively. The coefficient for value of tools used is however negative. A percentage increase in the amount invested in tools (hiring a tractor) rather decreases the value of agriculture output made by about 0.13 percent. This inverse relationship contradicts expectations, but may reflect differential factor use intensity. Besides, farmers in Ghana are generally smallholder farmers. An increase in the amount of tools employed perhaps increases the cost of production beyond the ability of output to compensate. In other words the marginal product from employing a tractor on a small farm size is insufficient to pay for the cost incurred.

DISCUSSIONS

In this study we provide empirical results to support earlier strand of micro- and macro-level analyses that conclude that ill-health has a significantly negative effect on agricultural productivity. However, unlike most of these studies, we used a panel data and a three-stage least squares estimation approach that allowed us to significantly overcome many of the biases associated with OLS and other simple estimation approaches. What makes this study so different from other studies is the fact that we recognised the different stages involved in agricultural productivity and the fact that ill-health potentially have differential impact at these different stages in the production process.

The results show that family labour used is very sensitive to ill-health at land preparation and farm management stage of the production process. This time of the season brings along a number of diseases and sickness. It is the time when rains incidentally coincide with high temperatures bringing along high incidence of malaria (ACMAD, 2008). Gastro-intestinal diseases such as diarrhoea are also very common around this time because of faeco-oral contamination of water. Health shocks around this time are therefore rampant. Whilst households appear able to substitute lost family labour at the farm management stage, they are unable to completely replace the labour of family members who are unavailable at the other two stages in the production process. In other words substituted labour turns out to be imperfect, especially at the land preparation and harvesting period.

We however also found that the family perhaps is able to protect itself against significant labour losses in the presence of an additional economically active person in the household, generating what is often called the "added worker effect" (Coile, 2004; Lundberg, 1985). At the land preparation stage people do not usually need to hire casual labour to clear the fields. Rather, the coping process involves perhaps the reallocation of tasks within the household as observed in Audibert et al. (1998) rather than outside it (Conly, 1975). We however further found that, the added worker effect is larger for men than for women. This is parallel to Coile (2004) who found that the added worker effect is small for men and no such effect for women. Draught animals such as donkeys and bullocks are also used during land preparation to plough the land. This is shown in the negative relationship between number of draught animals in the household and the family labour used even though it is not statistically significant.

Ill-health also strongly affects investment in inputs which have a direct impact on farm output values. Expenditures on health shocks affect the availability of disposable cash income. During episodes of illness, household financial resources are diverted to pay for medical treatment. Such resources may otherwise be used to purchase complementary inputs (e. g. new seeds or plants, fertiliser, pesticides, etc.). Where health shocks are severe, involving significant financial outlays for treatment, a credit package made available to farmers purposely to hire tractors, buy chemicals and invest in improved and quality seeds, is diverted to take care of medical bills. This is usually more serious in households where there is no health insurance present or is incomplete.

The final model presents very interesting results for greater attention. The results first of all confirm that ill-health has a significantly negative effect on total output. The results further suggest that whilst the effect of ill-health during land preparation can be catered for during farm management, any illness during harvesting can lead to significant output losses which cannot be corrected. That shows the large effect size associated with illness during harvesting as compared to illness during land preparation. Another very interesting result to note is the fact that hired labour brings positive contribution to productivity only when hired for farm management. Indeed, casual labour hired during land preparation and harvesting is negative and strongly associated with total productivity.

Conclusion

While there is a great deal of discussions on the effects of health shocks on agriculture production, there is relatively little hard empirical evidence. That is why perhaps there are little known agriculture policies that at the same time cater for health effects. What this study has shown is that a programme to promote agricultural productivity will need to include complementary arrangements to safeguard the possibility of health shocks. In this study, our intention was to move away from only directly measuring the impact of ill-health on total productivity, and to also place emphasis on connecting activities that have an ultimate effect on the total output.

The primary conclusion of this paper therefore is that even though health-agriculture policy options are important, they should target different stages of the agricultural production process to have an effect. Preventive health care interventions will be needed to first of all reduce exposure to health shocks. Implementation of "transient health policies" such as distribution of mosquito nets to prevent the incidence of malaria for instance are important, but the effect will be greater if distributed during the onset of the raining season (land preparation stage) when people have difficulties adjusting to the arrival of the rains and the breeding of mosquitoes, and where family labour replacement is extremely difficult. More long lasting health policies such as health insurance that have the potential to reduce out-of-pocket payments will equally be important to ameliorate the negative effects of health shock expenditures.

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Appendix A

Table 1: Description of variables used in the regression analysis

Variables	Description
Dependent variables	
llab_f1	Log(Family labour supply during land preparation (hours))
llab_f2	Log(Family labour supply during farm management (hours))
llab_f3	Log(Family labour supply at harvesting (hours))
llab_c1	Log(Casual labour hired during land preparation (hours))
llab_c2	Log(Casual labour hired during farm management (hours))
llab_c3	Log(Casual labour hired at harvesting (hours))
lsize_ha2	Log(Plot size (hectares) cultivated by household members)
ltool_val	Log(Value of tools used during the major agricultural season)
lseed_val	Log(Value of seed used)
lchem_val	Log(Value of chemicals used)
lprod_val	Log(Value of total output)
Independent variables	
lnumill_{t-1}	Log(no. of days household member was ill during land preparation)
lnumill	Log(no. of days household member was ill at harvesting)
ecoactiveM_{t-1}	No. of economically active males in household during land preparation
ecoactiveF_{t-1}	No. of economically active females in household during land preparation
depratio	Dependency ratio
highesteduc	Highest level of education completed by a household member
nlitt	Number of literate adults (15+ years) in household
headF_{t-1}	Head of household is a female
explight_{t-1}	Source of lighting is relatively expensive
bwater_{t-1}	Source of drinking water is not good
btoilet_{t-1}	Indicator for use of bad toilet facility
wall_{t-1}	Indicator for the use of relatively expensive wall material
bfloor_{t-1}	Indicator for the use of Earth/Mud/Mud bricks floor
roof_{t-1}	Indicator for the use of relatively expensive roofing material
drought_{t-1}	No. of drought animals household owns during land preparation
cattle_{t-1}	No. of cattle household owned during land preparation
asset_val_{t-1}	Value of household assets during land preparation
zone1	MiDA Zone - Southern hulticultural zone
zone2	MiDA Zone - Afram Plains
treatdum	Household receives MiDA credit and training
rice	Household cultivates rice
cassava	Household cultivates cassava
maize	Household cultivates maize
yam	Household cultivates yam
gnuts	Household cultivates groundnuts

Table 2a: Descriptive Statistics for the dependent variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Family labour used during land preparation (hours)	2706	253.08	425.06	2	6810
Casual labour used during land preparation (hours)	2706	220.78	444.87	2	7982
Family labour used during farm management (hours)	2706	550.96	1698.48	2	27482
Casual labour used during farm management (hours)	2706	171.99	433.26	2	6530
Family labour used at harvesting (hours)	2706	326.38	592.25	2	7359
Casual labour used at harvesting (hours)	2706	133.24	369.47	2	5654
Total size of farm land used by household members (hectares)	2706	3.84	7.92	0.02	177.78
Value of tools used during one agriculture season (GH¢)	2706	114.40	176.00	2.00	2342.00
Value of seed used (GH¢)	2706	155.30	267.15	2.00	4482.00
Value of chemicals used (GH¢)	2706	196.90	275.85	0.00	4599.05
Value of total output (GH¢)	2706	1514.45	2099.42	0.00	26250.00

Table 2b: Descriptive statistics for the independent variables selected

Variable	Obs.	Mean	Std. Dev.	Min	Max
No. of days ill by household members during land preparation	2610	2.4	0.7	2	7
No. of days ill by household members at harvesting	2706	2.6	0.8	2	8
Dependency ratio	2665	1.1	0.9	0	6
Highest level of education completed by a household member	2706	1.8	0.9	0	5
Number of literate adults (15+ years)	2706	3.7	2.0	0	18
Head of household is a female	2610	0.1	0.3	0	1
No. of economically active males during land preparation	2610	1.5	1.4	0	9
No. of economically active females during land preparation	2610	1.4	1.3	0	9
No. of economically active males at harvesting	2706	1.5	1.4	0	8
No. of economically active females at harvesting	2706	1.4	1.3	0	9
Value of household assets during land preparation (GH¢ '1000)	2610	10.94	23.97	0.028	591.24
Source of lighting is relatively expensive	2610	0.382	0.486	0	1
Source of drinking water is not good	2610	0.231	0.422	0	1
Indicator for use of bad toilet facility	2610	0.684	0.465	0	1
Indicator for the use of relatively expensive wall material	2610	0.313	0.464	0	1
Indicator for the use of Earth/Mud/Mud bricks floor	2610	0.122	0.328	0	1
Indicator for the use of relatively expensive roofing material	2610	0.630	0.483	0	1
No. of drought animals household owned during land preparation	2610	0.1	0.9	0	24
No. of cattle household owns during land preparation	2610	3.2	16.7	0	330
No. of sheep household owns during land preparation	2610	7.8	16.9	0	234
No. of goats household owns during land preparation	2610	11.5	17.3	0	180
No. of pigs household owns during land preparation	2610	0.9	7.6	0	150
No. of rabbits household owns during land preparation	2610	0.4	5.1	0	150
No. of poultry household owns during land preparation	2610	39.3	56.2	0	720
No. of fish (farmed) household owns during land preparation	2610	0.2	4.0	0	120
No. of other animals household owns during land preparation	2610	0.9	6.7	0	195
Household receives MiDA credit and training	2706	0.50	0.50	0	1
Household cultivates rice	2706	0.244	0.430	0	1
Household cultivates cassava	2706	0.439	0.496	0	1
Household cultivates maize	2706	0.925	0.264	0	1
Household cultivates yam	2706	0.254	0.436	0	1
Household cultivates groundnuts	2706	0.297	0.457	0	1
Average district price of major food crops	2706	28.36	8.89	14.20	44.87
MiDA Zone - Southern horticultural zone	2706	0.267	0.443	0	1
MiDA Zone - Afram Plains	2706	0.377	0.485	0	1
MiDA Zone - Northern Agricultural Zone	2707	0.356	0.479	0	1