HEALTH AND LABOR PRODUCTIVITY

Economic Impact of Onchocercal Skin Disease (OSD)

by

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ABSTRACT

This paper is a study of the economic impact of health status on productivity and income. We study the existence and magnitude of the adverse economic impact of onchocercal skin disease (OSD) on the labor force at a coffee plantation in southwest Ethiopia. We estimate the daily wage equation for plantation employees. The empirical analysis reveals that the core of the plantation labor force, namely male permanent employees, suffer significant economic productivity losses (in the form of lower daily wages earned) as a result of OSD. Depending on the severity of OSD and upon controlling for factors such as age, daily wages were 10 to 15% lower among those exhibiting skin-related problems.

Key Words: Onchocerciasis; Economic Productivity; Coffee Plantation; Ethiopia

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Introduction

This paper is a study of the economic impact of non-ocular (or non-blinding) onchocerciasis. Onchocerciasis, caused by infection with the nematode worm *Onchocerca volvulus*, is a serious public health problem in much of tropical Africa where an estimated 17.5 million people are infected.[3] Oncho-infected individuals exhibit a myriad of symptoms ranging from intense itching, skin depigmentation and atrophy, muscoskeletal pains, and blindness. The ocular pathology of onchocerciasis varies from region to region. In West Africa, for instance, prevalence of ocular damage is largely associated with the savanna strain of the worm. In East Africa, on the other hand, ocular damage is rare among both the savanna and forest strains. The devastating impact of blinding caused by onchocerciasis is relatively well known and documented.[4] The successful operation of the Onchocerciasis Control Programme (OCP) has virtually eliminated onchocercal blindness in 11 participating countries in West Africa.

Recent studies have shown that the non-blinding manifestation of onchocerciasis also causes significant adverse socioeconomic consequences.[5] Approximately 9 million infected people live in areas where oncho-related blindness is not common. Rather, skin-related symptoms are predominant, leading to intense itching, fatigue, and insomnia. This has prompted the initiation of a multi-country program, namely the African Programme for Onchocerciasis Control (APOC). This program, supported by a coalition of international donors (including the World Bank), national governments, as well as non-governmental organizations, is primarily oriented towards the large-scale distribution of ivermectin -- a drug that must be taken at least once per year for an extended period of time in order to kill skin microfilaria.[6]

In this study, we investigate the economic impact of the non-blinding strain of onchocerciasis [henceforth referred to as onchocercal skin disease (OSD)]. We examine data collected from a sample of workers at a coffee plantation in southwest Ethiopia: an area known for its high prevalence of OSD. Using regression and other data analysis techniques, we test a variety of hypotheses concerning the incidence and severity of OSD and its impact on economic productivity.

Study Area and Methodology

Our study site is the Teppi coffee plantation, which is situated 575 kms southwest of Addis Ababa, Ethiopia. The site was chosen for its high incidence of OSD, ready availability of reported wage and employment data, and the importance of coffee to Ethiopia's economy.[7] Coffee

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3 World Health Organization (1995a).

4 See Prost and Prescott (1984), Kim and Benton (1995), and Kim *et al.* (1996).

5 See, for example, Oladepo *et al.* (1996), Workneh *et al.* (1993), and World Health Organization (1995b).

6 Ivermectin does not kill the adult worm.

7 Ethiopia is classified as a low-income economy by the World Bank. In 1994, it had a per capita Gross National Product (GNP) of US$130 with an average annual growth rate of -0.7% over the past decade.

constitutes Ethiopia's single most important crop, contributing over half of the agricultural GDP. Coffee is also responsible for nearly 60% of the country's foreign exchange earnings. Teppi is the second largest coffee plantation in Ethiopia, administering 6245 hectares of fully-developed coffee-producing land. In Ethiopia, Teppi is second in size and output to the adjoining coffee plantation of Bebeka.

OSD is typically prevalent in the most fertile land areas of northwest, southwest, and western parts of Ethiopia. A 1984 study estimated the number of cases of OSD in Ethiopia to be 1.4 million, with a population at risk of 7.3 million (or 17.4% of the population). Point prevalence, determined by the skin-snip method, ranges from a high of 84% in the western endemic zone through 60% in the southwest, and a low of 19.5% in the northwest. Therefore, based on the WHO classification of endemicity, there are hyperendemic and mesoendemic regions in Ethiopia. The mean microfilarial load per infected person ranges from 3.6 to 34 microfilariae per mg of skin snip, depending upon the community. Most recently, Aga *et al.* (1995) reported a microfilarial load of up to 382 microfilaria per mg skin snip in a rural farming village in southwest Ethiopia.

Economic Methodology

We estimate the daily wage equation for plantation workers[8], which in the semi-log formulation[9], is given by:

$$ln\ W = a_1 \boldsymbol{X} + a_2 O + a_3 I + e$$

where,
- W: Daily wages earned.
- O: Severe OSD = 1.
- I: Intermediate OSD = 1.
- $\boldsymbol{X}$: Vector of control variables including age, age squared, gender of individual, and type of employment (permanent, temporary, or contract).

[8] For theoretical details on health-status augmented wage equation formulations see Grossman and Benham (1974).

[9] In this formulation, the coefficients on the independent variables represent the *percent* change in the daily wage caused by a unit change in any given independent variable (controlling for other independent variables).

We also estimate the labor supply curve of days worked per month. The supply curve is hypothesized to be a function of the logarithm of daily wages, age, and OSD status. Or,

$$ln\ S = b_1\ ln\ W^* + b_2\ O + b_3\ \boldsymbol{X} + e$$

where,
- S: Average number of days worked per month in the past year.
- W: Daily wages earned.
- O: Severe OSD = 1.
- $\boldsymbol{X}$: Vector of control variable such as age, gender, other income, and household characteristics.

Starred variables represent the fact that they are endogenous: we have a two-equation model with daily wages being endogenous. The wage equation is estimated using ordinary least squares and the predicted value of the wage rate obtained. This predicted value is then used to estimate the labor supply equation.

Results

Sociodemographic Characteristics of Study Participants

Data were collected from plantation records for a sample of 425 plantation workers.[10] Of those sampled, 235 (55.3%) were permanent employees. The remaining (44.7%) were temporary (daily and contract) workers.[11] Most sampled (82.1%) were male, this being representative of the gender composition on the plantation in general. Table 1 disaggregates the sample in terms of employment type (i.e., permanent or temporary), gender, and age.

[10] It must be noted at the outset that the data are available for *currently employed* workers only. Those plantation workers who are too incapacitated to work -- due to extremely severe manifestations of OSD, for instance -- are not included in the sample. This may create a sample selection problem typically referred to as the "healthy worker effect". In effect, this means the estimates produced may be somewhat biased: the true magnitude of the impact of OSD on economic productivity and capacity, in all likelihood, being higher than what is observed in our sample. Nevertheless, this possibility of sample bias ought not confound the hypothesized negative relationship between severity of OSD and economic productivity and labor supply, even though the observed magnitude may be somewhat on the low side.

[11] Daily and contract workers are guaranteed employment for a limited period of time only: usually during the harvest season, when labor demand is highest.

Table 1. Employment Type, Gender, and Mean Age

Employment Type	Females (%)	Males (%)	Mean Age
Permanent	6 (2.5%)	229 (97.5%)	35.5
Temporary	70 (36.8%)	120 (63.2%)	25.5
All	76 (17.9%)	349 (82.1%)	31.1

Most of the females in our sample are temporary workers. As can be seen in Table 1, permanent employees tend to be somewhat older than temporary workers.

Clinical Results

Clinical examinations of our sample indicated 96 (22.6%) to be severe-OSD and 157 were (36.9%) classified as non-OSD. The remaining 172 (40.5%) were classified as intermediate-OSD.[12] The mean age by employment type and severity of infection is reported in Table 2.

Table 2. Mean Age by Employment Type and Severity of OSD

Employment Type	Severity of Infection	Number	Mean Age
Permanent	Severe-OSD	63	36.5
	Intermediate	114	35.6
	Non-OSD	58	34.5
Temporary	Severe-OSD	33	27.1
	Intermediate	58	26.1
	Non-OSD	99	24.6

As the severity of OSD increases, we see an increase in the mean age of study participants. This may be indicative of the cumulative nature of the infection. Also, it alerts us to the importance of controlling for age in the subsequent analysis of the economic impact of OSD.

Economic Impact

In this subsection, we report on the economic impact of OSD. Data on economic variables from plantation records such as gross income and days worked were collected for the latest 12 months available. First, we report on differences of mean gross monthly income, mean days worked per month, and mean daily wage between those with severe-OSD and those classified as non-OSD. Data on income and wages is in the local currency: birr.[13] Subsequently, we conduct a regression

[12] Clinical classifications of the severity of OSD were based on the criteria in Murdoch *et al.* (1993).

[13] In 1996, US$1 = 6.33 birr.

analysis which enables us to control for confounding variables such as age and gender. Table 3 reports on the monthly income for those classified as severe-OSD and non-OSD, disaggregated by employment type.

Table 3. Monthly Income (in birr) and Days Worked by Employment Type and OSD Severity[a,b]

	Permanent			*Temporary*		
	N	Monthly Income	Days Worked	N	Monthly Income	Days Worked
Non-OSD[c]	58	172.0 (9.11)	28.8 (0.24)	99	76.3 (2.41)	21.8 (0.42)
Severe-OSD[c]	63	142.3 (6.15)	26.9 (0.41)	33	80.5 (4.22)	22.2 (0.80)
Difference[c,d]		29.7* (10.99)	1.9* (0.48)		-4.2 (4.86)	-0.4 (0.90)
Wilcoxon Rank-Sum Statistic[e]		3.180*	3.697*		-0.941	-0.599

a. Monthly income is the average gross monthly income for the latest 12 months of available data.
b. Days worked refers to the average number of days worked per month in the latest 12 months.
c. Standard errors in parentheses.
d. "*" represents statistical significance at 5% based on a t-test with unequal variances.
e. "*" represents statistical significance at 5% based on the Wilcoxon rank-sum test for equal medians.

As we can see from Table 3, severe-OSD permanent employees earned on average almost 30 birr less per month and worked almost 2 fewer days per month when compared with non-OSD workers in the same employment category. As reported, this difference is statistically significant for both variables. On the other hand, severe-OSD does not appear to cause a significant decline in the monthly average income or of days worked for temporary workers.

Arguably, though, the most pertinent measure of economic productivity would be daily wages earned, since that controls income for days worked.[14] Table 4 reports on daily wages earned by severe-OSD and non-OSD employees, disaggregated by type of employment.

[14] Daily wages earned at the plantation correspond directly to economic productivity. Workers are paid according to output produced. There are penalties for not achieving output quotas and bonuses if they can produce more than the minimum set for any given activity. However, the wages paid for a given activity are lower for temporary workers, hence in our analysis we separate the sample based upon employment type (i.e., permanent or temporary).

Table 4. Daily Wages (in birr) by Employment Type and OSD Severity[a]

	Permanent		*Temporary*	
	N	Daily Wage	N	Daily Wage
Non-OSD[b]	58	5.9 (0.29)	99	3.5 (0.07)
Severe-OSD[b]	63	5.2 (0.18)	33	3.6 (0.12)
Difference[b,c]		0.7* (0.34)		-0.1 (0.14)
Wilcoxon Rank-Sum Statistic[d]		2.068*		-1.432

a. Daily wages equal average monthly income over average days worked per month for latest 12 months.
b. Standard errors in parentheses.
c. "*" represents statistical significance at 5% based on a t-test with unequal variances.
d. "*" represents statistical significance at 5% based on the Wilcoxon rank-sum test for equal medians.

As reported in Tables 3 and 4, we see that severe-OSD permanent employees earn a lower monthly income not only because they work fewer days, but also because they are less productive on the days that they work. This can be seen in the statistically significant difference in daily wages earned. However, again we see that severe-OSD temporary employees do not show lower productivity in terms of daily wages earned.

Table 5 disaggregates the data for temporary workers by gender and age in order to see if OSD-related productivity differences may be revealed among certain subgroups. We examine two age categories: those below the mean age of 25 ("young") and those above 25 ("experienced").

Table 5. Daily Wages (in birr) by OSD Severity, Gender, and Age Category for Temporary Workers[a]

	Female Daily Wages				*Male Daily Wages*			
	N	Age 15-25	N	Age 25+	N	Age 15-25	N	Age 25+
Non-OSD[b]	30	3.11 (0.11)	8	3.2 (0.09)	39	3.5 (0.11)	11	4.3 (0.22)
Severe-OSD[b]	4	3.1 (0.33)	7	3.2 (0.06)	13	3.5 (0.12)	9	4.3 (0.29)
Difference[b,c]		0.0 (0.31)		0.0 (0.02)		0.0 (0.20)		0.0 (0.36)
Wilcoxon Rank-Sum Statistic[d]		-0.107		-0.847		-0.328		0.190

a. Daily wages equal average monthly income over average days worked per month for latest 12 months.
b. Standard errors in parentheses.
c. "*" represents statistical significance at 5% based on a t-test with unequal variances.
d. "*" represents statistical significance at 5% based on the Wilcoxon rank-sum test for equal medians.

As can be seen, there is no OSD-related statistical difference in the daily wages of temporary male and female workers across age categories. There are several factors to note before we limit the ensuing analysis to permanent workers. First, temporary workers may have alternate income sources that we are unable to control for. Secondly, the decision regarding labor supply for temporary workers are determined in part by plantation labor demand. Thirdly, the sample size is small for temporary workers, therefore causing possibilities of bias.

Estimation of Wage Equation: Given the preliminary indications in Tables 3 through 5, we estimate the wage equation for permanent workers at the plantation. We regress the logarithm of daily wages on the prevalence and severity of OSD controlling for other pertinent variables. As mentioned earlier, the model we estimate is:

$$ln\ W = a_1 \boldsymbol{X} + a_2 O + a_3 I + e$$

where,
- W: Daily wages earned.
- O: Severe OSD = 1.
- I: Intermediate OSD = 1.
- $\boldsymbol{X}$: Vector of control variables: age, age squared, and gender of individual.

Table 6 summarizes the regression results.

Table 6. Ordinary Least Square (OLS) Estimation of Daily Wage Equation for Permanent Workers[a]

Variables	All	Age 15-35	Age 35+
Severe-OSD	-0.159 (0.036)*	-0.136 (0.047)*	-0.163 (0.057)*
Intermediate-OSD	-0.100 (0.032)*	-0.081 (0.040)*	-0.108 (0.052)
Age	0.068 (0.010)*	0.161 (0.040)*	0.075 (0.062)
Age-squared	-0.0007 (0.0001)*	-0.002 (0.0007)*	-0.0008 (0.0006)
Gender[b]	-0.180 (0.083)*	-0.228 (0.097)*	-0.122 (0.152)
Intercept	0.344 (0.189)	-0.800 (0.549)*	0.281 (1.387)
Sample Size	235	130	105
R^2	0.39	0.31	0.08

a. Dependent variable: log of daily wage = log of average monthly income minus log of average number of days worked in past 12 months; standard errors in parentheses; "*" represents statistical significance of 5 percent.
b. Male = 0; Female =1.

Table 6 indicates that, controlling for several factors, presence of severe-OSD decreases the daily wage of workers by approximately 16%. Running the regression for two sub-samples: "young" (ages 15-35) and "experienced" (35+) indicates that the adverse impact of severe-OSD is slightly higher for the relatively older plantation workers. Those with intermediate manifestations of OSD earn approximately 10% lower than those who are non-OSD. Also, age significantly increases the daily wage of relatively younger plantation workers only. Furthermore, in general, women tend to have significant lower daily wages than men.

Estimation of Labor Supply Function: Next, we estimate the labor supply function for permanent workers. The model estimated is:

$$ln\ S = b_1\ ln\ W^* + b_2\ O + b_3\ \boldsymbol{X} + e$$

where, *S:* Average number of days worked per month in the past year.
W: Daily wages earned.
O: Severe OSD = 1.
X: Vector of control variable: age and gender.[15]

Table 7 reports the estimation results. We use instrumental variable estimation techniques since the number of days worked -- among other factors -- is also a function of daily wages, which are endogenous in our model.

Table 7. Instrumental Variables Estimation of Labor Supply Function for Permanent Workers[a]

Variables	All	Age 15-35	Age 35+	
Log of Daily Wage	0.427 (0.093)*	0.724 (0.153)*	0.052 (0.170)	
Severe-OSD	-0.020 (0.018)	-0.005 (0.027)	-0.043 (0.022)*	
Age	-0.003 (0.001)*	-0.004 (0.003)	0.001 (0.001)	
Gender[b]	-0.126 (0.047)*	-0.107 (0.070)	0.000 (0.056)	
Intercept	2.727	2.322 (0.116)*	3.21 (0.172)*	(0.328)*
Sample Size	235	130	105	

a. Dependent variable: log of average number of days worked per month in the past 12 months; standard errors in parentheses; "*" represents statistical significance of 10 percent.
b. Male = 0; Female = 1.

As can be seen from Table 7, the labor supply of older plantation workers appears to be significantly adversely affected by severe-OSD (after controlling for wage effects). Therefore, there are two avenues through which OSD impacts productivity and income-generating capacity, at least for older workers: the first is the "direct" negative impact on days worked. Older permanent employees work significantly fewer days per month (reduction of approximately 4% on average upon controlling for other factors) if they have severe-OSD. The second is the "indirect" impact whereby those with severe-OSD not only work fewer days but also earn lower wages -- as

[15] Data limitations preclude the inclusion of other household-level controls at this stage of the analysis.

is evident from the coefficients in the estimated wage equation in Table 6 -- which in turn has an additional depressant effect on labor supply.

Discussion

This paper is a study of the impact of OSD on the economic productivity of plantation workers at the Teppi coffee plantation in southwest Ethiopia. Analysis of data from plantation records indicates that the economic impact of OSD is a function of various factors including type of employment, age, and gender. In our sample, relatively older (35+), permanent, male employees have the biggest OSD-related loss in economic productivity in terms of diminished earnings and an adversely-impacted labor supply. In more general terms, OSD causes diminished daily earnings to the order of 10-15%. In other subgroups, such as temporary workers, OSD appears not to have a discernible impact on productivity. This may be due to several factors including confounding effects of alternate income sources, plantation demand driven employment, and small sample size.

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