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Mr Basta

TO : Mr. Clell G. Harral
Chief, Transport Research Division
FROM : Basil P. Coukis
DATE : 11 June 1976

MEETING WITH MR. R. OJIKUTU RE HEALTH/NUTRITION STUDIES

1. At the suggestion of Mr. Jaycox, Mr. Basta and I met with Mr. Ojikutu and discussed with him his possible involvement in the health/nutrition aspects of the SOL.

2. Mr. Ojikutu is a work physiologist and has studied with Professor B.S. Platt at Oxford. He has worked with the Nigerian Medical Research Council and he has carried out a WHO study on the performance of industrial workers. Both Mr. Basta and I were impressed with the descriptions he gave us of the work he has done in the health/nutrition field.

3. Mr. Ojikutu is currently teaching anthropology (and not at all enjoying it) in the University of Maryland. He would like to work in his field of specialty and this is why Mr. Jaycox suggested the meeting.

4. We described the scope and objectives of the SOL and the role that health/nutrition research is expected to play in the design and implementation of labor-intensive programs. Mr. Ojikutu expressed great interest.

5. We suggested that he reads (a) the reports on health/nutrition that we already have and (b) the Status Reports on the SOL so that he becomes more familiar with the precise nature of our activities. We also suggested that he prepares a research outline which will :

(a) summarize the findings available and (in the case of Kenya) expected
(b) identify areas of useful work for the future in Kenya and, possibly, Honduras
(c) list the practical steps that could come out of (a) and (b) with respect to the design of an efficient program of interventions specifically intended to increase labor productivity in civil construction projects.

6. Mr. Ojikutu has promised to bring us copies of his work in the health/nutrition field and I very much want to introduce him to you. He will telephone sometime on Monday 14 June and I would appreciate it if you could let me know of a time during the coming week when you could see him.

BPCoukis/bb

cc. Mr. Basta

8th October, 1979

Dr. C.G. Harral,
HDM Advisor,
Transportation Department,
The World Bank,
Washington D.C.,
U. S. A.

I will shortly send a short note updating the baseline productivity relationships.

Thank you for the paper on income distribution in Brazil - I shall read this with interest. I should be grateful for some information about the proposals you made to me concerning further work on the Highway Design Study as I shortly have to take decisions concerning my consulting commitments for 1980/81.

With best wishes,

Yours sincerely,

Andrew Chesher

Enc.

The University of Birmingham

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Logged 10/15/79

(1) cc Mr Best, Mr Carl...
(2) CGH.

ADC/LML

8th October, 1979

Dr. C.G. Harral,
Highway Design and Maintenance Advisor,
Transportation Department,
The World Bank,
1818 H. St. N.W.,
Washington D.C. 20433,
U. S. A.

Dear Clell,

I enclose copies of my report on the dietary supplementation experiment in Kenya. I have also sent copies to Michael Latham and to Mark Sharrock. I must apologise for producing this rather later than I had promised. My visit to Cornell produced some data on "days worked" which I had not expected to be able to use. Introducing this into the analysis improved matters substantially but did mean that, on my return to England, more computing (and thinking!) was needed than I had originally expected.

The main results of the analysis are that the intervention did produce some effects on productivity and on workers' physique. The effects are not very substantial and as we expected the small sample size has led to rather imprecise estimates. However an effect of supplementation on productivity has been found which advances the work in the area. In my report, which I hope is not too difficult to follow, I have devoted some time to discussing the effect of the relatively high rate of drop out of workers from the study. I believe these points are important and may lead us to systematically under estimate the benefits from dietary supplementaion.

As I have indicated in the report it will be useful to incorporate the home food consumption information. It may be that, per calorie consumed, productivity is higher than our results suggest though in practice if substitution of home food for work food occurs then it is our present equations that provide the appropriate magnitudes. The socio-economic data which is presently at Cornell may well be of use to the Bank. The interesting feature of the data is that we have attendance records for each worker as well as some measures of the attractiveness of their alternative opportunities.

/...

THE EFFECTS OF DIETARY SUPPLEMENTATION ON ROAD CONSTRUCTION WORKERS: KENYA HEALTH AND NUTRITION STUDY

Andrew Chesher

University of Birmingham, England

and Consultant to the World Bank

October, 1st 1979.

I N T R O D U C T I O N

The effects of dietary supplementation administered at two levels to road construction workers involved in heavy manual work in Kenya are investigated.

Productivity and anthropometric measurements were obtained on workers before and after an intervention lasting about 90 days during which a mid-day meal with either a calorific value of between 200 and of 1000 kilocalories was provided. In this report the data obtained are described in some detail, and a series of relatively simple models are developed. These models allow the effects of the intervention on productivity directly, on workers' physical attributes and through them on productivity to be assessed.

Estimates are produced for the models. These suggest that gains in productivity can be achieved via dietary supplementation and that these gains are achieved partially by changing the physical attributes of the workers. These attributes have already been shown to be related to productivity (see Chesher (1979)).

Considerable problems are caused by the sporadic attendance of individuals for work and for feeding, and by workers dropping out of the project. The implications of these factors are discussed and it is suggested that they may result in the effects of the intervention being understated. It seems likely that under a different payment method these problems would have been more severe.

The report falls into three sections: Data, Models and Data Problems, and Estimation and Interpretation.

D A T A

139 road construction workers were observed during the Kenya Health and Nutrition study. During a period of approximately one month during June/July 1978 productivity measurements were taken on 121 of these workers. Anthropometric and health status data was also obtained. The workers were involved in ditching, sloping and excavation in bulk and were set tasks on each day. On completion of a day's task a worker could leave the site. When the productivity measurements were taken, tasks were marked out in linear metres along the length of the road and workers' starting and finishing times were recorded on a number of days (from one to fourteen days depending on the attendance record of the worker). The average time for task completion was about four hours. An estimate was made of the volume of soil worked by each individual on each day and volume divided by time to give a measure of the productivity of each individual on each day that he worked. Productivity was measured in cubic metres per man hour (m^3/mh). Wage rates averaged US $1 per day.

After initial productivity measurements were taken the workers who continued to attend the site were given dietary supplementation in the form of a light mid-day meal. Workers were assigned to a control group or an experimental group, the former receiving a meal with calorific content of 200 kilocalories, the latter one with a content of 1000 kilocalories. This feeding proceeded for about 90 days.

Halfway through this period and at its conclusion, repeat anthropometric data was obtained on the workers who were still attending. At the conclusion of the intervention, repeat productivity measurements were taken. A considerable number of workers dropped out of the study - a contributory factor being the movement of the work on the road through the country, away from the homes of the workers initially measured. Both pre and post intervention productivity measurements were taken on 49 workers.

During the intervention, information was obtained on socio-economic attributes of the workers and on their home food consumption. Neither data sets were available when this analysis was performed. A record was kept of the number of days on which each worker was fed and the number of days that each individual worked during the intervention.

The workers were observed at two roads: Road 7, Mururini to Kibirigwi in Kirinyaga District and Road 12 at Kiamicho Forest in Murangu District. Alternative opportunities for the workers were better at Road 7 than at Road 12. In the neighbourhood of Road 7 land is fertile and cashcrops are grown. In the neighbourhood of Road 12 the soil is less good, the climate is drier and few cashcrops are grown, livestock farming being more common. Supervision was somewhat better at Road 7 being mostly red coffee soil. At Road 12 soil conditions were more variable, weathered rock, black cotton soil and some red coffee soil being worked. Most of the work at Road 7 was classified as excavation in bulk; most of the work at Road 12 was classified as ditching, sloping or ditching and sloping.

No formal record was kept of site conditions during the intervention. However, the general view is that soil conditions generally deteriorated somewhat as the intervention proceeded.

For reasons outlined in an earlier report (Chesher (1979)) the activities "ditching", "slopping" and "ditching and sloping" were considered as one activity which is termed "ditching".

Because of the significant drop out rate every effort was made to retain workers in the analysis. Workers were included in the data set even if they had only one day's productivity data at each measurement stage. Individuals with incomplete anthropometric or health status data were also retained, although they were not used in estimating equations which required such data. Unfortunately it was necessary to delete a very few females from the data set. It was felt that their reactions to the intervention might differ from the male's and there were insufficient females to enable fully or partially distinct models to be estimated for them. It was also necessary to delete from the data set a few individuals who had attended for the productivity measurements but had failed to attend the study at any other time. The resulting data set pertains to 42 workers, 21 observed at Road 7 and 21 at Road 12, (no worker attended both sites). The 21 workers at Road 12 were all observed in the ditching activity; the workers at Road 7 were observed mainly in the excavating activity though some ditching was also observed at Road 7. 16 of the 42 workers were in the control group and 26 were in the experimental group.

At Road 7 some workers were observed at more than one activity and some individuals were observed in different activities at the start and conclusion of the intervention. So that pre and post intervention comparisons could be made for as many workers as possible, a rather adhoc adjustment was made using the productivity relationships given in an earlier report on this study (Chesher (1979)). It was noted there that productivities were on average 0.38 m^3/mh higher in excavation than in ditching and the adjustment made involved converting both pre and post intervention productivities to ditching or excavating equivalent productivities, as necessary, by adding 0.38 or subtracting 0.38 from the observed productivities, as appropriate. Where an individual was observed in the two activities at a single measurement stage a weighted average of the actual and equivalent productivities was taken with "days observed" as weights. The data set analysed here consists of pairs of average productivities (relating to pre and post intervention measurement), associated anthropometric and health status data, number of days fed and worked and level of caloric supplementation. 5 workers were observed in two activities both before and after the intervention and those individuals appear in the data set twice. In all there are 47 worker/activities combinations present in the data set examined here.

The models applied to the data are now outlined.

MODELS AND DATA PROBLEMS

The material contained in this section is necessarily somewhat technical. The main points are summarised in the concluding paragraphs on page 10. The problem relating to dropouts from the sample raised in paragraph 1 on page 9 is most important and that section should not be omitted.

The model proposed here is similar to that outlined in the earlier report on this study (Chesher (1979)). It is supposed that productivity (or some transformation of it, e.g. log (productivity))for worker i on day t at measurement stage k, x^k_{ti}, is related to the attributes of the worker (or transformations of them) d^k_{mi}, $m = 1 \ldots M$ by:

$$(1) \quad x^k_{ti} = a^k + b_1 d^k_{1i} + b_2 d^k_{2i} + \ldots + b_m d^k_{mi} + u^k_{ti}$$

$k = 0$ represents a pre-intervention measurement, $k = 1$ represents a post-intervention measurement. The a's and b's are unknown coefficients though estimates of a^o and the $\overset{o}{b}$'s are contained in Chesher (1979). u^k_{ti} is a stochastic error term which may have an "error components" structure so that u^k_{ti} can be written as

$$(2) \quad u^k_{ti} = e^k_t + v^k_i + w^k_{ti}$$

here e^k_t is an error component specific to a day, v^k_i is a component specific to an individual and w^k_{ti} is a "pure" error term.

The average productivities for individual i are given by (3), where $\bar{u}^k_i = \bar{e}^k_i + v^k_i + \bar{w}^k_i$, and

$$(3) \quad \bar{x}^k_i = a^k + b_1 d^k_{1i} + b_2 d^k_{2i} + \ldots + b_m d^k_{mi} + \bar{u}^k_i$$

The change in individual i's productivity over the intervention is given by (4). Note that $\bar{e}^k_i$ differs from person to person because not all individuals were observed on the same days:

$$(4)\quad \bar{x}_i^1 - \bar{x}_i^o = (a^1 - a^o) + b_1(d_{1i}^1 - d_{1i}^o) + b_2(d_{2i}^1 - d_{2i}^o) + \ldots\ldots + b_m(d_{mi}^1 - d_{mi}^o) + (\bar{u}_i^1 - \bar{u}_i^o).$$

The intervention can affect productivity in two ways. It can change the attributes of the workers (the d_{mi}), for example by raising aim circumferences or haemoglobin levels. The effect of these changes on productivity is measured in (4) by the b's. The intervention can also affect productivity without passing via the d_{mi}'s - these effects will appear as changes in a, that is a^1 will be different from a^o and to a different extent depending on the nature of the intervention for the individual concerned. These direct effects perhaps arise because of a greater feeling of "well being" on the part of workers who have received mid-day meals or because of psychological effects associated with being chosen for the experimental group. These effects might be expected to be rather small. To allow for these "direct" effects $a1 - a^o$ is written as a function of the variables related to the intervention, possibly interacting with workers' attributes.

The "indirect" effects of the intervention on productivity can be measured in two ways. Relationships between changes in the d_{mi} (the workers attributes) and the level of supplementation can be specified as in (5), where g_{mi} is an error term.

$$(5)\quad d_{mi}^1 - d_{mi}^o = c_m + f_m \text{ (level of supplementation}_i) + g_{mi}$$

$$m = 1 \ldots\ldots M.$$

(5) can be estimated for each attribute in turn and the predicted changes in the attributes combined with the estimated b's (4) to give the "indirect" effects of the intervention. Alternatively (5) can be substituted into (4), thus eliminating the $(d_{mi}^1 - d_{mi}^o)$'s so that the change in productivity is related directly to variables pertaining to the intervention. Equations (4) and (5) are both of interest, as is the equation giving the combined "direct" and "indirect" effects; therefore all these

equations are examined in the next section. Attention is now turned to the statistical problems which arise in the analysis.

In estimation the error components structure of the error in equation (4) is ignored. The rationale for this is that by averaging, the time related component will be small, and that the worker specific component will disappear in differencing. A difficulty arises if the $\bar{e}_i^k$ are correlated with individual attributes or with non-contemporaneous productivities. This might occur if workers of particular types attended for measurement on days when work was, say, particularly arduous. It is supposed that this is unlikely to occur.

The resulting error term in equation (4) is necessarily heteroscedastic because different individuals were observed for different numbers of days. It is assumed that $\bar{u}_i^1$ and $\bar{u}_i^o$ are statistically independent and have common variance. In this case if a worker is observed for N_{oi} days prior to and N_{1i} days posterior to the intervention the variance of $\bar{u}_i^1 - \bar{u}_i^o$ is proportional to $\dfrac{N_{oi}+N_{1i}}{N_{oi}\ N_{1i}}$ - accordingly weighted least squares was used in the analysis reported here with weights equal to $\left[\dfrac{N_{oi}\ N_{1i}}{N_{oi}+N_{1i}}\right]^{\frac{1}{2}}$ This is particularly appropriate in the light of the fact that workers with only one day's productivity measurement at any measurement stage are among those included in the data set.

For the application of straight forward single equation estimation techniques to the model to produce estimates with good properties it is necessary that equation (4) and (5) form what is known as a fully recursive system (see e.g. Theil (1971), pp. 460-463). Essentially this means that the variables that describe the intervention should be exogenous to the system and that the error terms in equations (4) and (5) should be statistically independent. If the second assumption is thought to be suspect then estimates of equation (4) should be viewed septically but estimates of equations (5) and (6) (see below, (6) relates changes in productivity to the intervention alone, the changes in attributes being excluded) will still possess good properties.

Workers attended intervention for differing periods - as a result it does not make sense to compare directly the pre- and post- intervention productivities of the experimental and control groups. Information on days fed was available for each worker and a variable was constructed to represent the total caloric supplementation of each worker. This variable, denoted TK, was defined as TK = Days fed x 0.2 for the control group and TK = Days fed x 1.0 for the experimental group. The dimension of TK is therefore 1000's of kilocalories/day x days fed.

When the intitial analysis was performed it was found that TK was only weakly associated with productivity change, in some equations actually being inversely related to it, an increase in TK being associated with a decrease in$(\bar{x}^1 - \bar{x}^o)$. It was realised that the work being performed at the site could be debilitating and this could explain the result. The longer a worker attended the site the more he worked and if the level of supplementation was insufficient to make up for the physical wear and tear he experienced whilst working,TK would show this effect. Fortunately, though rather late in the analysis, information on days worked (DW) became available. Though quite highly correlated with TK and with days fed,the inclusion of the variable in the analysis allowed a reasonable effect for TK to be estimated. The variable DW can be regarded as measuring the debilitating effect of the work being performed while TK measures the improving effect of the intervention, though at least one other interpretation is possible. The close relationship between TK and DW should not be forgotten when the results reported below are used. In practice individuals will be fed only when they work and for the purpose of prediction days fed and days worked should be kept approximately equal. The point made in the next paragraph also bears heavily on prediction.

The major problem that arises with this data results from the drop-out rate experienced during the intervention. A substantial number of workers attended the intervention for less than its full period (see Table 1) and many did not appear for the final productivity measurements - only those who did are included in this analysis. If it is the case that attendance for the duration of the intervention is related to the productivity gain that was, or might have been achieved, then the estimates reported in the next section may be seriously biased. One way in which this might happen is as follows.

As work proceeded on the road during the intervention the road progressed through the country. Wage rates on the road were low for the districts in which they were being constructed and it is likely that workers with good alternative work opportunities (perhaps on their own farms) would be those most likely to leave the project. The work being performed was task work. When an assigned task was completed, an individual was able to return to his home and to his alternative work opportunities. The incentive to work hard and return a high productivity was the attractiveness of returning home and to those opportunities. Those with few opportunities would not be inclined to work hard and complete their task quickly, yet it is precisely these individuals who are most likely to remain on the project and to appear in the final data set. Is it likely that caloric supplementation will greatly affect the productivity of workers who are not working at full capacity? If not, then using the sample of workers that we have here, the effects of the intervention may be difficult to determine and it is possible that the effects estimated are smaller than those that would be obtained if, say, workers were employed on a piece-work basis. Introducing the variable "days worked" as well as TK (total calories) may help to lessen these biases, for workers with good opportunities elsewhere, who are more likely to be working to their full capacity and therefore to show productivity gains from the intervention will be those with low values for days worked. We would expect days worked to take a negative coefficient under these circumstances even if the work was not debilitating. If days worked removes some of the effect of the differential dropout rate then the coefficient on TK may be a truer representation of the effect of the intervention. Clearly the coefficients on TK and "days worked" must be interpreted with care.

The information on socio-economic attributes could be usefully employed to gain some understanding of this problem. Indeed the data (as yet not available) could be useful in its own right for the information that it could give us on the micro-economics of labour productivity.

During the analysis models were fitted by unweighted and weighted least squares. The results obtained by the two methods were similar as far as coefficients were concerned and the weighted least squares estimates are preferred as the summary statistics associated with them are likely to give a truer picture of the accuracy of the estimates. Equations were fitted using the change in the logarithm of productivities as dependent variable but the results were generally inferior to those obtained using change in productivity directly. Only the latter results are reported here.

It is useful to summarise the contents of this section. Three models are proposed for the change in productivity of the 42 workers retained in the data set. The first (Equation (4)) relates changes in productivity to the intervention and to changes in workers' attributes over the period of the intervention. The intervention variables, here pick up the direct effects of the intervention, those effects which do not arise through changes in the workers' attributes. The coefficients obtained on the changes in the worker's attributes should be similar to those obtained in the previous report (Chesher (1979)) in which pre intervention productivity was related directly to workers' attributes.

$$(4) \quad \bar{x}_i^1 - \bar{x}_i^o = (a^1 - a^o) + b_i(d_{1i}^1 - d_{1i}^o) + b_2(d_{2i}^1 - d_{2i}^o) + \ldots + b_m(d_{mi}^1 - d_{mi}^o) + (\bar{u}_i^1 - \bar{u}_i^o)$$

$a^1 - a^o$ = function of intervention,

d^k_{mi} are worker's attributes

$k = 0$ or 1 for pre or post intervention

$\bar{u}^k_i$ are random errors.

The second model (Equation (5)) relates workers' attributes to the variables describing the intervention. By combining (5) with (4) the

$$(5) \quad d^1_{mi} - d^o_{mi} = c_m + f_m \text{ (intervention)}_i + g_{mi}$$

change in productivity can be related directly to the intervention and this yields the third model (Equation (6)). The way in which the

$$(6) \quad \bar{x}^1_i - \bar{x}^o_i = \text{(function of intervention alone)}$$

intervention related variables enter these models is described in the next section. It should be noted that the dropout rate together with the nature of the payment method during the project may result in the effect of the intervention being understated in the estimates reported below. Attention is now turned to these estimates. The variables used in the next section are described below in Table 2.

TABLE 1

DAYS WORKED AND DAYS FED FOR 42 WORKERS IN DATA SET

	Days Worked (No's of Workers)		Days Fed (No's of Workers)	
	Road 12	Road 7	Road 12	Road 7
1 - 10	1	0	2	0
11 - 20	1	0	0	1
21 - 30	0	0	2	2
31 - 40	0	0	2	3
41 - 50	3	2	2	4
51 - 60	1	2	3	4
61 - 70	3	0	1	5
71 - 80	2	5	7	2
81 - 90	5	3	2	0
91 - 100	4	7	0	0
101 - 110	1	2	0	0
TOTAL	21	21	21	21

TABLE 2

VARIABLES - NOTATION AND DEFINITIONS

Note, throughout $k = 0$ denotes pre intervention, $k = 1$ denotes post intervention

$\bar{x}^k$	Productivity - average over days observed for each worker in each task (m^3/man hour).
E	$E = 0$ for control group workers, $E = 1$ for experimental group workers.
TK	Total calories provided in supplement. TK = Days fed x 0.2 for control group, Days fed x 1.0 for experimental group (1000's of kilocalories/day x days fed)
DW	Days worked (days)
AC^k	Arm circumference (mm)
TS^k	Triceps skinfold (mm x 10)
W^k	Weight as of percentage of standard weight for height (see Chesher (1979) for details) (percentage points).
MA^k	Muscle area, $MA = \pi\left[\frac{(AC}{2\pi} - \frac{TS/10)}{2}\right]^2$, (MM^2)

E S T I M A T E S   A N D   I N T E R P R E T A T I O N

As a first step the differences in productivity achieved by the control and experimental groups were compared. This was done by performing weighted least squares on the equation $\bar{x}^1 - \bar{x}^o = a_o + a_1 E + (\bar{u}^1 - \bar{u}^o)$ where E is a dummy variable equal to one for the experimental group workers and zero for the others. The results are shown below (Equation 7)(). This is a special case of equation (6),

$$(7) \quad \bar{x}^1 - \bar{x}^o = \underset{(.58)}{.0254} + \underset{(1.84)}{.1030E}$$

$$S = .3415 \qquad n = 47$$

and is really only meaningful if all individuals in a group received identical treatment. The increase in productivity is 0.10 m^3/mh greater for the experimental group than for the control group whose productivity increased by .03 m^3/mh. The average pre intervention productivity of all workers in the data set was .787 m^3/mh. The added gain shown by the experimental group is significantly different from zero at the 10% level.

From the discussion of the preceding section it should be clear that the members of each group did not receive identical treatment. Attendance at the sites was sporadic and individuals were not necessarily fed on all days that they worked. The intervention is better represented by the variable

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() Estimates are weighted least squares estimates unless otherwise stated. Figures in parentheses are t-ratios, i.e. ratios of coefficient estimates to their standard error. "n" is the number of observations used in the estimation and varies from equation to equation because of missing data. "s" is an estimate of the standard deviation of the error term in the weighted regression. "R^2", where reported, is the squared coefficient of multiple correlation obtained in unweighted estimation of the equation. The subscript i is ommited from the variables.

"total calories received", TK, defined as Days fed x 0.2 for the control group and Days fed x 1.0 for the experimental group. The units for TK are Days fed x 1000's of kilocalories per day.

Introducing TK alone produces disappointing results (see Equation (8)). TK is negatively associated with productivity gain and apparently the more workers are fed the less the gain in productivity that is achieved. However, the coefficient on TK is close to zero and the effect is not strong.

$$(8) \quad \bar{x}^1 - \bar{x}^o = \underset{(2.23)}{.1000} - \underset{(-.37)}{.000352}\ TK$$

$$S = .3536 \qquad n = 47 \qquad R^2 = 1.26$$

Fortunately, information on days worked is available and introducing this together with TK produces equation (9).

$$(9) \quad \bar{x}^1 - \bar{x}^o = \underset{(4.69)}{.3517} + \underset{(1.81)}{.00179}\ TK - \underset{(-3.93)}{.00451}\ DW$$

$$S = .3076 \qquad n = 47 \qquad R^2 = .226$$

Days worked has a strong negative effect on productivity gain but TK now has a positive effect, significant at the 10% level. Equation (8) and (9) can be thought of as special cases of equation (6), that is as estimates of the total effect of the intervention. As can be seen from equation (9), the coefficient on DW is overtwice as large as that on TK. This might be taken to indicate that the level of caloric supplementation was insufficient to make up for the debilitating effect of the work. Noting that TK = DW x 1000's of kilocalories provided per day (written TK = DW x k), equation (9) can be written as

$$(10) \quad \bar{x}^1 - \bar{x}^o = .3517 + (-.00451 + .00179k)\ DW$$

In order to obtain a zero coefficient on DW in (10), k must be equal to 2519 kilocalories per day. The supplementation actually received by the experimental group was 1000 kilocalories per day. These results should be viewed somewhat sceptically. The coefficient on TK is not well determined though its standard error is similar in magnitude to that obtained for DW's coefficient. Further, a supplement of 2500 kilocalories per day is outside the experience of this study and predictions at this level of supplementation are gross extrapolations. Also, the high negative coefficient on DW may be caused, at least in part, by workers with incentive to work hard dropping out of the study. Such workers would show higher gains in productivity than the others and would work fewer days, as was noted earlier. The possibility of interactions between workers attributes and TK was investigated but very little of importance was found. It appeared that individuals with initially low haemoglobin levels benefited least from the intervention but the coefficients concerned were very poorly determined and they are not reported here. The possibility that productivity gains might differ at the two roads was also investigated but no such effect was found.

The effects of changes in workers' attributes on productivity gains are now considered. Unfortunately no post- intervention data are available on the health status variables. Data are available on post- intervention arm circumference and weight as a percentage of standard weight for height. These variables are introduced one at a time, with the intervention variables, TK and DW, yielding equations (11) and (12). In equation (13) muscle area is included().

Equations (11) - (13) are special cases of equation (4).

() Muscle area (MA) is related to arm circumference (AC) and triceps skinfold (TS) by $MA = \pi \left[\frac{AC}{2\pi} - \frac{TS/10}{2} \right]^2 \quad MM^2$

(See Frisancho (1974)). In this formula bone area is ignored.

ARM CIRCUMFERENCE (AC)

$$(11)\quad \bar{x}^1 - \bar{x}^o = \underset{(4.37)}{.3535} + \underset{(1.21)}{.00128\ TK} - \underset{(-3.63)}{.00441\ DW} + \underset{(1.75)}{.00152\ (AC^1 - AC^o)}$$

$$S = .3091 \qquad n = 41 \qquad R^2 = .295$$

WEIGHT AS A PERCENTAGE OF WEIGHT FOR HEIGHT (W)

$$(12)\quad \bar{x}^1 - \bar{x}^o = \underset{(3.34)}{.2629} + \underset{(1.19)}{.00113\ TK} - \underset{(-3.11)}{.00353\ DW} + \underset{(3.50)}{.0310\ (W^1 - W^o)}$$

$$S = .2788 \qquad n = 41 \qquad R^2 = .341$$

MUSCLE AREA (MA)

$$(13)\quad \bar{x}^1 - \bar{x}^o = \underset{(3.74)}{.3746} + \underset{(1.21)}{.00131\ TK} - \underset{(-3.27)}{.00469\ DW} + \underset{(1.76)}{.0000480\ (MA^1 - MA^o)}$$

$$S = .3118 \qquad n = 40 \qquad R^2 = .303$$

In each of (11)- (13) the change in attributes variable is statistically significant and gains in attributes are associated with gains in productivity. In each case the coefficient on TK drops as is expected in the context of the model previously outlined, TK now measures only the "direct" effects of the intervention. It is interesting that the coefficients on arm circumference and muscle area are similar to those obtained on an enlarged data set relating pre intervention productivity directly to worker's attributes (i.e. estimating equation (1), see Chesher (1979) and a further report to be completed shortly; the comparisons are .00152 and .00171 for AC, .0000480 and .0000727 for MA). This result, which lends support to the models used here, does not hold when weight (W) is included. This variable had given trouble in the pre- intervention analysis and it is recommended that equation (12) is not used for prediction.

If the estimates in equations (9), (11) and (13) are accepted then it seems that approximately 70% of the effects of the intervention are "direct", or come through health status variables, and the remainder come through changes in worker's attributes(). The average changes in AC etc., are shown in Table 3.

In the model outlined earlier the changes in workers' attributes which appear in equation (11) - (13) are themselves related to the intervention variables. Estimating these relationships completes the model. Changes in each of the attributes arm circumference, muscle area, triceps skinfold and weight as a percentage of weight for height were related in turn to the intervention variables TK and DW. The results are shown in equations (14) - (17).

$$(14)\quad (AC^1 - AC^o) = \underset{(.46)}{8.418} + \underset{(1.46)}{.3040\,TK} - \underset{(-.55)}{.1418\,DW}$$

$$S^2 = 1031.7 \qquad n = 41 \qquad R^2 = .054$$

$$(15)\quad (MA^1 - MA^o) = \underset{(.54)}{374.22} + \underset{(1.42)}{9.716\,TK} - \underset{(-.55)}{5.308\,DW}$$

$$S^2 = 1102829.7 \qquad n = 40 \qquad R^2 = .052$$

$$(16)\quad (TS^1 - TS^o) = \underset{(.02)}{0.564} + \underset{(1.48)}{.3482\,TK} - \underset{(-.42)}{.1393\,DW}$$

$$S^2 = 1311.27 \qquad n = 40 \qquad R^2 = .058$$

$$(17)\quad (W^1 - W^o) = \underset{(1.43)}{2.286} + \underset{(.91)}{.01685\,TK} - \underset{(-1.15)}{.02630\,DW}$$

$$S^2 = 8.0574 \qquad n = 41 \qquad R^2 = .037$$

(Estimates are ordinary least squares estimates)

() From equations (9) and (11) the coefficients on TK are .00179 and .00128 Division gives .715, hence 70%. Unfortunately there has not been time to investigate the effect of introducing combinations of anthropometric variables in equations like (11). Multicollinearity amongst these variables

In each equation TK is associated with attribute gains and DW with attribute losses. For all the variables except weight,TK's coefficient is larger in magnitude than DW's coefficient though the relationshipsare all very weak and most of the coefficientsare insignificant at customary levels. This result lends support to the view that DW istaking negative coefficients because it picks up the effect caused by those worker's most likely to be working to their full capacity leaving the project early because of better alternative work opportunities at home. If the work were truely debilitating why would DW have so much less effect upon attribute changes than TK? As before the weight variable behaves peculiarly, the intervention apparently having very little effect on weight as a percentage of standard weight for height.

In estimating these equations a variety of variables were tried to improve their explanatory power. Some nonlinearity was detected in the effect of TK but the estimates were imprecise and are not reported here. The phenomenon of regression towards the mean, (i.e. that individuals with low arm circumferences, say, show higher gains in arm circumference than others) was investigated but no evidence for this was found.

It may be useful to summarise the results reported here. Relating change in productivity directly to total caloric supplementation and days worked (Equation (9)) shows a positive effect for the intervention and a negative effect for days worked. This latter effect may be due to the debilitating nature of the work or be caused by the early departure from the project of the workers who were not likely to show a good reaction to the intervention or both. If the days worked effect is believed to be associated entirely with the debilitating nature of the work then a supplement of about 2500 kilocalories seems to be necessary to offset this effect. A 1000 kilo-calorie supplement administered for 80 days increases productivity by .14 m^3/mh if the days worked effect is ignored, while a 200 kilocalorie supplement over the same period produces an increase of only .03 m^3/mh. These gains are small and the points made earlier which suggested that the estimates obtained with this sample of workers might be biased downward are relevant.

Changes in attributes like arm circumference and muscle area are significantly and positively related to changes in productivity (Equation (11), (13)). Introducing these changes in to the equation reduces the effect of total calories supplementation by about 30% which may be taken to suggest that the direct effects of supplementation are important. The effect on the days worked coefficient of introducing changes in attributes is much smaller and this lends support to the view that DW is not associated with the possibly debilitating nature of the work.

Changes in attributes are weakly associated positively with total calories and very weakly, negatively, with days worked (Equation (14) - (16)). 1000 kilocalories provided for 80 days is predicted to increase arm circumference by 24 mm, muscle area by 777 mm^2, and triceps skinfold by 2.8 mm.

Great care should be taken in extrapolating any of these equations. Clearly productivity and attribute gains cannot go on for ever; the relationship between these changes and supplementation are certainly non-linear but the data available do not allow the non linearities to be estimated. The time dimension is crucial in using the equations. The intervention lasted for 50 to 90 days depending on the worker and days worked was generally slightly larger than this. It would be foolhardy to employ these equations to predict the effect of a 200 day intervention or of a very substantial supplement. Further the working conditions and payment method should be borne in mind. Average productivity was around 0.8 m^3/mh and payment was by task work. Under a high incentive payment scheme such as piece work or under task work at good wages with workers who have a good alternative work opportunities, the intervention would have been more successful.

Much useful work remains to be done with these data despite the relatively small sample size. The introduction of the information on home the intervention. Using the socio-economic data will help to correct for the biases introduced by workers dropping out of the project which at present is only partially allowed for, if at all, by the use of the days worked variable.

TABLE 3

MEAN, STANDARD DEVIATION AND RANGES OF VARIABLES USED IN THE ANALYSIS

VARIABLE	UNITS	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
$\bar{x}^o$	m^3/mh	0 .787	0 .194	0.444	1.281
TK	Days fed x 1000's of Kilocalories /Day	37.8	28.0	1	88
DF	Days fed	53.2	21.3	1	88
DW	Days worked	76.0	21.5	6	104
AC^o	MM	250.8	17.3	213	279
TS^o	MM x 10	47.6	12.8	25	100
W^o	Percentage	80.15	8.23	64.8	110.0
MA^o	MM^2	4454	658	-	-
$\bar{x}^1-\bar{x}^o$	m^3/mh	0.065	0.175	-	-
AC^1-AC^o	MM	10.26	32.95	-	-
TS^1-TS^o	MM x 10	4.13	36.34	-	-
W^1-W^o	Percentage Points	0.949	2.88	-	-
MA^1-MA^o	MM^2	374	1061	-	-

TABLE 4

SIMPLE CORRELATIONS AMONGST VARIABLES USED IN THE ANALYSIS

	$\bar{x}^1 - \bar{x}^o$	TK	DW
TK	-.060	-	-
DW	-.374	.510	-
$AC^1 - AC^o$	.285	.229	.037
$W^1 - W^o$	.412	.080	-.125
$MA^1 - MA^o$	.305	.223	.023

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Theil, H. (1971) Principles of econometrics, North-Holland Publishing Company, Amsterdam-London.

July 24, 1979

Professor Peter Hopcraft
Institute of Development Studies
University of Nairobi
P. O. Box 30197
Nairobi, Kenya

Dear Peter:

Thanks for sharing a copy of your recent letter to Samir concerning Latham's project.

I was distressed to learn of your orthopedic problem and hope that you're on the mend. Your ailments probably are indicators of administrative achievement. All of us who spend too much time sitting at desks are vulnerable, while field people and others on the move do quite nicely, thank you.

Your comments on the Latham project are intriguing. I would like to hear more. I'm planning to be in Nairobi again for a day in early September enroute back from India. Maybe we can meet for a chat; I expect to find you leaping about like a swala tomi.

Thanks again for the letter.

With warm personal regards.

Sincerely yours,

James Greene
Senior Nutrition Specialist
Nutrition Division
Ag. & Rural Development Department

bcc: Mr. S. Basta, AGRNU

JGreene:jm

File Kenya Res.

Rec'd July 11/79

UNIVERSITY OF NAIROBI

INSTITUTE FOR DEVELOPMENT STUDIES

TELEGRAMS: "VARSITY" NAIROBI
TELEPHONE: NAIROBI 334244
337293/4

P.O. Box 30197
NAIROBI. KENYA

Dear Samir:

I agreed to consult on Michael Latham's project. I have had a number of meetings with the various people involved in Nairobi and also visited Kwale where the project work is currently going on. I have mapped out with Michael the areas where I might contribute and the nature of my contribution. The next step is purely putting pen to paper.

The problem is I had a lower back disc problem which, while it made the Kwale trip painful (and made me a rather troublesome guest of Michael and Lani's) did not completely incapacitate me. Unfortunately, on the way back in the train to Nairobi I developed a second spinal problem that sent extraordinary pain down my arm.

The doctor put me straight onto my back in a heavily drugged condition and this note , ten days after my leaving Kwale, is the first thing I have been able to do (even now from a position of traction).

Unfortunately this orthopedic problem of mine has seriously thrown out my work schedule for the summer which was a tight one. I have had to withdraw from projects in Tanzania and Botswana. A further IBRD project for the Kenya Government is now closing in on me and that is something from which I cannot withdraw.

I now have much of the material that I plan to put into my first report on the Latham project. The task is one of drawing it together. In some respects it will not quite coincide with your original terms of reference, partly because most of the data gathering was complete by the time I entered the project. Any contribution I may have made in those areas was purely verbal with the other project participants. I shall now try to pull together my initial report and get it to you as soon as possible, consistent with my physical condition.

My general impression is that while it would not be legitimate to pretend that conclusive findings in the area of nutrition health and worker productivity can be drawn from the study thus far, largely because of a number of unforseen problems with the research, a great deal of excellent groundwork has been done in the area of the health and nutritional state of labourers in different parts of the country at different periods. In view of what I regard to be the appropriate

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extent of the labour-intensive public works activity that should be undertaken over the years ahead, quite apart from the labour-intensity of most private sector economic activity, it is clear that this groundwork has very significant economic implications.

We clearly do not have the evidence to say that government feeding programs are justified in labour-intensive public works projects. I also happen to be one of those who are skeptical about food-for-work programs in general, largely because they do not build up a sustainable ~~substantial~~ local system of producing and marketing food and frequently undermine it. Nevertheless, health and nutritional factors as significant economic constraints, especially in certain seasons and for certain segments of the population, have been brought to light by the project. Another useful feature of the project is the very practical experimentation with ways of handling those constraints. There are, therefore, useful proposals and policy prescriptions that can already be drawn from the study.

Given the research problems that have arisen, especially in the area of labour productivity measurement, I believe that a number of useful insights are available from this study that should be borne in mind for any further efforts to investigate the nutritional and health determinants of labour productivity in a quantitative fashion, whether these are in the form of an extension to the existing study or represent fresh research undertakings.

It is some thoughts in the above areas that I hope to make the topic of a brief preliminary paper.

My regrets again that I have not been a better correspondent keeping you abreast of my activities and thoughts in relation to this study.

Yours sincerely,

Peter

Peter Hopcraft

cc: Mr. C. Harral TRP
Mr. J. Greene AGRNU
Mr. E. Schebeck AGRNU
Dr. M. Latham (Kenya)

Samir S. Basta
Nutrition Division
Agr. & Rural Dev. Dept.

Janssen Pharmaceutical Limited

Janssen House, Marlow, Bucks SL7 1ET
Telephone: Marlow (06284) 71744
also from London on 75 28416
Telex: 847788 Cables: Janpharm Marlow

Mr S S Basta

From: R Levin

With Compliments

Janssen Pharmaceutical Limited

Janssen House, Marlow, Bucks SL7 1ET
Telephone: Marlow (06284) 71744
Telex: 847788 Cables: Janpharm Marlow

RL/DA

12 July 1979

Dr A Jansen
Medical Research Centre
Nairobi
KENYA

Dear Dr Jansen

Your name has been given to me by Mr Clel Harral, to whom I had written following my reading of World Bank Technical Memorandum No. 26 dated May 1977.

In the Memorandum I noted in particular paragraph 67 which recommended that the Kenya Ministry of Works "should shoulder some responsibility for the well being of its workers, thereby improving productivity, increasing health, setting an example to other employers and to the general public and other government departments etc."

I had written to Mr Harral asking whether, to his knowledge, the Ministry of Works acted on the above-mentioned recommendation and whether any attempt has been, or is being, made to control the intestinal worm burden by means of the simple, safe and reliable anthelmintics which are presently available such as those used by Dr Latham (i.e. levamisole) in World Bank Working Paper No. 271, with which project I believe you are now also associated.

In November 1975 Janssen Pharmaceutica n.v. of Belgium, our parent company, issued a brochure, of which I enclose a copy, in which you will note a leading statement to the effect that for use in mass worm eradication programmes the Company is prepared to provide supplies of its two major anthelmintics, mebendazole and levamisole, at especially low prices and my purpose in writing this letter is to re-confirm this position and ask if you could make that known to the relevant personnel in the Ministry of Health or conversely could inform me the identities of the individuals to whom that offer should be made known.

I look forward to hearing from you.

Yours sincerely

Denise Angus

pp R Levin
Deputy Chairman

cc Mr S S Basta

P.S. I would be grateful if you could pass the duplicate of this letter to Dr Latham, who is I believe visiting with you at this time.

SB/File

UNIVERSITY OF NAIROBI

INSTITUTE FOR DEVELOPMENT STUDIES

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P.O. Box 30197
NAIROBI. KENYA

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Can you follow up on this?
Ed

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extent of the labour-intensive public works activity that should be undertaken over the years ahead, quite apart from the labour-intensity of most private sector economic activity, it is clear that this groundwork has very significant economic implications.

Why?

[illegible] that's not the issue

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Yours sincerely,

Peter Hopcraft

cc: Mr. C. Harral TRP
Mr. J. Greene AGRNU
Mr. E. Schebeck AGRNU
Dr. M. Latham (Kenya)

Samir S. Basta
Nutrition Division
Agr. & Rural Dev. Dept.

Kenya Research

MRC

Medical Research Council

MRC Environmental Physiology Unit (Annexe)
242 Pentonville Road
London N1 9LB

telephone 01-837 7842

reference KJC/ET.

11th July 1979.

Dr. S.S. Basta,
Nutrition Expert,
Nutrition Division,
Agriculture and Rural Development Dept.,
The World Bank,
1818 H Street,
N.W., Washington D.C.

Dear Dr. Basta,

Thank you for your most helpful letter of July 2nd. and your cogent suggestions concerning the work we are pursuing in the Sudan on work performance and schistosomiasis. I was also extremely pleased to have the reprints of your work on related problems.

I am hoping that we will be able to simplify the conduct of the field work by using Oxylog instruments for recording oxygen consumption on the spot and there will then be more opportunity to undertake studies on self-paced tasks without the presence of observers. Haemoglobin levels, as you so rightly point out, are closely correlated with egg load and aerobic capacity. The reason why the levels were higher in the second study compared with the first study on cane cutters I think may partly be due to a different technique of measurement. I am extremely interested in work on this aspect which Dr. Latham is conducting in Kenya and I would be grateful if you would be good enough to let him know of our interest in this area. We also have plans to apply our work performance approach to people with malaria.

We have attempted to make assessments of the factors involved in the economic analysis of work output and schistosomiasis in the Gezira area of Sudan. It is, as you know, possible to make gross errors in an economics balance sheet unless at least one knows that the important parameters are adequately estimated and defined. We are naturally cautious about such predictions, even privately, because we are aware that such figures can be used out of context.

My thanks to you again for your helpful remarks which we will have in mind during our forthcoming investigations.

Yours sincerely,

K J Collins MBBS.DPhil.

~~(1) EMS~~
(2) File Kenya Research

July 2, 1979

Dr. Michael C. Latham
P.O. Box 96192
Mombasa
Likoni, Kenya

Dear Michael:

Kenya: Health & Nutrition Study

We are closing accounts for the fiscal year which prompts a quick letter on administrative aspects. First, as noted in your letter of appointment of April 7, 1978, you are required to submit an invoice (or accounting) of expenditures at the end of each calendar year. The first was in fact due last December 31, but I cannot find it on our files. If you did prepare it then, please have your secretary send me another copy. If you did not prepare it at that time, it would be acceptable to us if you wish to wait until, say, November or even December of this year and cover both years in one accounting. However, we will require this accounting before the next payment can be made -- which as you know is provisionally planned for December 1, 1979, at the beginning of Phase II.

A more important requirement before we can proceed to Phase II is that we have some reasonably complete draft report from you on the results of Phase I (Studies 2, 3 and 4) and that this be discussed in a Bank seminar. We are flexible as to the timing of this except that it must be done before we can take formal decision on the continuation of the study or issue any further payments. If you require the next payment by December 1, then you should submit a report adequate as a basis for the seminar by about October 1; we would require about four weeks to circulate the paper within the Bank before we can hold the seminar which you (and Lani, if you desire) would address. We would also require some reports or written input from Peter Hopcraft, although we do not envisage at this time that he would be required to attend the seminar in Washington.

On the issue of Hopcraft we are a bit concerned that he may be finding no time for this work. The only written communication we have had from him was months ago, when he indicated in accepting his letter of appointment that he would be delayed by about six months. Jim Green, a colleague of Samir's in the Nutrition Division, saw Hopcraft when he passed through Nairobi a few weeks ago. Hopcraft at that time indicated he would be working on the project shortly and was planning to submit a suggested work program -- but we have so far received nothing. If he has not in fact brought some serious effort to bear before you have left Kenya, then we shall be forced to think of cancelling Hopcraft's contract and turning to someone else. Nicholas Prescott at Magdalen College Oxford has been quite interested in this work and might be a good choice. But hopefully you will have already gotten substantive help from Hopcraft.

So much for the administrative aspects. I trust all is going well as to the substantive aspects of the work. I am enclosing herewith copy of a letter just received from Andrew Chesher commenting on the comments by Basta and Chernicovsky which we earlier sent you.

With renewed best wishes.

Sincerely yours,

C.G.H

Clell G. Harral
Highway Design & Maintenance Adviser
Transportation Department

Enclosure

CGHarral:phm

cc: Messrs. E.Schebeck/S.Basta, AGR

July 2, 1979

Mr. Nicolas Prescott
Magdalen College
University of Oxford
Oxford, OX1 4AU
ENGLAND

Dear Mr. Prescott:

Many thanks for your letter and the helpful comments and suggestions. I think it would be advisable for you to contact Andrew Chesher directly about these, expressing your interest in the study, your previous work, and your correspondence with us. His address is:

Dr. Andrew Chesher
The University of Birmingham
Department of Economics
P. O. Box 363
Birmingham B15 2TT
England
Tel: 021-472-1301, Ext. 2569

I am sending you a copy of Technical Memorandum No. 4 on the India study. As you will note, the study is incomplete and inconclusive. We had some problems with the communities at that time because they understandably confused anyone looking faintly medical with certain zealots connected with vasectomies. I will ask Michael Latham, upon his return here in July, to forward you a copy of his studies on cane-cutters in Jamaica. I'm afraid I cannot locate my copy.

My plans have changed for the summer and it will not be possible for me to go to Europe until at least October. I do hope, however, that we can keep in touch. Thank you very much for the additional reprints on schistosomiasis and your outline for WHO. Dr. Collins of MRC has also contacted me, and I have sent him some ideas for his studies in the Sudan.

Yours sincerely,

Samir S. Basta
Nutrition Expert
Nutrition Division
Agriculture and Rural
Development Department

Enclosure

SSBasta:jm

June 29, 1979

Dr. R. Levin
Deputy Chairman
Janssen Pharmaceutical Limited
Janssen House
Marlow, Bucks, SL7 1ET
ENGLAND

Dear Dr. Levin:

In reply to your letter dated June 4, Dr. D. W. T. Compton and his staff at Cambridge University are responsible for some of the parasitology determinations for Research Study RPO 671-15. Dr. A. Jansen of the Royal Dutch Tropical Institute, now at the Medical Research Center, Nairobi, is I believe the principal investigator for previous and current long-term studies on ascariasis (independent of the World Bank research grant).

Since Mr. Clell Harral passed on to me a copy of the letter you sent him on June 21, may I suggest you contact Drs. Latham and Jansen directly for the interesting and worthwhile recommendations you make for mass worm eradication. Your offer should also of course go to the Ministry of Health. We in the Bank cannot recommend your firm or any other to the Government of Kenya. As far as Ministry of Works is concerned, I was informed a year ago that they would find it logistically very difficult to implement and follow-up any <u>mass</u> eradication campaigns. They made it clear that that is not their responsibility.

Yours very sincerely,

Samir Sanad Basta
Nutrition Expert
Nutrition Division
Agriculture and Rural
Development Department

cc: Mr. C. Harral, TRP

SSBasta:jm

Joy please send a copy of this to Latham in Cornell, with my reply - and file under Kenya.

Janssen Pharmaceutical Limited

Janssen House, Marlow, Bucks SL7 1ET
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also from London on 75 28416
Telex: 847788 Cables: Janpharm Marlow

RL/DA

4 June 1979

Dr S S Basta
Nutrition Expert
Nutrition Division
Agriculture & Rural Development Dept
World Bank
1818 H Street NW
Washington DC 20433
U.S.A.

Dear Dr Basta

I have received your 29 May complete with attachments, for which I am extremely grateful.

Thank you also for the more complete version of your earlier work on anaemia/hookworm, published recently in the American Journal of Clinical Nutrition, of which I was not previously aware.

I note that the long-term de-worming programmes in Kenya are currently under way and are under the supervision of Professor M Latham and Dr L Stevenson-Latham of the Department of Nutritional Sciences, Cornell University, with whom, as you have suggested, I will now make direct contact.

I have seen both in Report No. 271 and in your letter of 29 May a reference to involvement in the Kenya study by Cambridge University (U.K.) but without identification. I would be grateful if you would be kind enough to let me know who is involved at Cambridge University since, in the first instance, this would be the easiest person with whom to make direct personal contact. I would be grateful also for the identity of members of the Royal Dutch Tropical Institute who are involved since these too would be very accessible.

I have noted your availability through 1979 and hope to catch up with you at one or other location during the year.

Please don't hesitate to let me know if there is any way in which we can be of help with the project.

Yours sincerely

R. Levin

R Levin
Deputy Chairman

Dear DR ~~Levin~~

~~Before his~~

Because of DR. Samir Basta's unavailability this month ~~he has asked me~~ I am foreswarding a copy of your letter to

FORM NO. 75
(9–78)

THE WORLD BANK

ROUTING SLIP	DATE: 6/26/79

NAME	ROOM NO.
1) ~~Basil Coukis's~~ BHC	
2) Sami Basta	
Let's discuss when I return 7/3/79. CGH	

	APPROPRIATE DISPOSITION		NOTE AND RETURN
	APPROVAL		NOTE AND SEND ON
	CLEARANCE		PER OUR CONVERSATION
	COMMENT		PER YOUR REQUEST
	FOR ACTION		PREPARE REPLY
	INFORMATION		RECOMMENDATION
	INITIAL		SIGNATURE
	NOTE AND FILE		**URGENT**

REMARKS: Sami: I'm not sure whether you feel the evidence is strong enough to merit a massive worm control effort & even if we did I'm not sure that the Kenya MOW would be the appropriate implementing agency. However, we should not dodge the issue & should pursue the matter somehow if it has merit.

FROM: CGH	ROOM NO.:	EXTENSION:

File
Kenya Res.
Logged 6/26/79.

Janssen Pharmaceutical Limited

Janssen House, Marlow, Bucks SL7 1ET
Telephone: Marlow (06284) 71744
also from London on 75 28416
Telex: 847788 Cables: Janpharm Marlow

RL/DA

21 June 1979

Mr Clell Harral
Transportation Department
World Bank
1818 H Street NW
Washington DC 20433
U.S.A.

Dear Mr Harral

I have just seen a copy of World Bank Technical Memorandum No. 26 dated May 1977, kindly provided to my colleague, Mr Nicholas Prescott, here in Oxford by your colleague, Dr S S Basta.

I have noted in particular Paragraph 67 of the memorandum, which recommended that the Kenya Ministry of Works "should shoulder some responsibility for the well being of its workers, thereby improving productivity, increasing health, setting an example to other employers and to the general public and other government departments etc."

My purpose in writing is to ask whether, to your knowledge, the Ministry of Works acted on your recommendation and, more particularly, whether any attempt has been or is being made to control the intestinal worm burden by means of the simple, safe and reliable anthelmintics which are presently available such as that used by Dr Latham (i.e. levamisole) in World Bank Working Paper No. 271.

In so far as we are willing to provide bulk supplies of levamisole tablets or mebendazole tablets at especially low prices for mass worm eradication programmes, perhaps you would care to recommend to whom, at the Ministry of Works in Kenya, our proposal should be addressed so as to maximise the likelihood of implementation.

I look forward to hearing from you.

Yours sincerely

R Levin
Deputy Chairman

TELEX 22022

June 29, 1979
73294

INTBAFRAD

NAIROBI, KENYA

PLEASE PASS JUDY EDSTROM KRAFFT. 1. WOULD YOU BE AVAILABLE JOIN APPRAISAL MISSION FOR TAMIL NADU (INDIA) NUTRITION PROJECT AS EDUCATION SPECIALIST/FINANCIAL ANALYST BEGINNING AROUND JULY 26? PROPOSED $50 MILLION IDA PROJECT INVOLVES RESTRUCTURING NUTRITION DELIVERY AND PRIMARY HEALTH CARE SYSTEMS COVERING SIX OF STATE'S 14 DISTRICTS. ALSO INCLUDES MAJOR NUTRITION EDUCATION EFFORT AND SUBSTANTIAL MONITORING AND EVALUATION COMPONENT. 2. FRANCIS LETHEM, WHO TOOK PART IN PREAPPRAISAL SUGGESTED WE EXPLORE YOUR POSSIBLE INTEREST. BELIEVE YOU COULD ASSIST MISSION IN TWO PRINCIPAL AREAS ON WHICH PREAPPRAISAL DATA ALREADY AVAILABLE: (A) COLLABORATING WITH EXPERIENCED COMMUNICATIONS MARKETING SPECIALIST IN APPRAISING THAT COMPONENT WITH PARTICULAR REFERENCE TO ITS ORGANIZATION, MANAGEMENT, SCHEDULING AND COSTS AND (B) PREPARING DETAILED PROJECT COST TABLES BY COMPONENT. 3. ASSIGNMENT WOULD INVOLVE THREE WEEKS FIELD WORK FOLLOWED BY REPORT WRITING WASHINGTON. 4. PLEASE PHONE ME FOR FURTHER DETAILS OR TELEX COMMENTS SOONEST. REGARDS

SCHEBECK, INTBAFRAD

India Nutrition

JGreene:jm

cc: Mr. R. Carriere, AGRNU

Emmerich M. Schebeck

AGR

June 4, 1979

Dear Peter:

I hope you received another copy of the terms of reference as well as the recently written reports by Michael Latham and Andrew Cheshire on the Nutrition/Productivity Research, which I forwarded to you.

We understand from James Greene that you informed him while he was briefly visiting Kenya on a stopover that you will be commenting in writing to us as regards your proposed work program for this project. Since we have not as yet heard from you, I assume that you are discussing this with Michael, who is at present in Kenya. It would be helpful if you could therefore forward to us a formal note or a letter outlining what you have agreed upon.

While Michael Latham is of course the primary investigator, both Clell Harral and I as supervisors of the project, have an obligation to the Research Committee to report on the progress of this research.

Thus, some clear indication from you on the course you intend to follow to supplement the nutrition/productivity data and its implications, will be most helpful for our next progress report.

Hoping all is well with you.

Sincerely,

Samir S. Basta
Nutrition Division
Agr. & Rural Dev. Depart.

Dr. Peter Hopcraft
Institute of Development Studies
University of Nairobi
P.O. Box 30197
Nairobi, Kenya

cc: Mr. C. Harral, TRP
Mr. J. Greene, AGRNU
Mr. E. Schebeck, AGRNU
Dr. M. Latham (Kenya)

SSBasta:mw

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF
HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

(1) cc Berg: lets discuss Kenya Res. Possibly you may wish to send copies of the letter to Chesher before Crompton are attached. If your nutritionist colleagues judge the progress is adequate, I suggest respond affirmatively to all 4 points of Latham's on p. 3.
Cl
(2) cc Conhaim
(3) file

March 23, 1979

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

Lani and I returned last week end from 10 weeks of intensive work on the World Bank/ODM supported project in Kenya. We also had brief stopovers in London where on two occasions we met with both Andrew Chesher and Mark Sharrock.

In general I am pleased with the progress that we have made, with the level of cooperation that we are receiving and with the performance of the various members of our team.

Dr. David Crompton (from Cambridge), Dr. Lani Stephenson and myself spent the greater part of January in the two villages in Machakos District doing the annual examinations on some 800 children (pre-school and school) for Study No. 4. The work included clinical, nutritional, anthropometric and stool examinations on each child. All were given an anthelminthic. Attendance was very satisfactory. The main cause of missing children is that they are not in the locality at the time of our examination. Our two Kenyan field workers, Ms. Esther Ndunda and Ms. Rose Nzuki, appear to be doing a good job. They are responsible with a little supervision, for the provision of anthelminthics at home and school to each child on two occasions (May-June and September-October) between each January. Stools have been taken to Cambridge for examination. As stated before, this study will yield important data not only on control of intestinal parasites, especially round worm (Ascaris), but also will provide a very useful set of longitudinal growth data for Kenyan children. This is something that does not exist and which many people believe will be of very great interest to planners, health workers, and others. While in Machakos, Dr. Stephenson organized a full day workshop/seminar for the primary school teachers from Kanzalu and Mwatati Primary Schools. Dr. Jansen (from MRC Nairobi), Dr. Crompton and I assisted Dr. Stephenson by giving presentations at this seminar on local health and nutrition problems, and their control. The workshop was so successful that we have been asked to provide a "session" or "baraza" for the public and the local chief. This kind of educational activity may be quite valuable.

In mid January we spent a few days in Kwale making preparations for the work there in February. Terry Elliott (Cornell nutritionist) who has been resident in Kwale doing the first anemia studies will remain there until July 1979. June Wolgemuth (Cornell nutritionist) and Andrew Hall (Cambridge parasitologist) moved in January to Kwale from Karatina where the work is complete. Both will remain in Kwale until June or July 1979 working on the project.

Dr. Crompton spent a few days in February in Kwale helping with the planning of the projects there and then returned to Cambridge. Dr. Stephenson and I were in Kwale for all of February and the early part of March 1979. Work was devoted mainly to Study No. 2d which is an evaluation of the control of hookworm, schistosomiasis and malaria, and their relationship to the anemia which is prevalent among workers, and which is related to low work output.

We received excellent cooperation in Kwale from the new RAR Engineer, Mr. Sauerlia. He is interested in our project, and goes out of his way to provide assistance.

A decision was made to work on 4 road sites in order to be sure that our N was well over 150 which was the number planned. We therefore completed examinations on the following roads:

Road 4 (Near Shimoni)	58 workers
Road 30 (Near Tiwi)	63 workers
Road 17 (Near Msambweni)	39 workers
Road 19 (Near Likoni)	57 workers
Total	217 workers

The examinations included clinical and nutritional status assessment; anthropometric (weight, height, skinfold thickness, arm and chest circumference); blood (for hemoglobin, hematocrit and malaria); stool (for parasites); and urine (for schistosomiasis ova and other abnormalities). Although these data have not been analyzed we found that around 60% were infected with hookworm, about 35% with urinary schistosomiasis, and between 30-40% have hemoglobin levels below 13 g/100 ml, the WHO cut off point for anemia. The malaria slides are being examined in Cambridge and full results are not yet available.

Before I left Kwale in March we had also almost completed dosing all workers with Combantrin (perhaps the best anthelminthic against hookworm) and those workers found to have schistosomiasis (S. hematobium) were treated with Metrifonate. On Road 4 and Road 30 we had divided the workers into two matched groups of equal size, and with nearly similar mean hemoglobin rates, and levels of infection with hookworm and schistosomiasis. One group of about 60 subjects will receive a malaria prophylaxis (chloroquine) each week and the second group will receive a placebos each week. This will allow us, as proposed, to assess the feasibility and possible benefits of a malaria prophylaxis over a period of about 12 weeks.

These road sites seem very satisfactory, and all should be in operation until June-July 1979 when the final examinations will be done. There is a risk with Road 30 because there are some problems with regard to property compensation for farms through which the road is passing.

As mentioned earlier, Lani and I met with Mark Sharrock and Andrew Chesher in London both on our way to Kenya (on January 5, 1979) and on our return in mid-March 1979. Andrew has almost completed a report to you which will be self explanatory. From what we learnt he has done a very thorough job, and has found some interesting relationships between health and nutritional status on the one hand, and work output on the other. The analysis so far undertaken is based only on the cross-sectional base-line findings. Andrew does need to be provided with further funding for perhaps 3-4 weeks work in July or August to undertake the rest of the analysis including that on the results of intervention. When that is done a discussion about a further productivity study should be held. We discussed with Andrew a possible visit by him to Cornell this summer when he will be in the U.S. on some other mission.

Because of the pressure of work we were not able to do either of the new 10-14 day ecological zone studies in new parts of the country (Study No. 3). It is my proposal that we do one of these probably in Western Kenya near Kisumu in June 1979 and the second one in an arid region (perhaps West Pokot, Baringo or Kitui) in February 1980. This then is one way in which we will not follow our time table as included in the proposal.

I am with a separate letter sending you some accounts in respect to the Range Rover. This vehicle is invaluable to us but is very costly to maintain (repairs) and to run (gas guzzling).

I wonder in the next few weeks if you could respond to the following:

(1) Provide your agreement to doing the two ecological zone studies in June 1979 and February 1980 as stated above. OK

(2) Comment on the possibility of having Andrew Chesher completing the analysis. OK

(3) Indicate that you can reimburse us for the Range Rover repairs, details of which you will have received. ?

(4) Confirm that funds for year 3 of the project are assured as budgeted. These are of course essential for completion of the project and to allow analysis of the data being collected. OK

In conclusion then, I am quite satisfied with this phase of the work. The first three months of the year have been very productive. We were also impressed with the smooth transition in Kenya following the death of President Kenyatta. President Moi seems to be very popular, and the new government have indicated their increased concern for rural development and in dealing with problems of poverty. It is also clear that there is a greatly increased interest in nutrition.

With all good wishes.

Sincerely,

Michael

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

cc? S. Basta
L. Stephenson
A. Chesher
M. Sharrock

May 29, 1979

Mr. R. Levin
Deputy Chairman
Janssen Pharmaceutical Limited
Janssen House
Marlow, Bucks SL71ET
ENGLAND

Dear Mr. Levin:

Thank you for your letter of May 17, 1979. I am glad you find the summaries of our working papers on hookworm and ascariasis research interesting.

In reply to your queries, we are currently funding further long-term (three years) deworming programs in Kenya in order to ascertain:

(i) reinfection rates;
(ii) longitudinal growth patterns of children with and without worms;
(iii) further options for national planning strategies and refinement of costs for ascariasis control.

These studies are being carried out in the field by Professor M. Latham and Dr. L. Stephenson-Latham of the Department of Nutritional Sciences, Cornell Univessity, Ithaca, New York 14853, to whom you should address any further inquiries regarding the technical aspects of this study. Cambridge University (U.K.) and the Royal Dutch Tropical Institute are also involved in the Research.

With reference to your second query regarding the affects of anemia on learning behaviour, I suggest you consult the paper by E.D. Pollit et al - Behavioral Effects of Iron Deficiency among Pre-school Children in Cambridge, Massachusetts, Federation Proceedings 37 487, 1978.

I will be in Washington during the month of July, in Egypt during early September and in Washington or Senegal during October. However, it would be more worthwhile for you to meet with Drs. Latham and Stephenson-Latham since they are the principal field investigators. They will be in Kenya from early June to mid-July and back at Cornell during September.

I am enclosing a copy of Working Paper No. 271 and a more complete version of my earlier work on anemia/hookworm which was recently published in the American Journal of Clinical Nutrition.

Yours sincerely,

Samir Sanad Basta
Nutrition Expert
Nutrition Division
Agriculture and Rural
Development Department

Enclosures
cc: Dr. Michael Latham (Cornell University)
Mr. C. Harral (TRP)

SSBasta:jm

May 25, 1979

Dr. Dov Chernichovsky
Health and Welfare Economics
Ben Gurion University
P. O. Box 653
Beersheva 84 120, Israel

Dear Dov:

Thank you very much for your comments on A. Cheshire's paper regarding the interim results of Stage I of the Kenya research. I found these to be very useful, and Clell and I are sending copies to Drs. Cheshire and Latham.

As regards your stopping off in Kenya on your way to Botswana, it would be difficult at the moment to arrange this. Dr. Latham has already left for Kenya and he will mostly be in Kwale (around the Mombasa area), where he will be hard to reach. It would be more worthwhile for us to wait until Cheshire sends us his replies to your comments, and we could then arrange for you to meet with him in Birmingham or London at a later date. Dr. Latham is in any case, mainly involved at present in evaluating some feeding and parasite control studies South of Mombasa (Stage II of the research).

The 'productivity' research in the North has more or less terminated at this stage, so these would be little for you to see in the field. I will of course inform you about any subsequent follow-up work.

With reference to the kind invitation to lecture at your University, I cannot accept this at the moment for reasons that you are no doubt aware of. More can be said on this when you are next here. As regards Brazil, tentative agreement was reached during my last mission to fund the analytical group in IBGE among other things. Shlomo will probably brief you more fully on this. We will also go ahead with some nutrition questions in the forthcoming demographic survey. When you are next in Washington you should check with us whether these activities indeed will take place. If they do, we can talk about possible roles for you.

Best regards to you and the family.

Sincerely yours,

Samir S. Basta
Nutrition Expert
Nutrition Division
Agriculture and Rural
Development Department

PS: You might find pp. 715-716 and pp. 916-925 in the April issue of the American Journal of Clinical Nutrition (32, No. 4, April 1979) of some interest.

cc: Mr. T. King (DED)
Mr. C. G. Harral (TRP)
Dr. M. Latham

SSBasta:jm

International Bank for Reconstruction and Development

International Finance Corporation International Development Association

ADMINISTRATIVE CIRCULAR

AC/24/79

May 25, 1979

File
Kenya
Research

STAFF ANNOUNCEMENT

I am pleased to announce the promotion of Mr. Shankar Acharya as Research Adviser, Development Policy Staff, to be effective July 1, 1979.

Mr. Acharya, an Indian national, joined the Bank through the Young Professionals Program in October 1971. Since his graduation from the Program in 1972, Mr. Acharya has worked as an economist in the Development Policy Staff and the Eastern Africa Regional Office. Since July 1978 he has been directing the core team engaged in the preparation of World Development Report, 1979.

Martijn J.W.M. Paijmans
Vice President
Administration, Organization, Personnel Management

File Kenya Research.

The World Bank / 1818 H Street, N.W., Washington, D.C. 20433, U.S.A. • Telephone: (202) 393-6360 • Cables: INTBAFRAD

May 22, 1979

61251

Dr. Dov Chernichovsky
Health and Welfare Economics
Ben Gurion University
P.O. Box 653
Beer Sheva 84 120, Israel

Dear Dov:

On or about June 17, 1979 you should travel to Botswana to assist in the preparation of, and to participate in, the seminar based on the Botswana Rural Income Distribution Survey, Research Project 671-61. The seminar will be held in Gaborone, Botswana between June 26-29.

You may stay in Botswana until about July 5, 1979 to follow up on any necessary post-seminar arrangements.

On your way to or from Botswana you may stopover in Nairobi for a day or two. There you will meet Mr. Gerhart of the Ford Foundation and discuss with him the progress of the Botswana project. If an arrangement is worked out, you may also meet, per the request of S. Basta, AGRNU, with Dr. Latham's team working on Nutrition and Productivity (RPO 671-15).

? did not request

Sincerely,

Timothy King
Chief
Population & Human Resources Division
Development Economics Department

cc: Mr. S. Basta, AGRNU ✓
Mr. B. King, DEDDR
Ms. O. Meesook, DEDPH
Mr. R. Sullivan, EA1

WORLD K / INTERNATIONAL FINANCE CORPORATION

File Kenya Research File

OFFICE MEMORANDUM

TO: Mr. S. Basta, AGR

DATE: May 21, 1979

FROM: D. Chernichovsky, Consultant, DEDPH

DC

SUBJECT: Comments on "Worker Productivity and Its Relation to Physique and Health" by A. Chesher

1. I read with great interest this paper on which you asked me to comment.

2. Mr. Chesher undoubtedly invested much time and energy in exploring the data in spite of the small sample size, the limitations of which are well recognized in the paper.

3. The basic problem I have is that the paper takes a pure statistical approach which does not acknowledge or make use of any prior knowledge about structural or particular functional relationship among variables. Consequently, although the data may have been explored extensively, one does not get the impression that all that could have been said with these data was indeed said. Moreoever, the paper is very technical; it is a "dry" statistical report with no discussion of issues.

4. I suggest the following added steps to the statistical work:

a. The basic model (p.3) should be explored with the logarithmic relationship

$$\log X = a_0 + a_1 \log D_1 + a_2 D_2 + U$$

(or some similar Semi-log variant) where D_1 denotes the vector of continuous variables and D_2 denotes the vector of dichotomous variables taking the values of either "0" or "1." Such a relationship will, first, give the estimated function more "flexibility" by allowing for (even) slight non-linearities. Second, this will allow for interaction among all the variables--which is most likely to exist and can be justified on a priori grounds--and should improve the results significantly. Third, the logarithmic specification is more consistent with the likely log-Normal distribution of the productivity measure and of the random disturbance term. Fourth, the estimated coefficients will be comparable "dimension free" elasticities which can be easily interpreted.

b. "Age" should be kept as a continuous variable, and the "infection" variable could possibly be somewhat diaggregated. If the linear estimate of the equation provides the best fit, "Age" and "Age" squared could be used.

c. The number of days (observed) for each individual should be kept in the equation as an independent variable of some form. First, the number of days work, within a given time period, is known to be positively correlated with productivity; it accounts for experience, persistence, etc. Second, the averaging and subsequent use of weighted least squares seems fairly arbitrary and may "destroy" some interesting variation in the data. Using each day of observation as an observation will also "weight" the coefficients. I would devise a "calendar" for the observation period by assigning number to days, not individuals, of observation (either 1....n, or even better -k....-2, -1, 0, 1, 2, 3....+k). Thereby each observation will have a date. This date will capture any productivity effects of days worked as well as seasonality that may exist in the data.

d. There is little, or no, justification for using z-scores on the regression analysis. Mr. Chesher acknowledges this point, and justifies using z-scores for comparability with another study. Well,.....

e. Although colinear, it is of interest to show an equation including both "W" and "AC."

f. Equation 4, which in terms of coefficients is almost identical to equation 2, could be eliminated.

g. The model should be estimated with the male population only. The "sex" variable is colinear with everything else and may be responsible for the insignificance of "W." In any event we are likely to get different results from those reported. Sex-specific estimates are also more relevant from a policy viewpoint. Unfortunately, the female sample is too small for a comparable exercise.

5. The paper can be shortened considerably, and greatly enhanced by adding a biomedical as well as a behavioural (socioeconomic) discussion.

6. All the above can be accomplished with a minimal marginal effort given the work already done by Mr. Chesher. He may wish to collaborate with somebody on these matters.

7. Per your suggestion, I may stopover in Kenya, in conjunction with your project, for two or three days on my way to Botswana, about mid June, or from Botswana, about the beginning of July. The air fare and my time is DEDPH Gratis (as usual!). However, we cannot pay my subsistence and related expenses in Kenya from our Botswana project. Please clear such a stopover with T. King.

cc: Mr. C. Harral, TRP
Mr. T. King, DEDPH

DChernichovsky:lkt

① Send a copy to Latham with my reply please.
② File Kenya Res.

Janssen Pharmaceutical Limited

Janssen House, Marlow, Bucks SL7 1ET
Telephone: Marlow (06284) 71744
also from London on 75 28416
Telex: 847788 Cables: Janpharm Marlow

RL/JPW

17 May 1979

The World Bank
1818 H. Street N.W.
Washington DC 20433
USA

Attention: S.S. Basta, Agriculture & Rural Development Department, (Nutrition Division)

Dear Mr. Basta,

I have recently seen and read with great interest the summaries of two working papers Nos. 175 and 271 in which you have had a hand.

I am currently studying the relatively sparse literature describing studies on the social and economic benefits of mass worm eradication programmes and therefore found your studies both helpful and stimulating. I would be grateful for copies of the complete papers and, indeed, any others relevant to this subject prepared by yourself or colleagues. For example, the summary of Paper No. 271 refers to "additional studies will explore the feasibility and costs of large scale treatment." ?

With reference to Paper No. 175, Summary para. 4, you state "affects of anaemia on women and on the learning behaviour patterns of schoolchildren is documented in other studies." I would be grateful for the relevant references.

Perhaps I should mention that Janssen discovered both mebendazole and levamisole which are widely used for worm eradication and that moreover Janssen has made known its willingness to provide supplies of these drugs at specially favourable terms for use in worm eradication programmes - cost falling to as little as 10-12 cents per annum per person.

After reading the full reports, I suspect that I will feel that personal discussion could be helpful in dealing with unanswered questions. If so, where and when would you be generally available during the months of July, September and October of this year? Are there any other colleagues or contacts with whom you would recommend me to discuss the implications of the studies?

Yours sincerely,

R. Levin

R. Levin
Deputy Chairman

Sonia Baston

60012

WORLD BANK / INTERNATIONAL FINANCE CORPORATIC

OFFICE MEMORANDUM

671-73

Update last one

File Kenya Research.

TO: Supervisors of External Research Projects

DATE: April 30, 1979

FROM: Suman Bery, VPD SKB

SUBJECT: Project Narratives

1. In preparing the 1979 edition of the Abstracts of Current Studies booklet, we plan to retain substantially the same format followed last year. On this basis and following the guidelines set out below, I would appreciate it if you would prepare, by c.o.b. Thursday, May 31 a narrative on the research project(s) that you supervise. Your draft of 3-4 pages (double spaced) should consist of a main narrative section followed by three summary sections on project responsibility, completion, and published reports.

2. Though coverage will vary among projects, the Narrative Section should deal with the following:

(i) The Project Framework: The nature of the topic being considered; the approaches taken so far and how this research project differs from or improves upon other studies in the same area of concentration, and how the Bank has so far dealt with the problem being considered. For research that evaluates Bank development projects, the project should be described in some detail.

(ii) Objectives and Strategy: This discussion, with the one on methodology, forms the major part of the narrative. It should address the issue of the usefulness of this study for Bank policy and operations, for policymaking agencies in developing countries, and more generally, for the development community? It would be helpful if you could make explicit why the Bank and not a university or some other institution has undertaken this research. Include here, or as a separate paragraph, a description of the output(s) expected from the project. If the study is carried out in phases, describe how the current phase builds on earlier ones (enumerating major findings from these earlier phases) and how it lays the groundwork for further analysis.

(iii) Methodology: Describe, as appropriate, the features of the model structure used; how surveys have been designed and carried out;

how different portions of the research relate to each other. Avoid equations, but do not hesitate to elaborate on technical aspects you feel are essential for a clear understanding of the project.

(iv) Outputs of the project (if not covered elsewhere), and planned extensions of the work.

3. The narrative should end with three Summary Sections giving the following information:

(i) Responsibility: The names of the Departments, Bank staff members, and consultants involved in the project. For research with collaborating institutions, list their full names and locations and summarize their contributions to the research design and execution. In addition, this section should also indicate whether government ministries or other public agencies are involved, through awareness and approval, if not active participation.

(ii) Completion Date: The month and year in which the project is expected to be completed. Please be more specific than "final report is being prepared."

(iii) Reports: List the books, Occasional Papers, Staff Working Papers, journal articles, and other reports that have been completed and are available to the public. Articles issued in the World Bank Reprint Series should be so indicated. The reports should be listed in a standard professional format, with author, title, publisher, date of publication, and, for a journal article, volume number and date. For publications in languages other than English, special attention should be given to accents and spelling.

4. An assistant will be available in early June for a limited time to work with you, as necessary, to revise your drafts. Please, therefore, make sure that the drafts reach me no later than c.o.b. Thursday, May 31.

Attachment

cc: Mrs. Hughes, Messrs. Duloy, B.B. King, Habte, Haq, Jaycox, Rovani, Willoughby, Yudelman, de la Renaudiere, Thalwitz
Ms. Hidalgo-Gato, Peter, Stout, McLeod, P. Moses, C. King,
Messrs. Bhatnagar, Veraart, Gomez, Soncini, Kang, Rathnam, Lowther

WORLD BANK / INTERNATIONAL FINANCE CORPORATION

OFFICE MEMORANDUM

TO: Messers. S. Basta and B. Coukis, TRP

DATE: April 24, 1979

FROM: Suman Bery, VPD

SUBJECT: Completion Report " Effects of Health and Nutrition Standards on Worker Productivity" (Ref. No. 671-15)

From the statement provided in the most recent Status Report, the above project appears to be complete from the point of view of the External Research Program. Please prepare the attached completion report and return it to me by c.o.b. on Friday, May 25, 1979. If for some reason the completion report cannot be returned by the above date, please let me know as soon as possible.

cc: Mr. C. Willoughby
Ms. P. Moses

WORLD BANK RESEARCH PROGRAM

COMPLETION REPORT

Date of Submission

May 25, 1979

I. PROJECT IDENTIFICATION AND APPROVAL OF REPORT

1. Title: Effects of Health and Nutrition Studies	2. Project No. 671-15
3. Department: Transportation	4. Division: Standard and Procurement Advisory Unit
5. Staff Participation a. Principal Supervisor: Samir S. Basta SB b. Others Responsible: Basil Coukis	6. Date Approved by Research Committee: June 1974

7. Departmental Approval:

Division Chief (signature) Department Director (signature)

II. IMPLEMENTATION

1. Date of First Contract: December 1974	2. Date of Final Disbursement:	3. Date Final Reports Completed: May and September 1977

4. Reports

a. Final Report The Nutritional and Economic Implications of Ascaris Infection in Kenya

b. Other Publications/Reports by L. Latham, M. Latham (Consultants) and S. Basta, Nutrition Division, AGR, September 1977

The Relationship of Nutrition and Health to Worker Productivity in Kenya by the Transportation Department and the Nutrition Division, AGR, May 1977

NOTES: Item II, 3: Date when final report available for dissemination.
II, 4: Journal articles, Staff Working Papers, Departmental reports, technical memoranda, and other reports prepared under the project. List authors and dates of completion or publication.

III. SUMMARY OF RESOURCES

Expenses through FY75: $3,050	2. Research Committee Authorizations as from FY76: $35,000	3. Total Research Committee Financing: $38,050
Expenses as from FY76: FY 76 : 20,712 FY 77 : 14,288 FY___: FY___: Total: $35,000	5. Other Financing: a. Bank Departments FY___: FY___: FY___: FY___: Total	b. Outside Sources FY___: FY___: FY___: FY___: Total

Staff Time (weeks):	Professional	Assistant	Total
FY 75 :	2	1	3
FY 76 :	2	2	4
FY 77 :	2	2	4
FY___:			
Total	6	5	11

ES: Item III, 1: The sum of actual expenses, if any, from Research Committee authorizations in FY75 and earlier years.

III, 2: The "total authorization" of the project, i.e., the authorization for FY76 (if any) and all subsequent years.

III, 3: Equals III, 1 + III 2.

III, 4: Actual expenditures of funds authorized by the Research Committee, FY76 through FY of final disbursement.

III,5a: Departmental discretionary funds spent primarily or exclusively on project (if any).

III,5b: Breakdown of contributions by donor. Include estimates, to extent possible, of local contributions.

Narratives in the following sections summarize the results of the project in relation to its objectives and describe the design, organization, and dissemination strategy adopted. The categories and topics are intended to correspond closely to those of the "Guidelines for Evaluation of Completed Research Projects." Using additional space as necessary, the principal supervisor should give particular attention to the points listed.

IV. OBJECTIVES AND STRATEGY

- objectives of the research, as originally formulated and with later modifications
- intended beneficiaries (Bank staff; planning authorities and decision makers in developing countries; other researchers)
- contribution to research or other analytical capacity in the countries under study
- efforts to coordinate work with other research in the Bank and outside

Roundworms are believed to affect a quarter of the world's population. The present study carried out in Kenya by a research team from Cornell University, was undertaken to determine the effect this disease may have both from a nutritional and an economic viewpoint. Although the results presented largely pertain to children, its implications are equally valid to the well-being and productivity of adults. The research indicates that children with light infections in Ascariasis absorb less nutrients, and this is translated into a food loss of an average of 3% of ingested calories. Heavy infections could lead up to non-utilization of 25% of ingested calories. This may have important repercussions for nutritional programs. The research also calculates costs of medication, hospitalization, and loss of income from Ascariasis in the general population based on hospital statistics. Deworming undertaken on an average of twice a year could lead to a benefit cost ratio as high as 10:1. Additional studies will explore the feasibility and costs of large scale treatment.

The worker productivity studies on the other hand were a follow-up to the earlier studies carried out in 1973 in Indonesia. The studies demonstrated that the presence of anemia could affect work output by as much as 25%. It was thus decided to extend the work to other countries and other occupations to further test the hypothesis. This research and its resultant implications has been studied by Ministry of Planning officials in both Indonesia and Kenya and the implications are discussed in some National Planning documents. The research has also led to training of some nationals in these countries and has led to collaborative arrangements between the Bank and ODM (U.K.) for further funding of such studies.

V. DESIGN AND ORGANIZATION

- methodology or analytical framework employed; difficulties encountered in application of methodology; how these difficulties were or were not overcome
- sequencing of research tasks
- reliability of data
- performance of consultants or consulting firms
- extent of Bank staff involvement in design, implementation, supervision
- extent of awareness, support, or participation among Bank operating departments, local research institutes, government agencies
- main reasons for overruns or savings in cost and time

Because of the nature of this research, Sections V., VI., and VII., have been grouped together.

Published Reports: The Nutritional and Economic Implications of Ascaris Infection in Kenya by L. Latham, M. Latham (Consultants) and S. Basta of the Nutrition Division, AGR, September 1977

The Relationship of Nutrition and Health to Worker Productivity in Kenya by the Transportation Department and the Nutrition Division, AGR, May 1977

Follow-up studies on a larger sample to look at other treatment methods are being undertaken (RPO 671-73).

Mr. Basta participated in a workshop on Nutrient Intake, Work Output and Physical Activity at the University of California, San Diego, October 30 to November 3, 1978.

The participation by the Bank's consultant has been good. Although Bank staff supervised his work, the results could have been more conclusive if the collaboration between the Nutrition Division (AGR) and Transportation had been better arranged. As it was, Transportation carried most of the research burden, rather than the other way around.

VI. RESULTS

- nature of project findings; correspondence with what was originally intended; reasons for differences between intended and actual objectives
- suggestions for follow-up, including other research topics

See last paragraph of Section IV.

VII. DISSEMINATION

- presentation of results to facilitate access to intended audiences
- methods (published reports, seminars, conferences, etc.) for dissemination of findings to these audiences

See last paragraph of Section IV.

RECONSTRUCTION AND DEVELOPMENT | CORPORATION

OFFICE MEMORANDUM

TO: Mr. Edward V. K. Jaycox, TRU

DATE: April 14, 1975

FROM: M. Hazzan, VPD MH

SUBJECT: Research Project Status Reports - Third Quarter FY75

Mr. Harral pls. coordinate response for dept. E.

I would appreciate it if you could have the attached Quarterly Status Report forms completed and sent to my office (F1233) not later than Monday, April 28. The information provided in the forms should be current as of March 31, 1975. Listed below are the project numbers and the name of the responsible staff member, for which Quarterly Status Reports are required.

I am attaching copies of the March External Research Computer Printout where necessary.

RPO No.	Responsible Staff Member
226	I. Sud
~~227~~ ✓	C. Harral
229	B. Mitchell
~~313~~ ✓	C. Harral-SA.
~~314~~	B. Mitchell
315	I. Sud
316	G. Beier
320	E. Holland

Attachments

WORLD BANK RESEARCH PROGRAM

QUARTERLY STATUS REPORT

Date of Submission: April 17, 1975

I. PROJECT IDENTIFICATION AND APPROVAL OF REPORT

Title: Effect of Health Nutrition Status on Worker Productivity		Project No. RPO 315
Department: Transportation and Urban Projects	Division: Transport Research Division STET	Staff Member Responsible: S.S. Basta
Date Approved 1/ June 1974	Total Amount Authorized 2/ (to date) $35,000	Total Amount Disbursed 3/ (to date) $550

Approval:

Division Chief (signature)

Department Director (signature)

II. IMPLEMENTATION

Date of First Contract 4/ December 11, 1974	Date of First Draft Expected: November 1974	Date Final Report Expected: March 1975

Reports Completed

Reports Expected (Current Fiscal Year)

A proposed plan of work was prepared by the Nutrition Institute. The scope of work was accepted by the Bank but the cost estimates exceeded slightly our budget estimates. The Institute is preparing a revised budget. In any case field work should begin before the end of May 1975.

NOTES:
1/ Month/Year first approved by Research Committee.
2/ Amount authorized, at the time of approval, plus all supplemental authorizations (if any).
3/ Total disbursement to date, including previous fiscal years. (Sum of disbursement column in Part III and total of disbursements in previous years).
4/ Date first contract was signed.

III. FINANCIAL AND STAFF DATA

Research Number: RPO 315

Total Amount Authorized (by Research Committee) For the Current Fiscal Year $35,000

Total Disbursements in Previous Fiscal Year (s)* NONE

Date: April 20, 1975

	Disbursements in Current Fiscal Year					Disbursements Next FY	
	Actual Disbursements To Date In Current Fiscal Year	Forecast Disbursements through June 30, . Based on: Balance of Signed Contracts Not Yet Disbursed (1)	Firm Arrangements (2)	Tentative Arrangements (3)	Total (1)+(2)+(3)	Total Expected	Portion Which Are Signed Contracts As of This Date
A. Contracts (by firm or consultant)							
Nutrition Research Institute (Indonesia)	$550			15,000	15,000	15,000	
Sub-Total A	$550			15,000	15,000	15,000	
B. Travel**						5,000	
C. Data Processing ***Internal (IBRD)						2,000	
External (Timesharing, Remote Batch)							
Sub-Total (B+C)						7,000	
TOTAL (A+B+C)	**** $550			15,000	**** 15,000	22,000	

NOTE:
(1) Do not overlap with previous column.
(2) Firm arrangements lacking only formal contract.
(3) Agreements not yet complete.
*/ Including disbursements for Consultants, travel and Data Processing.
**/ This item includes staff travel and travel by consultants when a Bank travel form (#6) is used. The total forecast disbursements for the fiscal year can be listed in the total column if information is lacking to provide the breakdown requested in columns (1), (2) and (3).
***/ The total forecast disbursements for the fiscal year can be listed in the total column if information is lacking to provide the breakdown requested in columns (1), (2) and (3).
****/ The total of these two figures should not exceed the total amount authorized for the current fiscal year.

Staff Time (staffmonths)	Current FY	Next FY
Professional	2	2
Special Services	1	1
Total	3	3

IV. STATUS OF PROJECT

explain, using an additional page if necessary:
rogress of study, including any changes in time schedule.
he nature of the firm and tentative budgetary arrangements made and reported in columns (2) and (3) of Part III of the Form. If contracts are being negotiated, indicate parties involv
List all publications (journal articles, symposium papers, etc.) based on the research proje
Update as and when necessary.
If any financing has been received from Bank and non-Bank sources other than the External Research Budget, mention amounts, dates (quarters/FY) and sources. Do not include these amounts in Part III.

We expect the work to start by May 1975, unless delays in receiving the final proposal causes some slight slippage.

File

WORLD BANK RESEARCH PROGRAM

STATUS REPORT

Date of Submission: August 25 1975

I. PROJECT IDENTIFICATION AND APPROVAL OF REPORT

Title: Effect of Health and Nutrition Standards on Worker Productivity		Project No. RPO 671-15
Department: ansportation & Urban Projects	Division: Transport Research	Staff Member Responsible: I.K. Sud, S.S. Basta
Date Approved 1/ June 1974	Total Amount Authorized 2/ (to date) $35,000	Total Amount Disbursed 3/ (to date) $550

Approval:

Division Chief (signature)

Department Director (signature)

II. IMPLEMENTATION

Date of First Contract 4/ December 1974	Date of First Draft Expected: a/	Date Final Report Expected:

Reports Completed

Reports Expected (Current Fiscal Year)

a/ Inception report from Indonesia received. Date of project initiation is still uncertain

S: 1/ Month/Year first approved by Research Committee.
2/ Amount authorized, at the time of approval, plus all supplemental authorizations (if any).
3/ Total disbursement to date, including previous fiscal years. (Sum of disbursement column in Part III and total of disbursements in previous years).
4/ Date first contract was signed.

III. FINANCIAL AND STAFF DATA

Research Number: RPO 671-15

Total Amount Authorized (by Research Committee) For the Current Fiscal Year $34,500 (carried forward from FY75)

Total Disbursements in Previous Fiscal Year (s)* FY75 $550

Date: August 25, 1975

	Disbursements in Current Fiscal Year					Disbursements Next FY	
	Actual Disbursements To Date In Current Fiscal Year	Forecast Disbursements through June 30, . Based on: Balance of Signed Contracts Not Yet Disbursed (1)	Firm Arrangements (2)	Tentative Arrangements (3)	Total (1)+(2)+(3)	Total Expected	Portion Which Are Signed Contracts As of This Date
A. Contracts (by firm or consultant)							
Nutrition Institute							
Indonesia	$550						
Philippines						35,000	
Sub-Total A	$550					35,000	
B. Travel**							
C. Data Processing***Internal (IBRD)							
External (Time-sharing, Remote Batch)							
Sub-Total (B+C)							
TOTAL (A+B+C)	**** $550				****	35,000	

NOTE: (1) Do not overlap with previous column.
(2) Firm arrangements lacking only formal contract.
(3) Agreements not yet complete.
*/ Including disbursements for Consultants, travel and Data Processing.
**/ This item includes staff travel and travel by consultants when a Bank travel form (#6) is used. The total forecast disbursements for the fiscal year can be listed in the total column if information is lacking to provide the breakdown requested in columns (1), (2) and (3).
***/ The total forecast disbursements for the fiscal year can be listed in the total column if information is lacking to provide the breakdown requested in columns (1), (2) and (3).
****/ The total of these two figures should not exceed the total amount authorized for the current fiscal year.

Staff Time (staff months)	Current FY	Next FY
Professional	2	-
Special Services	2	-
Total	4	-

IV. STATUS OF PROJECT

Please explain, using an additional page if necessary:

(1) Progress of study, including any changes in time schedule.

(2) The nature of the firm and tentative budgetary arrangements made and reported in columns (2) and (3) of Part III of the Form. If contracts are being negotiated, indicate parties involved.

(3) List all publications (journal articles, symposium papers, etc.) based on the research project. Update as and when necessary.

(4) If any financing has been received from Bank and non-Bank sources other than the External Research Budget, mention amounts, dates (quarters/FY) and sources. Do not include these amounts in Part III.

No change from the last status report. We are looking for either the Philippines or Kenya to undertake this study. Negotiations presently underway.

Record Removal Notice

The World Bank Group Archives & Records Management

File Title	Barcode No.
Sectoral Analysis and Linkages - Kenya Health and Worker Productivity Studies - Kenya Research - Correspondence - Volume 2	30253109

Document Date	Document Type
07 March, 1979	Report

Correspondents / Participants

Subject / Title
World Bank Research Program Status Report

Exception(s)
Personal Information

Additional Comments

The item(s) identified above has/have been removed in accordance with The World Bank Policy on Access to Information. This Policy can be found on the World Bank Access to Information website.

Withdrawn by	Date
Tonya Ceesay	16-Apr-15

Record Removal Notice

File Title	Barcode No.
Sectoral Analysis and Linkages - Kenya Health and Worker Productivity Studies - Kenya Research - Correspondence - Volume 2	30253109

Document Date	Document Type
18 February, 1977	Report

Correspondents / Participants

Subject / Title
World Bank Research Program Status Report

Exception(s)
Personal Information

Additional Comments

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Withdrawn by	Date
Tonya Ceesay	16-Apr-15

Record Removal Notice

The World Bank Group Archives & Records Management

File Title	Barcode No.
Sectoral Analysis and Linkages - Kenya Health and Worker Productivity Studies - Kenya Research - Correspondence - Volume 2	30253109

Document Date	Document Type
21 September, 1976	Report

Correspondents / Participants

Subject / Title
World Bank Research Program Quarterly Status Report

Exception(s)
Personal Information

Additional Comments

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Withdrawn by	Date
Tonya Ceesay	16-Apr-15

Record Removal Notice

The World Bank Group Archives & Records Management

File Title	Barcode No.
Sectoral Analysis and Linkages - Kenya Health and Worker Productivity Studies - Kenya Research - Correspondence - Volume 2	30253109

Document Date	Document Type
14 May, 1976	Report

Correspondents / Participants

Subject / Title
World Bank Research Program Status Report

Exception(s)
Personal Information

Additional Comments

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Withdrawn by	Date
Tonya Ceesay	16-Apr-15

Record Removal Notice

The World Bank Group Archives & Records Management

File Title	Barcode No.
Sectoral Analysis and Linkages - Kenya Health and Worker Productivity Studies - Kenya Research - Correspondence - Volume 2	30253109

Document Date	Document Type
21 January, 1976	Report

Correspondents / Participants

Subject / Title
World Bank Research Program Status Report

Exception(s)
Personal Information

Additional Comments

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Withdrawn by	Date
Tonya Ceesay	15-Apr-15

Record Removal Notice

The World Bank Group Archives & Records Management

File Title	Barcode No.
Sectoral Analysis and Linkages - Kenya Health and Worker Productivity Studies - Kenya Research - Correspondence - Volume 2	30253109

Document Date	Document Type
30 January, 1975	Report

Correspondents / Participants

Subject / Title
World Bank Research Program Quarterly Status Report

Exception(s)
Personal Information

Additional Comments

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Withdrawn by	Date
Tonya Ceesay	16-Apr-15

April 9, 1979, Nairobi

Distribution: a
Agri. & Rural Dev.

FOR BASTA - NUTRITION DIVISION

HOPCRAFT TERMS REFERENCE NOT REPEAT NOT RECEIVED DELHI.

PLEASE URGENTLY TELEX DUPLICATE NAIROBI.

REGARDS

GREENE

Sudy

WORLD BANK / INTERNATIONAL FINANCE CORPORATION

OFFICE MEMORANDUM

TO: Mr. Emmerich M. Schebeck, AGRNU

DATE: April 11, 1979

FROM: Samir S. Basta, AGRNU SB

SUBJECT: KENYA: Nutrition/Productivity Research Study (RPO #671-73)

1. I have just received the report and statistical analysis of stage 1 of this project by Dr. Andrew Chesher, Statistician, Birmingham University. Dr. Chesher as you probably recall is serving as an independent consultant to this research project per the Research Committee's recommendation.

2. The results of his analysis of the data sent from Kenya and Cornell University, N. Y., reveal that hemoglobin levels (an index of anemia), are positively and linearly correlated to the productivity (ditching and excavation) of both female and male road workers in Kenya. Thus a one standard deviation rise in hemoglobin (1.32g/100 c.c.) is associated with a 4% increase in output per man-hour.

3. In practical terms, since many such populations suffer from hemoglobin levels 4 to 5 points below "normal", their productivity could be said to be some 20% below what it should be because of anemia. There are important implications in this for countries, such as Indonesia, Egypt, Thailand, Senegal, etc., where anemia is a significant problem.

4. While these results and figures confirm precisely my earlier (1973) observations on Indonesian labourers (Bank Working Paper No. 175), those of Latham in Kenya in 1976, as well as those undertaken by the University of California in 1976 in Sri Lanka, Dr. Chesher's conclusions go even further. His analysis also reveals that arm circumference, a good indicator of protein/calorie status is also significantly correlated in both men and women to work output ($r = 0.59$), and that caloric status (weight for standard height) in males is also positively correlated to work output, independently of hemoglobin (iron) status.

5. The analysis also reveals that presence of parasitic infections (either hookworm, trichuris, schistosomiasis and/or strongyloides stercoralis) are also associated with reduced work output. The presence of such infections are estimated to reduce productivity (output) by some 4% to 8% per man-hour according to his analysis independantly of the other variables. Severity of infection was unfortunately not analysed.

6. The complete report with the statistical methodology (linear and multiple regression and analysis of covariance) is on file in my office. It will be interesting to see whether the diets given subsequently to these workers have any influence on these results. That second report should be due in a few months time.

cc: Messrs. King (DED); Keare (DED); Harral, Coukis (TRP); Miller and Ward (EDI); Koch-Weser (EXC); Golladay, Lee, Leise (PAS); Lethem (PAS); Berg, Christoffersen and Yudelman (AGR); Churchill (URB); Hall (POP); Selowsky and Reutlinger (DED); Greene, Amla, Wilkie, Carriere, (Ms. Hamann), (AGRNU); de Leede (WA2); Ikram (EM1); Shilling (AEA); Ms. Hadler (AEA); Faruqee (DED); Bery (VPO); Ms. Goris (Nairobi); van der Tak (PAS); Scandizzo (AGR); Knudsen, Davis and Donaldson (AGR)

SSBasta:jm

FORM NO. 27-OCR (5-77)

WORLD BANK OUTGOING MESSAGE FORM (Telegram, Cable, Telex)

IMPORTANT (PLEASE READ INSTRUCTIONS BELOW BEFORE TYPING FORM.)

Class of Service: TELEX 22022

Date: APRIL 9, 1979

Telex No.:

Originators Ext: 73597

START HERE

TO: INTBAFRAD

CITY/COUNTRY: NAIROBI, KENYA

MESSAGE NO.:

FOR GREENE REYRCAB HOPCRAFT TERMS REFERENCE 1. HOPCRAFT WILL BE RESPONSIBLE TO DR. MICHAEL LATHAM WITH COPIES CORRESPONDENCE TO BASTA. SHOULD PLAY MAJOR ROLE IN SORTING OUT EFFECT OF BROADER SOCIOECONOMIC PARAMETERS FROM NUTRITIONAL FACTORS IN SERIES OF STUDIES AND DELINEATING SPECIFIC PRACTICAL RECOMMENDATIONS FOR FUTURE NUTRITION PROGRAMS IN KENYA. EXPECTED TO ASSIST IN DATA COLLECTION, DATA ANALYSIS AND REPORT PREPARATION. 2. SHOULD REVIEW AND PREPARE LIST OF SOCIOECONOMIC INDICATORS WHICH SHOULD BE MONITORED DURING DATA COLLECTION PHASE OF STUDIES 1 AND 2. SHOULD REVIEW OVERALL STATISTICAL DESIGN OF THESE TWO COMPONENTS PROVIDED BY DR. LATHAM TO ENSURE THAT SUFFICIENT NON-CLINICAL VARIABLES ARE MEASURED SO THAT SOCIAL AND ECONOMIC CONDITIONS ARE TAKEN INTO ACCOUNT WHEN EXPLAINING PRODUCTIVITY CHANGES IN CONTROL AND TARGET POPULATIONS. 3. SHOULD REVIEW DIFFERENT DIETARY INTERVENTIONS PROPOSED FOR STUDIES 1 AND 2 AND ADVISE DR. LATHAM AND RESEARCH TEAM ON SUITABILITY OF PROPOSED DIETS FROM COST POINT OF VIEW AND FEASIBILITY THEIR INTRODUCTION INTO LONG TERM PROGRAMS. 4. SHOULD

/c

END OF TEXT

NOT TO BE TRANSMITTED

SUBJECT: KENYA Research RPO 67173

DRAFTED BY: SSBasta:ap

CLEARANCES AND COPY DISTRIBUTION:

AUTHORIZED BY (Name and Signature): Samir Sanad Basta

DEPARTMENT: AGR & Rural Development

SECTION BELOW ... RESPONSIBLE SECTION

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FORM NO. 27-OCR (5-77) **WORLD BANK OUTGOING MESSAGE FORM (Telegram, Cable, Telex)**
IMPORTANT (PLEASE READ INSTRUCTIONS BELOW BEFORE TYPING FORM.)

Class of Service: TELEX 22022 Date: APRIL 9, 1979
Telex No.: Originators Ext: 73598

START HERE

TO

CITY/COUNTRY

MESSAGE NO.:

ADVISE AS NECESSARY ALTERNATIVE CHOICES AND SITES FOR STUDY 1 INCLUDING POSSIBILITY REPLACING STUDY 1 ROAD WORKERS WITH AGRICULTURAL LABORERS ON PLANTATIONS OR FARMS. 5. SHOULD HELP DR. LATHAM DIFFERENTIATE BETWEEN REAL AND APPARENT EFFECTS OF VARIOUS INTERVENTIONS. CAREFUL SCREENING NON-NUTRITIONAL OR CLINICAL EFFECTS UPON PRODUCTIVITY, INCOME AND OVERALL WEIGHT GAINS IN VARIOUS POPULATIONS UNDER STUDY. 6. IMPLICATIONS AND RECOMMENDATIONS ARE THIRD AREA OF RESPONSIBILITY. SHOULD PLAY KEY ROLE ADVISING RESEARCH TEAM AND BANK WHAT LONG AND SHORT TERM ECONOMIC IMPLICATIONS OF RESULTS STUDIES 1 AND 2, FOR EXAMPLE IN BOTH LABOR ABUNDANT AS WELL AS LABOR CONSTRAINED SCENARIOS. SHOULD PROVIDE ADVICE AS NECESSARY CONCERNING ECONOMIC AND POLICY IMPLICATIONS OF STUDIES. 7. ALONG WITH DR. LATHAM AND CONSULTATION WITH OFFICIALS FROM MINISTRY PLANNING AND FINANCE, SHOULD ALSO ADVISE GOVERNMENT AND BANK HOW BEST TO IMPLEMENT STUDY RESULTS IN KENYA'S NATIONAL DEVELOPMENT PLANS. 8. SHOULD PREPARE FIRST PROGRESS REPORT OUTLINING FINDINGS AND RECOMMENDATIONS NO LATER THAN FEBRUARY 1979. SECOND REPORT DUE FEBRUARY 1980 AND FINAL REPORT BY DECEMBER 31, 1980. REGARDS BASTA, INTBAFRAD

END OF TEXT

NOT TO BE TRANSMITTED

SUBJECT: KENYA Research RPO 67173

DRAFTED BY: SSBasta:ap

CLEARANCES AND COPY DISTRIBUTION:

AUTHORIZED BY (Name and Signature): Samir Sanad Basta

DEPARTMENT: AGR & Rural Development

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TELEX 953313150

April 3, 1979
73597

INTBAFRAD

NEW DELHI, INDIA

FOR GREENE. WITH REGARDS TO KENYA NUTRITION RESEARCH PROJECT PLEASE LIMIT YOUR VISIT TO OBTAINING FROM HOPCRAFT A TENTATIVE SCHEDULE AND WORK PLAN PER HIS TERMS OF REFERENCE SENT TO YOU LAST WEEK. NOTE THAT PRODUCTIVITY STUDIES IN KERATINA HAVE NOW BEEN ANALYZED BY BIRMINGHAM UNIVERSITY AND REVEAL SIGNIFICANT ASSOCIATION ASSOCIATIONS BETWEEN WORK OUTPUT AND BOTH ANTHROPOMETRY AND ANEMIA. SOME OF HOPCRAFTS INPUTS COULD BE TO OBTAIN SUPPLEMENTARY SOCIO ECONOMIC DATA ON THAT POPULATION, TO EXTRAPOLATE PRODUCTIVITY RESULTS AND TO ADVISE ON POSSIBLE SUPPLEMENTARY PRODUCTIVITY STUDIES ON THESE OR OTHER SITES INCLUDING PLANTATIONS. YOUR ADVICE TO HIM SHOULD BE IN FORM OF SUGGESTIONS ONLY IN ORDER TO AVOID MISUNDERSTANDINGS REGARDING LINES OF AUTHORITY PER MY EARLIER EXPLANATION TO YOU. REGARDS BASTA, INTBAFRAD

Kenya Research #67173

SSBasta:jm

Samir S. Basta

AGR

Scott Wilson Kirkpatrick & Partners

Consulting Engineers and Transportation Planners

Basingstoke Hants
RG21 2JG

and at
53 Bedford Square London WC1B 3DP

Telephone Basingstoke (0256) 61161
Telegrams Pontifact Basingstoke
Telex 858805

File
Kenya
Research

To: Samir Basta

Logged
4/4/79

Ms. June Wolgemuth
P. O. Box 96192
Mombasa
Kenya

Your ref

Our ref MJS/PDG/78126

29th March 1979

Dear June

HEALTH & NUTRITION STUDY 1

Thamk you for your letter of 20th March enclosing the additional data.

I enclose the corresponding updated part of the computer listing for your records. I also enclose a copy of Andrew Chesher's report on his preliminary analysis, as requested. I hope you will find the results so far quite encouraging.

Andrew Chesher is away at present, and I don't think any further analysis will be done until around July, most probably. (IBRD do not want my firm to actually work on the analysis, I am only assisting by processing the raw data into punch-cards).

Regarding further queries, I think Andrew might need the actual attendance record in some form, rather than just the days supplement recieved, so I may write to you again on his return. Also, as you will see, one surprising finding is the apparent importance of the arm circumference measurement. Third arm circumference and skinfold, if available, would certainly be used.

Thanks for the slide, which I received safely. Best wishes to yourself, Andrew and Terry.

Yours sincerely
for SCOTT WILSON KIRKPATRICK & PARTNERS

MJS

M. J. Sharrock

cc: C. Harral ←
A. Chesher
M. Lathan

KENYA HEALTH AND NUTRITION STUDY

STUDY NO.1 PRODUCTIVITY/DIETARY SUPPLEMENTATION

DATA AVAILABLE AT 26/03/79

ANTHROPOMETRIC DATA REVISED TO INCLUDE 2ND AND 3RD WEIGHTS, AND 2ND AC.TS PLUS CALORIC SUPPLEMENT. (DAYS FED=NO OF DAYS SUPPLEMENT TAKEN, 1000KCAL EXPTL GROUP, 200KCAL CONTROL GROUP)

RD. NO.	ID	M =1	E =1	AGE+ YRS-	HT MM	WT.KG*10 1ST	2ND	3RD	STD WT	TS.MM*10 1ST	2ND	3RD	AC.CM*10 1ST	2ND	3RD	DAYS FED
12	2	1		59	1600	479	495	495	604	40	45		249	214		47
12	3	0	1	16	1599	437	457		519	40	45		219	228		23
12	6	1	1	40	1702	516	555	538	667	35	40		236	255		80
12	9	0		30	1608	593	600		568	205	165		300	297		31
12	11	1		30	1665	520	520	536	643	45	40		247	260		48
12	12A	1		39	1650	500	510		634	40	35		261	255		66
12	13	1	1	49	1593	389	415	414	600	35	35		216	244		92
12	15	1		22	1619	585	565		615	70	50		275	265		52
12	16	0		59	1680	542	540	527	614	70	90		263	262		45
12	19	0	1	40	21653	460	457	482	597	80	40		223	227		56
12	20	0	1	40	1436	422	437	430	468	105	135		259	263		31
12	21	0	1	35	51654	552	540	529	597	150	145		286	279		41
12	25A	1	1	35	51628	474	498	484	621		40		248	260		9
12	26	0		24	1486	462	473		495	155	190		272	279		8
12	28	1		35	1591	455	448		598	45	45		246	255		57
12	29	0	1	49	11655	473			598	35			225			
12	30	1	1	64	1581	432	446	456	592	35	40		251	267		82
12	33	0	1	30	1547	567	569		530	90	70		279	274		16
12	36	1		39	1685	548	570	541	656	45	40		253	255		56
12	39	0	1	45	51603	622			565	145			291			
12	41	0	1	24	1556	457	460			105	120		249	250		4
12	46	1	1	45	51619	557	574	579	615	100	100		261	270		80
12	49	1		26	1621	430	441	427	616	45	40		213	225		64
12	50A	1	1	18	1679	479		528	589	35			250			39
12	51	1	1	23	1705	514	564	503	669	50	35		253	244		35
12	52	1		26	1791	644	443		733	50	65		266	242		0
12	53	1	1	25	1720	580	580	573	680	40	40		259	263		90
12	54A	1	1	18	1461	472	488	493	429	55	45		235	240		76
12	58	1		69	1690	517	515		628	70	65		225	246		0
12	63	0		65	51462	402	392	393	482	75	60		241	235		73
12	64A	1	1	18	1698	598			574	50			269			
12	69	1	1	29	1637	527			626	50			250			
12	70	0		15	1440	372	377	374	408	55	60		210	217		70
12	73A	1		15	1537	369			433	40			223			
12	76	1	1	33	1700	523	538		666	40	40		246	254		38
12	78A	0		17	1599	567	577	598	527	150	155		272	280		54
12	79A	1	1	20	1672	539			608	70			263			
12	80	1	1	31	1673	514	534	547	647	40	40		248	254		35
12	83	0		16	1524	455	462	462	472	60	80		250	249		54
12	84	0	1	16	1546	482	496	505	489	145	120		261	261		35
12	86	1		46	1719	477			679	35			239			
12	87A	1		65	51658	480	505	496	639	35	40		225	232		62
12	89	0		28	1570	447	452	440	543	90	95		247	253		77
12	90A	1		25	1618	500	510	515	614	60	60		268	273		46
12	92	0		38	1486	472	487	485	496	85	80		270	270		15
12	94	1	1	26	1581	419		439	592	40			239			46
12	95	1		41	1745	553	547	547	697	45	35		263	260		81
12	96A	1		20	1667	507			605	40			265			
12	97	1	1	45	1724	558	568	550	682	45	35		267	270		73
12	98	0		18	1569	552			513	120			265			
12	99	1	1	21	1592	435	460	453	598	100	80		240	254		59
12	105	1	1	37	11690	540		538	628	40			243			67
12	106A	1		20	1684	459	462		616	40	40		244	242		1
12	107	1		36	1605	450	473	471	607	40	35		240	255		84
12	109	0		16	1600	432	417	432	520	120	155		235	232		73
12	110	0	1	18	1583	492			524	140			254			
12	134N	1		25	1618	500			614	55			268			
12	136N	1		38	1693	565			661	50			246			
7	4	1	1	29	1583	465	478	458	593	45	30		252	257		74
7	7	1	1	24	1592	451	459	438	599	70	45		231	244		46
7	12	1	1	28	1728	559	564	550	685	60	55		256	272		71
7	19	1		38	1757	605			706	58			265			
7	21	1		30	1845	579			777	45			243			
7	23	1	1	28	1653	558	565	563	636	45	43		277	270		62
7	26	1		30	1583	494	499	500	593	45	40		257	261		48
7	31	1	1	43	1645	449	454	449	631	45	38		254	256		46
7	34	1	1	43	1554	430	435	433	576	40	40		232	237		54
7	38	1	1	44	11665	505			643	40			255			
7	48	1	1	40	1670	450	455		646	35	35		242	253		30
7	54	1		45	1572	425		430	587	45			235			76
7	76	1	1	34	1598	494	500	510	602	40	35		245	255		78
7	79	1	1	34	1569	414	419	422	585	55	55		254	253		75
7	85	0	1	20	1520	442			515	155			277			
7	88	0	1	20	1527	428	450		518	125	120		236	248		0
7	90	1	1	36	1630	483			622	35			231			
7	95	0		18	1533	421			522	110			234			
7	95N	1		28	1637	513			626	40			261			
7	106	1	1	50	1551	381	355	357	574	40	45		233	230		65
7	109	1	1	50	1675	558	547	535	649	50	40		272	267		74
7	113	1	1	27	1653	509	529		636	50	70		263	272		53
7	114	0		20	1598	505			561	105			261			
7	114N	1			1664	575			642	55			282			
7	117	1	1	19	1595	493	509		550	40	45		245	249		70
7	118	1		20	1782	532	549		690	40	45		232	240		64
7	119	0	1	26	11582	435			550	100			253			
7	121A	1		26	1572	572	577	573	587	70	90		284	290		79
7	122	0	1	25	1544	465			528	185			254			
7	126	1		22	1631	512		523	623	40			270			45
7	135	1	1	23	1658	572	600	568	638	50	40		279	290		44
7	137	1		24	1745	515			697	45			238			
7	143	1	1	32	1608	450	469	449	608	25	25		252	256		48
7	146	1	1	30	1731	654		618	687	70			284			54
7	148	1		24	1643	439	471		630	45	40		241	239		27
7	149	1		32	1607	455	455	438	607	60	50		231	231		63
7	150	1		26	1618	470			614	45			240			
7	154	0	1	22	1547	525			530	155			262			
7	155	1	1	43	1666	484			643	35			253			
7	165	0		18	1628	480			546	100			239			
7	167	1	1	27	1640	520			628	45			273			
7	168	1		54	1693	520	515		661	45	40		251	253		54
7	171	0		20	1553	470	481	479	534	185	145		254	260		73
7	172	0		20	1477	342			490	85			198			
7	173	1	1	21	1674	609	648	631	648	60	70		278	294		74
7	174	1		19	1656	518	539	542	584	55	75		247	265		72
7	177	1	1	26	1615	500	545	530	612	50	40		267	291		75
7	183	1	1	22	1663	504			642	43			239			
7	185	1		23	1595	499			601	60			271			
7	186	1	1	33	1635	520			625	40			252			
7	189A	1		22	1509	452	459	444	550	45	35		259	265		43
7	190	1	1	25	1672	544	555	567	647	40	55		244	245		61
7	191	1		30	1734	600			689	50			298			
7	191N	1		21	1583	440			624	35			246			
7	192	1		43	1669	530			645	45			271			
7	193	0		19	1464	435			471	135			257			
7	194	0		20	1550	420			531	155			267			
7	199	0		15	1550	447			480	70			222			
7	202	1		31	1643	494			630	40			233			
7	205	1	1	32	1688	500		489	658	40			270			46
7	206N	1		19	1603	460			555	40			250			
7	209	1	1	23	1756	561	569	547	705	45	35		267	265		60
7	211	1		20	1585	477	489	484	555	30	40		258	270		69

Kenya Research

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

1818 H Street, N.W., Washington, D.C. 20433. U.S.A.

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March 23, 1979

Prof. Maarten D. C. Immink
International Nutrition
Division of Nutritional Sciences
Cornell University
Savage Hall
Ithaca, N.Y. 14853

Dear Prof. Immink:

Thank you for your letter of March 14 and the copy of your paper on energy intake, stature, and productivity among Guatemalan cane cutters. I have just read the paper and found the results interesting indeed.

Two questions. The central (but not only) point of the paper is, as I read it, to demonstrate returns to improved childhood nutrition through the impact of such improvements on adult stature and the subsequent impact of adult stature on productivity. You provide evidence on the stature-productivity link and refer to evidence on the childhood nutrition-adult stature link (p. 3). My questions are: (i) On p. 5 you suggest that medium height workers may have higher productivity than tall ones; are your detailed analyses of this relation available? (ii) You touch only briefly on the childhood nutrition-adult stature link, and, while what you do say is suggestive (and accords with common sense), the importance of this link leads me to wonder how well-established the quantitative evidence is?

I myself will soon be examining some data from Nepal to ascertain, among other things, whether there is a link between adult stature and productivity in rice farming. I thus found your paper both timely and stimulating, and hope we can stay in touch. If sometime you are planning to be in Washington please call (202 /676-1262); perhaps we could meet over lunch and I could introduce you to some of my colleagues who deal more regularly with nutrition issues.

Sincerely,

Dean T. Jamison

Dean T. Jamison
Economist
Development Economics Department

bcc (w/copy of incoming and paper): A. Berg
J. Greene
J. Leslie
T. King
M. Selowsky

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF
HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

March 14, 1979

Dr. Dean T. Jamison
Economist
Development Economics Department
International Bank for Reconstruction and Development
1818 H Street, N.W.
Washington, D. C. 20433

Dear Dr. Jamison:

Dr. Helms of the University of North Carolina has requested me to send you a copy of our paper presented at the Rio conference on energy intake and human capital formation. That paper has already undergone one revision, and I enclose a copy of the revised version. It is still a preliminary draft, and I am now re-working it for submission to a journal.

I hope that there may be an opportunity in the future for us to discuss our mutual interests in this area of research.

With kind regards.

Sincerely yours,

Maarten D. C. Immink
Assistant Professor
International Nutrition

MDCI:dd

Enc.

Preliminary Draft

Not to be quoted without permission from the authors.

Energy Intake During the Life Cycle and Worker Productivity in Guatemalan Sugarcane Cutters

by

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November 1978

ENERGY INTAKE DURING THE LIFE CYCLE AND

WORKER PRODUCTIVITY IN GUATEMALAN SUGARCANE CUTTERS

Authors: M. D. C. Immink, F. E. Viteri and R. W. Helms

(Paper to be presented at the Symposium on Nutrition, Health and Human Variability II, Am. Anthropological Assn. Meetings, Los Angeles, November 1978)

Introduction

Improved nutritional intake is clearly a form of investment in human capital whenever a stream of economic benefits results beyond the immediate food consumption period. The question that is being addressed in the present study is whether increased energy intake in the rural work force of developing countries may be expected to result in human capital formation. Of equal importance is the question related to the optimal life cycle pattern of investments in human capital. Little evidence is available to evaluate the relative economic returns of improvements in nutritional status during the early stages of the life cycle, versus improvements in the nutritional status during the different stages of the productive phase. Yet, these are basic issues which need to be resolved before rational decisions can be made regarding the allocation of the scarce resources available to improve the nutritional status of both present and future rural work forces in developing countries. Some evidence is available that suggests that improved nutrition during the pre-productive phase of the life cycle may be expected to improve mental development, with obvious implications for future productivity once adulthood is reached (1,2). However, the effect of childhood malnutrition on future productivity in <u>physically strenuous</u> occupations has not previously been estimated. In such occupations, <u>physical</u> rather than <u>mental</u> ability may well have a more significant effect on worker productivity, and thus, on the economic conditions of the worker and his family.

(Slide 1)

Methods

A group of 158 sugarcane cutters who permanently resided on a large sugarcane plantation located in the coastal lowlands of Guatemala, constituted the subjects of the study. The data presented here were obtained during a four-month period in 1974, prior to the introduction of an energy supplementation program. These sugarcane cutters normally cut and load sugarcane during approximately 30 weeks each year. During the remainder of the year they are employed in canefield maintenance tasks. They are paid a piece rate, in addition to certain payments in kind, and they determine their own working hours. The workers voluntarily participated in the study, and were not paid any remuneration for their participation.

The workers ranged in age from 17 to 73 years. The median age was 31. Their mean height was 160 centimeters, and they weighed on the average 53 kilograms. They generally had a lean appearance and reduced energy stores as evidenced by their weight deficiency relative to their height. Thirty-eight percent of the workers weighed in at 85 percent or less of their reference weight (3). The mean upper-arm muscle area in the group was 28.9 mm^2 per cm of height. The daily energy intake of the workers was obtained using the one-day recall method. Their daily energy requirement was estimated using a coefficient of 62 kilocalories per kilogram of body weight. This is the estimated energy requirement for extremely active men. On the average, these workers met 90 percent of their estimated daily energy requirement. The daily productivity of these sugarcane cutters was low relative to the productivity levels reported for sugarcane cutters in Colombia, Jamaica, Tanzania, Rhodesia and Australia (4,5,6,7). No doubt inter-country differences in work organization, environmental conditions and socio-cultural factors contributed to these differences in productivity levels. The workers' mean gross weekly earnings were approximately ten dollars. This did not include payments in kind.

(Slide 2)

The group of sugarcane cutters were classified as either being "tall," "average" or "short," as either having "very low," "low" or "normal" energy stores, as either having "low," "average" or "high" muscularity, and as either being on "low," "average" or "high" daily energy intakes. For stature, upper-arm muscle area and daily energy intake, the 33rd and 67th percentiles of the respective distributions were used as cut-off points.

The stature of the workers is of interest in the present study as an indicator of the nutritional history of the workers during childhood. Adult stature in healthy males is usually reached by the age of 16-17, but may be delayed until age 20 in malnourished males. In the present sample, only 4 workers were below age 20, and thus, the results were not seriously affected when we assumed that all workers had reached adult height by the time the study was initiated. Genetic as well as environmental factors including nutrition, during the growing years, determine adult length. However, in populations of low socio-economic status, environmental factors appear to play a relatively greater role than genetic factors: for example, in school aged children suffering from protein-energy malnutrition, the parent-child height correlations are significantly lower than in well-nourished school-aged children (8). A positive relationship between stature and productivity levels have been reported for sugarcane cutters in Colombia (4). Taller workers reportedly have a greater mechanical efficiency in cutting sugarcane (7). cf. Kenya roadworkers -

Work with sugarcane cutters in Jamaica lead to the conclusion that workers who are relatively weight deficient are probably less able to maintain a constant level of productivity over time when faced with significant daily variations in energy intake (5). Body weight reflects energy intake levels relative to energy expenditure levels during the recent past. Low energy stores may be indicative of low levels of energy intake, or of high levels of energy expenditure. Thus, an inverse relationship between the level of weight deficiency and productivity is also possible for limited periods of time.

Upper-arm muscle area, standardized for height, is included as another nutritional parameter. Significantly reduced muscle mass is indicative of a more serious and chronic condition of inadequate energy intake, in which part of the protein intake is diverted for energy purposes. The results of Viteri's study of Guatemalan agricultural workers clearly suggest that chronically low levels of energy intake lead to low muscularity. Increased levels of energy (and protein) intake seem to improve muscularity. And workers on higher levels of energy intake and with greater muscularity tend to be more productive (9). Thus, higher levels of current energy intake were also positively associated with increased levels of energy expenditure and improved worker productivity.

AB to note

Results

(Slide 3)

This graph represents the age-productivity profile of the Guatemalan sugarcane cutters as estimated by a polynomial regression of the second degree. Daily productivity appears to be decreasing with age, except for younger workers. In the age-group 17-28 years, age seems to have little effect on worker productivity. The estimated peak is at age 24. Probably several factors are responsible for the negative effect of age on productivity among older workers. Maximal aerobic power, muscle strength and psychomotor skills decline with age. Poor health is associated with older age. In addition, there may be a "cohort"-effect: the more capable workers are likely to be promoted before they reach older age.

(Slide 4)

The various parameters were correlated and the results tend to indicate:

a) that there was no secular improvement in environmental factors in this population as age and stature were not significantly correlated;

b) older workers tended to be on lower daily energy intakes;

c) taller workers, and workers on higher daily energy intakes, tended to be more productive.

The degree of weight deficiency was not significantly related to the level of daily productivity or to the current level of energy intake. The same held true for the degree of muscularity. However, certain caution is required in drawing general inferences from these last results. There may be minimum critical values for energy stores and muscularity below which daily productivity is seriously affected. The results here may merely indicate that none or few of the workers had extremely low energy stores or seriously impaired muscularity. It would also appear that workers on higher daily energy intake tended to exhibit higher levels of daily energy expenditure which may explain the positive association between energy intake and productivity.

(Slide 5)

This represents the age-productivity, or age-earnings profiles associated with two different levels of adult stature. A detailed analysis revealed that "tall" workers were significantly more productive than "short" workers (as previously defined), and that the difference in productivity remained constant over the whole productive phase of the life cycle. Workers with "average" height were not significantly ~~more~~ productive than "tall" workers. The shaded area then represents the incremental life time earnings from sugarcane cutting associated with a significant increase in adult stature.

(Slide 6)

The present value of this increment in life time earnings at age 17 was calculated assuming different discount rates, and annual growth rates in wages. Given the wage history of the last five years on the plantation where this study took place, an average annual wage increase of 6 percent seems reasonable to assume. Thus, for example, at a discount rate of 8%, the present value of the incremental life time earnings was estimated at 450 dollars per worker. The estimated amounts do not seem large, but it should be remembered that: (a) it only represents the earnings from sugarcane cuttings during 30 weeks of the year; taller workers may also be more productive in other agricultural activities during the remainder of the year; thus, these amounts probably underestimate the addition to the stock of human capital associated with better childhood nutrition; and (b) the mean annual earnings from sugarcane cutting in this group was only about 300 quetzales in 1974.

(Slide 7)

In this graph are presented the age-productivity profiles, by three levels of daily energy intake, and as estimated by the indicated regression equations. The numbers in brackets below the regression parameters are the corresponding t-values. The three intake levels did not cover the same age-groups, so the regressions were extrapolated to age 72 for the "average" and "high" intake groups, as indicated by the interrupted segment of the regression lines. A detailed analysis revealed no statistically significant difference among the regression intercepts. But the regression slopes were

too low

significantly different at the 5 percent level, though only the regression slope for the "low" intake group was significantly different from zero at the one percent level. Thus, it appears that "low" daily energy intakes place a severe constraint on the level of daily productivity among older workers. Daily productivity appears to be largely unrelated to daily energy intake levels among younger workers. Substantially higher daily energy intakes, over and above the "average" level as defined here, are not significantly associated with higher levels of daily productivity.

(Slide 8)

The findings of the study may be summarized as follows:

1. Daily productivity levels of Guatemalan sugarcane cutters decrease with age, except among young workers;

2. Taller sugarcane cutters tend to be more productive over the whole life cycle than shorter cutters;

3. A significant increase in the stock of human capital of sugarcane cutters may be expected from better childhood nutrition which results in increased adult stature;

4. Sugarcane cutters of all ages with greater energy stores, or with greater muscularity, are not more productive than their colleagues with lower energy stores, or with less muscularity; and

5. Higher daily energy intakes are generally associated with higher levels of daily productivity in sugarcane cutting, especially among older sugarcane cutters.

and 6.

The evidence suggests that variability in adult stature and in daily energy intake among Guatemalan sugarcane cutters significantly affects their productivity. High energy intakes, during the growing years and during most of the productive life cycle, should have significant economic returns by increasing life time productivity and earnings. Investments in worker feeding programs would appear to have the greatest economic returns among older workers on relatively low levels of daily energy intake. Admittedly, the interpretation of the present results is subject to one caveat: an inter-temporal extrapolation from the results of an intra-temporal analysis has ??

limited validity. Nevertheless, these results do suggest that increased energy intakes of rural workers in developing countries, as well as of their offspring, may be an important form of investment in their stock of human capital, with significant socio-economic consequences. . . . NOT indicated from results

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Age, Body Composition, Daily Energy Intake and Productivity
of Guatemalan Sugarcane Cutters, January-April, 1974
(n = 158)

	Age (years)	Stature (cms.)	Body Weight 1/ (kgs.)	Percent Weight/Height 1/ (%)	Upper-Arm Muscle Area/Height 1/ (mm^2/cm)
Mean	35.1	159.7	53.1	88.1	28.9
± S.D.	11.0	5.6	5.7	7.1	3.8
Range	17-73	144-174	41.6-65.9	75-104	20.8-38.1

ENORMOUS

	Daily Energy Intake 1/ (kcals.)	Daily Energy Requirement 1/ 2/ (kcals.)	Cane Deliveries/ Manday (cwts.)	Weekly Gross Earnings (Quetzales 3/)
Mean	2951	3292	24.3	10.27
± S.D.	689	354	2.7	2.21
Range	1480-5276	2579-4086	18.0-31.0	0.00-14.90

1/ Sub-sample only
2/ 62 kcals/kg of body weight
3/ 1 Quetzal = 1 U.S. $

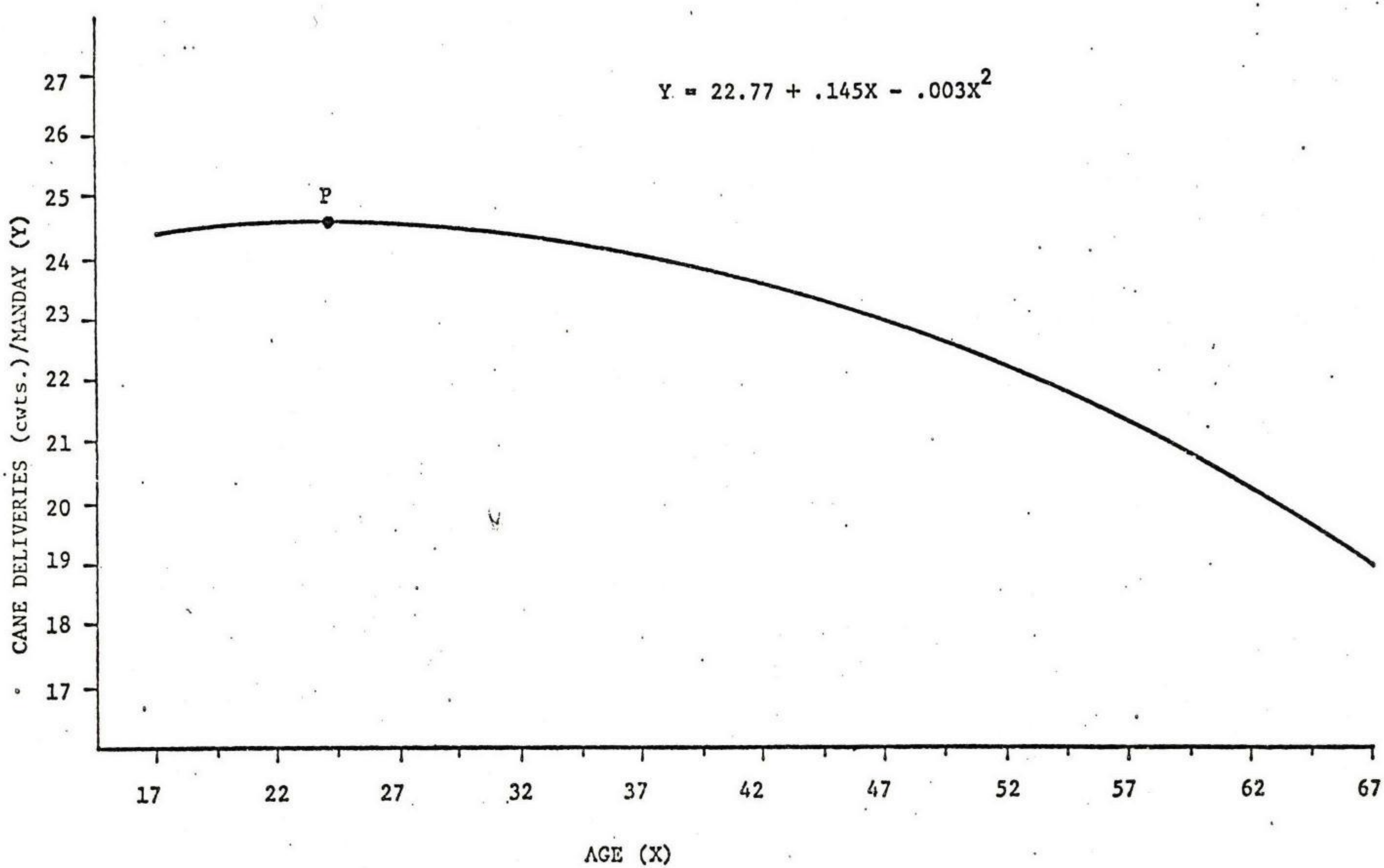
Classification of Guatemalan sugarcane cutters by selected phenotypic characteristics and daily energy intake

	Stature (cms.)		
	"Short"	"Average"	"Tall"
Mean (± S.D.) Range	153.4 (2.9) 144 - 156	159.5 (1.7) 157 - 162	165.9 (2.9) 163 - 174
	Energy Stores (Percent weight/height)		
	"Very low"	"Low"	"Normal"
Mean (± S.D.) Range	81.0 (2.3) 75.0 - 84.0	89.2 (2.9) 85.0 - 94.0	98.7 (2.8) 95.0 - 104.0
	Muscularity (Upper-arm muscle area (mm^2)/height (cm)		
	"Low"	"Average"	"High"
Mean (± S.D.) Range	24.9 (1.6) 20.8 - 26.9	28.6 (1.0) 27.0 - 30.3	33.2 (2.3) 30.4 - 38.1
	Daily Energy Intake (Kcals./24 hours)		
	"Low"	"Average"	"High"
Mean (± S.D.) Range	2208 (341) 1408 - 2673	2965 (188) 2674 - 3225	3680 (445) 3226 - 5276

DIFF, TOO SMALL
There is a 20% - 30%,
error in dietary interviews
on average

So what?

Age-Productivity Profile of Guatemalan Sugarcane Cutters, Estimated by Polynomial Regression Equation. (n=158)



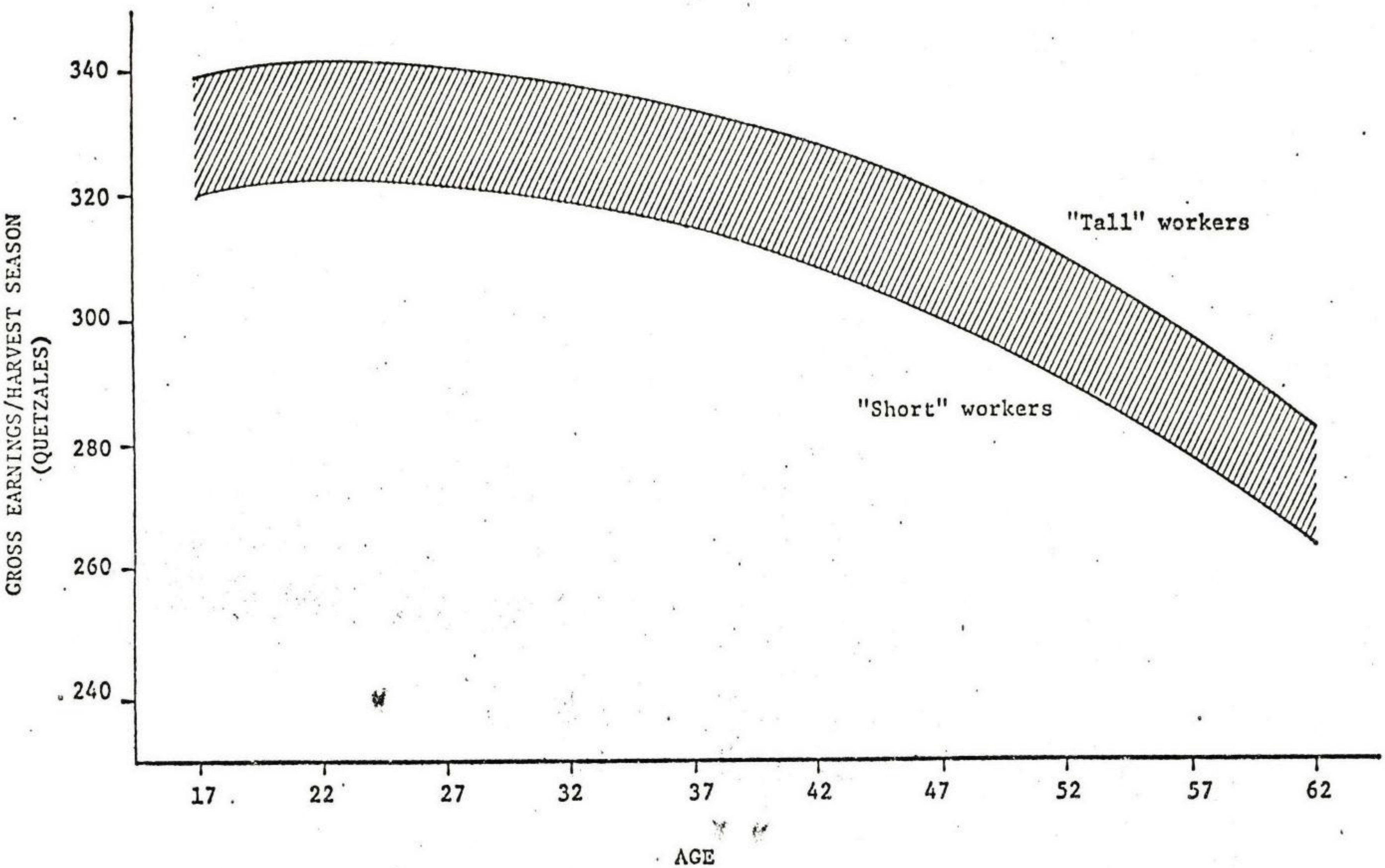
Age, Daily Productivity, Stature, Percent Weight/Height, Muscularity and Daily Energy Intake of Guatemalan Sugarcane Cutters
January-April, 1974
($n = 158$)

Product-Moment Correlation Coefficients

	Age	Cane Deliveries/ Manday (cwts)	Stature (cms)	Percent Weight/Height (%)	Upper-Arm Muscle Area/Height (mm^2/cm)	Daily Energy Intake (kcals)
Age						
Cane Deliveries/ Manday (cwts)	-.240*					
Stature (cms)	-.100	.171**				
Percent Weight/Height (%)	-.173	.172	.140			
Upper-Arm Muscle Area/ Height (mm^2/cm)	-.193	.154	.062	.759*		
Daily Energy Intake (kcals)	-.276*	.344*	.034	.098	.155	

* $p < .01$
** $p < .05$

Age-Earnings Profiles of "Tall" and "Short" Guatemalan Sugarcane Cutters, Harvest Season Only. (n=158)



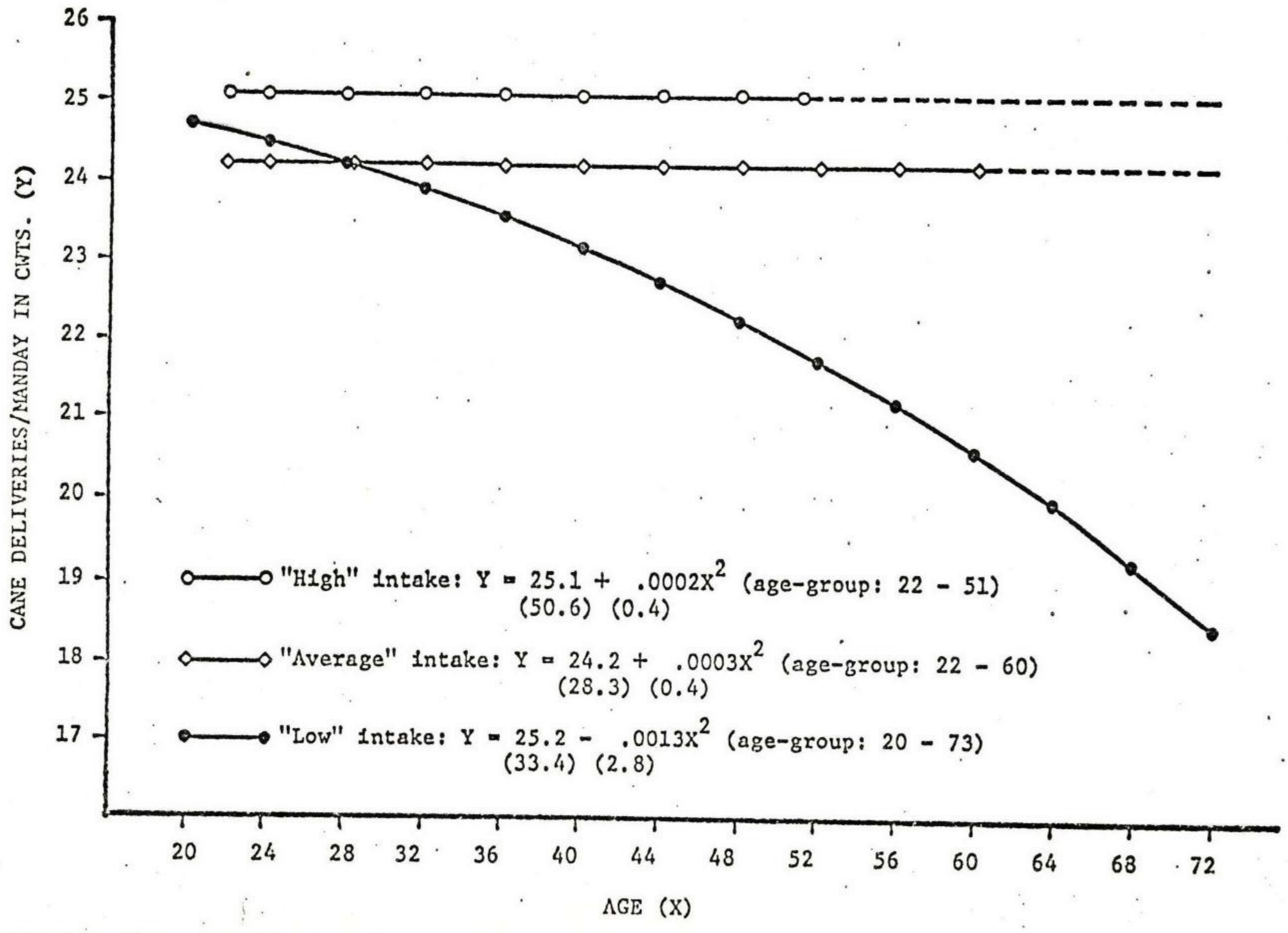
Present Values at Age 17 of Incremental Life Time Earnings from Sugarcane Cutting (30 weeks/year): "Tall" versus "Short" Worker, January-April, 1974
(n = 158)

(in Quetzales[1/])

Discount Rate (%)	Annual Growth Rate (%)			
	0	3	6	10
6	292	414	616	1,127
8	229	315	454	796
10	186	249	348	583

1/ 1 Quetzal = 1 U.S. $

Age - Productivity Profile of Guatemalan Sugarcane Cutters, by Three Levels of Daily Energy Intake.



SUMMARY OF FINDINGS

1. Daily productivity levels of Guatemalan sugarcane cutters decrease with age, except among young workers.

2. Taller sugarcane cutters tend to be more productive over the whole productive life cycle than shorter cutters.

3. A significant increase in the stock of human capital of sugarcane cutters may be expected from better childhood nutrition which results in increased adult stature.

4. Sugarcane cutters of all ages with greater energy stores, or with greater muscularity, are not more productive than their colleagues with lower energy stores, or with less muscularity.

5. Higher daily energy intakes are generally associated with higher levels of daily productivity in sugarcane cutting, especially among older sugarcane cutters.

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

File Kenya Res.

Logged 3/27/79

March 23, 1979

(1) cc without attach. Basta ✓ + Cook

(2) CGH.

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

Before I left for Kenya in early January 1979 I discussed with you the major expenses that we had encountered with the old Range Rover which our project inherited from Baertl Nilsson in about March 1978. You told me that separate funds held by you could cover these major expenses which I told you had amounted to close to $1000.00. These kind of expenses were not included in our research budget. As you know we had originally hoped that all local transport would be provided by the Ministry of Works. Up and above these repairs we are of course faced with very heavy petrol bills because the Range Rover is a real gas guzzler. I do recognize that the Range Rover has been terribly useful and that the project could not have been run or continue to run without it.

I would however be most grateful if you could refund our project with the major expenses which have been involved. I attach to this an accounting for the sum of Shillings 7754.65 which is $1053.62 at Shs 7.36 per U.S. $1.00, plus xerox copies of the receipts.

Could you please arrange for this sum of U.S. $1053.62 to be paid to us?

Many thanks.

Sincerely,

Michael

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

Enc.

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

File, Kenya
my Res. file
please

A DIVISION OF THE NEW YORK STATE COLLEGES OF HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

March 23, 1979

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

What about
(1) Peter Haycraft
(2) Productivity studies?

Dear Clell:

Lani and I returned last week end from 10 weeks of intensive work on the World Bank/ODM supported project in Kenya. We also had brief stopovers in London where on two occasions we met with both Andrew Chesher and Mark Sharrock.

In general I am pleased with the progress that we have made, with the level of cooperation that we are receiving and with the performance of the various members of our team.

Dr. David Crompton (from Cambridge), Dr. Lani Stephenson and myself spent the greater part of January in the two villages in Machakos District doing the annual examinations on some 800 children (pre-school and school) for Study No. 4. The work included clinical, nutritional, anthropometric and stool examinations on each child. All were given an anthelminthic. Attendance was very satisfactory. The main cause of missing children is that they are not in the locality at the time of our examination. Our two Kenyan field workers, Ms. Esther Ndunda and Ms. Rose Nzuki, appear to be doing a good job. They are responsible with a little supervision, for the provision of anthelminthics at home and school to each child on two occasions (May-June and September-October) between each January. Stools have been taken to Cambridge for examination. As stated before, this study will yield important data not only on control of intestinal parasites, especially round worm (Ascaris), but also will provide a very useful set of longitudinal growth data for Kenyan children. This is something that does not exist and which many people believe will be of very great interest to planners, health workers, and others. While in Machakos, Dr. Stephenson organized a full day workshop/seminar for the primary school teachers from Kanzalu and Mwatati Primary Schools. Dr. Jansen (from MRC Nairobi), Dr. Crompton and I assisted Dr. Stephenson by giving presentations at this seminar on local health and nutrition problems, and their control. The workshop was so successful that we have been asked to provide a "session" or "baraza" for the public and the local chief. This kind of educational activity may be quite valuable.

In mid January we spent a few days in Kwale making preparations for the work there in February. Terry Elliott (Cornell nutritionist) who has been resident in Kwale doing the first anemia studies will remain there until July 1979. June Wolgemuth (Cornell nutritionist) and Andrew Hall (Cambridge parasitologist) moved in January to Kwale from Karatina where the work is complete. Both will remain in Kwale until June or July 1979 working on the project.

Dr. Crompton spent a few days in February in Kwale helping with the planning of the projects there and then returned to Cambridge. Dr. Stephenson and I were in Kwale for all of February and the early part of March 1979. Work was devoted mainly to Study No. 2d which is an evaluation of the control of hookworm, schistosomiasis and malaria, and their relationship to the anemia which is prevalent among workers, and which is related to low work output.

We received excellent cooperation in Kwale from the new RAR Engineer, Mr. Sauerlia. He is interested in our project, and goes out of his way to provide assistance.

A decision was made to work on 4 road sites in order to be sure that our N was well over 150 which was the number planned. We therefore completed examinations on the following roads:

Road 4 (Near Shimoni)	58 workers
Road 30 (Near Tiwi)	63 workers
Road 17 (Near Msambweni)	39 workers
Road 19 (Near Likoni)	57 workers
Total	217 workers

The examinations included clinical and nutritional status assessment; anthropometric (weight, height, skinfold thickness, arm and chest circumference); blood (for hemoglobin, hematocrit and malaria); stool (for parasites); and urine (for schistosomiasis ova and other abnormalities). Although these data have not been analyzed we found that around 60% were infected with hookworm, about 35% with urinary schistosomiasis, and between 30-40% have hemoglobin levels below 13 g/100 ml, the WHO cut off point for anemia. The malaria slides are being examined in Cambridge and full results are not yet available.

Before I left Kwale in March we had also almost completed dosing all workers with Combantrin (perhaps the best anthelminthic against hookworm) and those workers found to have schistosomiasis (S. hematobium) were treated with Metrifonate. On Road 4 and Road 30 we had divided the workers into two matched groups of equal size, and with nearly similar mean hemoglobin rates, and levels of infection with hookworm and schistosomiasis. One group of about 60 subjects will receive a malaria prophylaxis (chloroquine) each week and the second group will receive a placebos each week. This will allow us, as proposed, to assess the feasibility and possible benefits of a malaria prophylaxis over a period of about 12 weeks.

These road sites seem very satisfactory, and all should be in operation until June-July 1979 when the final examinations will be done. There is a risk with Road 30 because there are some problems with regard to property compensation for farms through which the road is passing.

As mentioned earlier, Lani and I met with Mark Sharrock and Andrew Chesher in London both on our way to Kenya (on January 5, 1979) and on our return in mid-March 1979. Andrew has almost completed a report to you which will be self explanatory. From what we learnt he has done a very thorough job, and has found some interesting relationships between health and nutritional status on the one hand, and work output on the other. The analysis so far undertaken is based only on the cross-sectional base-line findings. Andrew does need to be provided with further funding for perhaps 3-4 weeks work in July or August to undertake the rest of the analysis including that on the results of intervention. When that is done a discussion about a further productivity study should be held. We discussed with Andrew a possible visit by him to Cornell this summer when he will be in the U.S. on some other mission.

Because of the pressure of work we were not able to do either of the new 10-14 day ecological zone studies in new parts of the country (Study No. 3). It is my proposal that we do one of these probably in Western Kenya near Kisumu in June 1979 and the second one in an arid region (perhaps West Pokot, Baringo or Kitui) in February 1980. This then is one way in which we will not follow our time table as included in the proposal.

I am with a separate letter sending you some accounts in respect to the Range Rover. This vehicle is invaluable to us but is very costly to maintain (repairs) and to run (gas guzzling).

I wonder in the next few weeks if you could respond to the following:

(1) Provide your agreement to doing the two ecological zone studies in June 1979 and February 1980 as stated above.

(2) Comment on the possibility of having Andrew Chesher completing the analysis.

(3) Indicate that you can reimburse us for the Range Rover repairs, details of which you will have received.

(4) Confirm that funds for year 3 of the project are assured as budgeted. These are of course essential for completion of the project and to allow analysis of the data being collected.

In conclusion then, I am quite satisfied with this phase of the work. The first three months of the year have been very productive. We were also impressed with the smooth transition in Kenya following the death of President Kenyatta. President Moi seems to be very popular, and the new government have indicated their increased concern for rural development and in dealing with problems of poverty. It is also clear that there is a greatly increased interest in nutrition.

With all good wishes.

Sincerely,

Michael

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

cc? S. Bastau
L. Stephenson
A. Chesher
M. Sharrock

Mr Basta (2 copies)

KENYA HEALTH AND NUTRITION STUDY

WORKER PRODUCTIVITY AND ITS RELATION TO PHYSIQUE AND HEALTH

Andrew Chesher*

(University of Birmingham, England)

March 6, 1979

* Consultant Statistician, International Bank for Reconstruction and Development.

1. INTRODUCTION[1)]

Data concerning worker productivity in labour intensive road construction and worker physical and health status is analysed to determine the effects of the latter on productivity. Significant effects are found for arm circumference and haemoglobin level. The effects of age and presence of parasitic infection are also measured as are differences in productivities of male and female workers and differences in productivity due to construction activity. Section 2 describes the data, Section 3 the model. In Section 4 the estimation procedure and the estimates are discussed and Section 5 contains concluding comments.

2. DATA

150 road construction workers were observed in Kenya over approximately one month in June and July of 1978. Various features of the workers were measured. Some, like weight, height and arm circumference, related to their physique; others, like haemoglobin as percentage of blood volume and severity of parasitic infection, related to their health status. The workers observed were involved

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1) The assistance of Ralph Bailey, Faculty Programmer, Faculty of Commerce and Social Science of the University of Birmingham in organising and running the many complicated analyses necessary to produce the results reported here, was indispensable and is much appreciated.

in ditching, sloping and excavation in bulk and were set tasks each day. On completion of the day's task, a worker could leave the site. Tasks were marked out in linear metres along the length of the road and the workers' starting and finishing times were recorded on a number of days. Tasks were generally completed in around 4 hours. An estimate was made of the volume of soil worked by each individual and volume divided by time to give a measure of the productivity of each individual on a number of days. Productivity was measured in cubic metres per man hour (m^3/man hour). Wage rates averaged US $1 per day.

Two roads were observed: Road 7, Mururini to Kibirigwi in Kirinyaga District and Road 12 at Kiamicho Forest in Murangu District. Alternative opportunities for workers were better at Road 7 than Road 12. In the neighbourhood of Road 7, land is fertile and cash crops are grown. In the neighbourhood of Road 12 the soil is less good, the climate more arid, and few cash crops are grown, livestock generally being farmed. Supervision was somewhat better at Road 7 than at Road 12. The soil was generally uniform at Road 7 being mostly composed of red coffee soil. At Road 12 there was less uniformity, weathered rock, black cotton soil and some red coffee soil being worked. Most of the work at Road 7 was classified as excavation in bulk; most of the work at Road 12 was classified as ditching, or sloping, or ditching and sloping.

The data is discussed further in the next section as the variables used in the analysis are specified.

3. THE MODEL

Denoting the productivity on day t of worker i on road j in task k by x_{tijk} and the M^{th} attribute of the i^{th} individual by d_{Mi}, the general form of the model proposed is:

$$(I) \quad x_{tijk} = \alpha + \beta_1 d_{1i} + \beta_2 d_{2i} + \dots + \beta_m d_{mi} + u_{tijk}$$

where u_{tijk} is a random disturbance. Productivities are assumed to be determined, at least in part, by the physical and health status of the individual. It is assumed that the individuals do not change in this respect over the relatively short period of observation.

Productivity might also be expected to depend on the wage rate, on the alternative opportunities of the workers, on the type of working adopted, and on the level of supervision. It is assumed that these factors remained constant over the period of observation, thus they do not appear in (I). However, it should be noted that these factors may be different in the environments in which the results reported here are applied. If the effect of these factors may be subsumed in the constant term "α" (i.e. if (I) shifts its level only as these factors alter) then the estimates of the β_M's reported here will hold good elsewhere. However, this may not be the case and in certain circumstances even the β_M's reported here should be used with caution. For instance, if more strenuous working is to be considered then the physical constraints imposed by a worker's body on his own performance may bite harder raising the magnitude of the β_M's above those reported here.

Many of the attributes d_{Mi} may be expected to have non-linear effects on productivity. Some limited experimentation was carried out with a non-linear analogue of (I) but in the time available no substantial improvement on (I) could be obtained. Care should be taken in extrapolating linear equations and it is recommended that (I) should be used only for values of the attributes within 3 observed standard deviations of their observed means. Table 3 contains details of these means and standard deviations.

Certain variables (e.g. age) very clearly affect productivity non-linearly and to allow for this these variables were transformed before being introduced into (I). The attributes considered are now described in turn.

(a) Arm Circumference (AC) fat + muscle develop.

Measured in millimetres. Measures the stature of the individual and serves as a surrogate for physical strength. NO For the data used AC was higher (9.09 mm on average) for females than for males. This variable averages 254.8 for the data used. ?

(b) Weight as a percentage of standard weight for height (w)

Measured in percentage points. Weight is expressed as a percentage of a "standard" weight for height. Standard weight for height was obtained by interpolation from tabulated values of percent weight for height in "The Assessment of the Nutritional Status of the Community" by D.B.Jelliffe, W.H.O., Geneva, 1966. The adult standard was used for males over age 20 years and females over age 19 years. For males age 20 years or less, and females age 19 years or less, a percentage of adult standard was taken based on interpolation from weight for height for age tables in the same reference.

w provides a measure of stature and a surrogate for physical strength. For the data used w was positively correlated with AC (simple correlation = 0.59) and w was higher (14.0 percentage points) for females than for males - note that w is not weight but weight as a percentage of standard weight for height. This variable averaged 83.02 for the data used.

(c) Haemoglobin (H)

Haemoglobin content of blood by weight per unit of blood volume, measured in grams/100 mills. An indicator for anaemia. For the data used this variable averaged 14.53 and was on average 1.45 lower for females than for males. H was weakly negatively correlated with AC and w (simple correlations of -.11 and -.12 respectively).

(d) Infection (I)

Information on the detected presence or absence, and extent of each of seven 7 types of parasitic infection was available. Separate examination of these infections was not possible in the time available. Nor was any examiantion of the effect of severity of infection possible. Both are interesting topics for further study. Four infections were isolated as being likely to be most debilitating. These were: hookworm, trichuris, schistosoma mansoni and strongyloides stercoralis. An "infection" variable, I, was defined. I = 1 for an individual who has one or more of these infections; I = 0 for an individual who has none of these infections. Of the 84 individuals used in the analysis, 26 were infected of whom 2 were females. Presence of infection was associated weakly with lower weight as percentage of weight for height, and lower arm circumference but much of this association is probably due to the uneven incidence of parasitic infection in the sexes. IMPORTANT

(e) Age (A)

Very young and very old individuals may be expected to have lower productivities than individuals of intermediate ages for whom age may not affect productivity at all. Some of the effects of age may be felt via the measures of stature and health but there are likely to remain effects due to age even when these are discounted, because of age dependent constitutional weaknesses. No data on very young (< 16 years) workers was used but 5 workers over 50 years old were included in the analysis. To incorporate the effect of age into (I) a variable "A" was defined. A = 1 for individuals aged over 50; A = 0 for individuals aged 50 or less. This variable could doubtless be refined in later analysis but time has not permitted this to date.

(f) Sex (S)

Female workers are expected to have lower productivity than males in heavy manual work even when of identical stature and health. Productivity will be even lower if the female is pregnant or lactating. Only 3 women were in these latter states and they were excluded from the analysis. A variable "S" was defined. S = 1 if the worker is female, S = 0 if the worker is male. For the data used there were 14 females and 70 males. All the females were under 51 years old and 2 of them had detected parasitic infections of the types described above.

(g) Road (R)

To allow for the effect of differing environments (e.g. soil type) at the two sites, a variable "R" was defined. R = 1 for work done at Road 7; R = 0 for work done at Road 12. No workers were observed at both roads. There were 43 workers observed at Road 7 and 41 at Road 12.

(h) Task (T)

Four tasks were observed: ditching, sloping, ditching and sloping (combined) and excavation in bulk. Insufficient data and time prevented the analysis of the effects of all four tasks on equation (I) and the first three tasks were merged into one, henceforth termed "ditching". A variable T was defined. T = 1 for excavation; T = 0 for ditching and related activities. A few workers took part in both activities and their productivities are treated as separate observations in the subsequent analysis. Ideally this problem would have been handled by using an error components model for equation (I) but this was not possible in the time available. The result of proceeding as above will be to overstate the precision of estimation and goodness of fit of the fitted relationships but the magnitudes involved are likely to be relatively small. In the data used 41 observations were obtained on excavation (of which 36 were at Road 7) and 43 observations on ditching (of which 36 were at Road 12).

The attributes listed above and their representations used in the analysis are summarised at the end of this section on page 10. The dependent variables used are now considered.

A number of days' data was available for each individual for each activity in which he or she was involved. Because of daily changes in climate, soil conditions and other environmental conditions, the relationship (I) may be expected to alter from day to day. Using daily data presents statistical problems because of the repeated occurrence of the same individuals in the resulting data set. This would indicate the use of an error components model for (I) but time was not sufficient to adopt such a model.

Two options were open: first to simply average the productivity for each individual in each task in which he was involved. This was done and the resulting variable denoted $\bar{x}_{ijk}$ was used as a dependent variable in the analysis. Since individuals worked differing numbers of days more reliance should be placed on some of the $\bar{x}_{ijk}$'s than on others. To allow for this a weighted least squares analysis was performed. If the day to day unmeasured variations in productivity are unassociated with the attributes described earlier then using $\bar{x}_{ijk}$ as a dependent variable should yield good estimates of the β_m's.

The alternative is to measure for each individual on each day the extent to which his productivity was above or below average productivity <u>for the day</u>. This measurement can be carried out in standard deviation units (the standard deviation being that for productivity on the day in question). The resulting measure is termed the "Z-score" for the individual and has the formula

$$z_{tijk} = (x_{tijk} - \bar{x}_{tjk})/s_{tjk}$$

where $\bar{x}_{tjk}$ is the mean productivity on day t on road j in task k and s_{tjk} is the associated standard deviation of productivity. The "Z-scores" thus obtained were averaged for each individual in each task in which he was involved to give the second dependent variable used in the analysis, $\bar{z}_{ijk}$. It should be noted that only individuals for whom two or more days' data were available were included in the analysis though all individuals were used in the calculation of $\bar{x}_{tjk}$ and s_{tjk} to produce the Z-scores. Individuals for whom information on attributes was incomplete were deleted. 84 data points remained.

Equations estimated with mean productivity, $\bar{x}_{ijk}$, as dependent variable are simple to use and interpret. Equations using $\bar{z}_{ijk}$ are slightly more complicated. To illustrate their use suppose that the equation (I) has been estimated using $\bar{z}_{ijk}$ with coefficients $\hat{\alpha}$, $\hat{\beta}_1$, $\hat{\beta}_2$, ..., $\hat{\beta}_m$ so that the predicted value for $\bar{z}_{ijk}$ is $\hat{\bar{z}}_{ijk}$ given by

$$\hat{\bar{z}}_{ijk} = \hat{\alpha} + \hat{\beta}_1 d_{1i} + \hat{\beta}_2 d_{2i} + \dots + \hat{\beta}_m d_{mi}$$

Suppose that predictions of <u>productivity</u> are required for a new environment in which average productivity is AV and standard deviation of productivity is SD. Productivity, P, would be estimated as

$$P = AV + (\hat{\alpha} + \hat{\beta}_1 d_{1i} + \hat{\beta}_2 d_{2i} + \dots + \hat{\beta}_m d_{mi}) \times SD$$

or $\quad P = AV + SD \times \hat{\bar{z}}_{ijk}$

The use of Z-scores presents statistical problems which have not been addressed here. They are briefly outlined in the Appendix to the report. Z-scores were used here (a) to obtain results comparable with previous work on similar data, (b) to allow for non-random day to day variation in productivity. In fact the results obtained using Z-scores and mean productivities are rather similar.

this is a ±S.D.

For the data used $\bar{z}_{ijk}$ averaged 0.098 and $\bar{x}_{ijk}$ averaged 0.773 m^3/man hour. Both measures were higher on Road 7 than Road 12 in excavation than in ditching, and higher for males than for females. $\bar{x}_{ijk}$ and $\bar{z}_{ijk}$ were negatively correlated with w, positively correlated with AC and H and I.

The disposition of the sample of workers by road, task and sex is shown in Table 1 and by age, sex and infection in Table 2. In Table 3 means and standard deviations of attributes and of $\bar{x}_{ijk}$ and $\bar{z}_{ijk}$ are given for all the data and for various subsets of it. In Table 4 simple pairwise correlations amongst all the variables are shown for all the data and for males and females separately. Tables 6(A) and 6(B) give daily means and standard deviations of productivity by road and task. These were used in calculating Z-scores and should help in their interpretation. Below the variables used in the analysis are summarised.

Summary of the Variables Used

$\bar{x}_{ijk}$ — Average productivity for individual i on road j in task k (m^3/man hour)

$\bar{z}_{ijk}$ — Average Z-score for productivity of individual i on road j in task k (units are: no. of standard deviations from mean)

AC_i	Arm circumference of individual i (mm)
w_i	Weight as percentage of standard weight for height of individual i (percentage points)
A_i	A_i=1 if individual is aged 51 or more A_i=0 if individual is aged 50 or less
S_i	S_i=1 if individual is female S_i=0 if individual is male
H_i	Haemoglobin content of blood by weight per unit of volume (grams/100 mills)
I_i	I_i=1 if individual i is known to be infected with hookworm or trichuris or schistosoma mansoni or strongyloides stercoralis. I_i=0 if individual i is not known to be infected with these parasites.
T_i	T_i=1 if individual is excavating T_i=0 if individual is ditching, ditching and sloping, or sloping.
R_i	R_i=1 if individual is working at Road 7 R_i=0 if individual is working at Road 12.

ESTIMATION

Though equation (I) gives the general form of the model to be used, in practice many variations on it are possible. The following choices have to be made.

(a) Is the relationship appropriately specified as linear? If not, what functional form should be used?

(b) What attributes affect productivity?

(c) Does the equation (I) apply to all tasks, to all roads, for all sexes or should the relationship be allowed to differ as some or all of these variables change?

Unfortunately, in the time available these three questions could not be investigated simultaneously as in principle they should. Accordingly, (a) and (b) were attacked using a relatively homogeneous body of data - the 34 observations obtained on men excavating at Road 7. Various functional forms and lists of attributes were tried and it was concluded that the linear form and the list of attributes introduced in the previous section were adequate. It was noted that some of these attributes might be redundant in the analysis of the complete data so the possibility of deleting attributes was acknowledged when (c), the homogeneity of the data, was assessed.

At this stage, an analysis of covariance was performed, a number of variants of equation (II) being investigated. These variants were fitted to the complete data and to various subsets of

(II) $$\bar{x} = \alpha + \beta_1 w + \beta_2 A + \beta_3 AC + \beta_4 H + \beta_5 I + u$$
$$\bar{z} = \alpha + \beta_1 w + \beta_2 A + \beta_3 AC + \beta_4 H + \beta_5 I + u$$

it. The fit obtained by allowing the variants of (II) to differ for different subsets was compared with fit obtained when a single equation was fitted to the complete data or to less fine partitions of it. In this way the homogeneity of the sample with respect to the relationship (II) was assessed while allowing for the possibility that some of the variables appearing in (II) might be redundant.

Analysis of covariance with three dichotomous categorisations (sex, task and road) is a complex procedure and here, because of the desire to investigate variants of (II), involved the fitting of over three hundred separate regression equations. The results are not reproduced in full here but can be summarised as follows.

Whatever variant of (II) is used it is clear that the relationship between productivity and individual attributes does depend on the sex of the workers. Also it depends on either the task carried out or the site at which work was done or both. Unfortunately, the effects of road and task are difficult to disentangle. This is because most excavating occurred at Road 7 and most ditching at Road 12 (see Table 1). The sample sizes in each of the cells of Table 1 are not large enough to give good estimates of any variant of (II) for any single sex/task/road combination. If it were the case that (II) varied from cell to cell only in its intercept (α) then reasonable estimates of the β_m's might be obtained by pooling the data and allowing α to alter from cell to cell. Accordingly the dummy variables S, T and R were introduced and variants of equation (III) were fitted to the complete data and to subsets of it.

$$\text{(III)} \quad \bar{x} = \alpha + \beta_1 w + \beta_2 A + \beta_3 AC + \beta_4 H + \beta_5 I + \beta_6 S + \beta_7 R + \beta_8 T + u$$

$$\bar{z} = \alpha + \beta_1 w + \beta_2 A + \beta_3 AC + \beta_4 H + \beta_5 I + \beta_6 S + \beta_7 R + \beta_8 T + u$$

It was concluded that whatever variant of (III) was used the coefficients β_6, β_7, and β_8 were jointly significant at better than the 1% level. Further comparing the fit obtained using (III) with that obtained when (II) is fitted to each cell of Table 1[1)] it was concluded that letting the intercept, α, vary from cell to cell allowed for most of the non-homogeneity of the sample. This result was not particularly strong and with a larger sample it is likely that significant differences in some of the coefficients $\beta_1, \ldots, \beta_m$ would have been found. It may therefore be wise to regard the reported estimates of the β_m's as estimates of "average" marginal effects of individual attributes on productivity.

The relationships reported here are obtained using equation (III). The analysis proceeded to this point using ordinary least squares in order to estimate coefficients. At the conclusion of the analysis the final equations were re-estimated using weighted least squares. The rationale for this is that the dependent variables in the analysis are both averages taken over all days worked by individuals. Since some individuals work more days than others some averages are more reliable than others. To allow for this <u>all</u> the variables were

---

1) Of course some cells in Table 1 are empty and others are very sparsely populated. However, valid tests of the homogeneity of (II) over the sample can still proceed by fitting (II) where possible and modifying the "standard" analysis of covariance test statistics.

weighted by $\sqrt{N_{ik}}$ where N_{ik} is the number of days' data used to produce the value of the dependent variable for individual i in task k. In this way more weight is given to data arising from individuals on whom more days' data are available. The homogeneity of the sample was re-assessed after weights by performing a generalised analysis of covariance and the final equations are reported in Table 5. Both weighted and unweighted estimates are reported and four variants of equation (III) are given. These are now discussed.

because female hormones × fat!

2

Throughout the analysis it was clear that weight as a percentage of standard weight for height (w) was not an important determinant of productivity for this data. Simple correlations coefficients can be seen in Tables 4(A), 4(B) and 4(C). With the complete data and for females along, w is <u>negatively</u> correlated with X and Z though for males alone w is positively correlated with X and Z but only weakly with X. When w was included in equation (III) either with or without arm circumference (with which it is quite strongly correlated (r = .59)) its estimated coefficient was not significant at even the 10% level. To allow comparability with previous studies equations (II) and (IV) which exclude AC and include w, are reported (Table 5). Here the coefficient on w does have the right sign (despite the negative correlations in Table 4) but it is poorly determined.

3

Better results were obtained using arm circumference as a measure of stature and physical strength. This variable generally took a significant coefficient whether w was included or not. Equations (1) and (3) of Table 5 are estimates of (III) with AC included and w deleted.

4

A considerable improvement in the fit of the relationships was obtained on the introduction of the haemoglobin variable (H). It invariably took a positive sign (as H rises, so does productivity) and was strongly significant (at better than the 5% level generally and sometimes at better than the 1% level). Beautiful!

The age and infection variables had coefficients which were rarely significant but they did have correct signs (both negative) and seemed to be of reasonable orders of magnitudes. Further experimentation here might well produce interesting results. The age variable used probably does not capture the non-linearity of the effect of age particularly well and could be improved. The infection variable is presently rather weakly specified and has no connotations of the degree of infection.

The equations (1)-(4) of Table 5 are now discussed in turn. Since equation (1) is the final choice for the productivity/attribute relationship it is discussed at greater length than the others.

Equation 1

Here w is excluded and AC is included along with A (age), H, I, S, R and T. Equations 1a and b are weighted estimates, 1c and 1d are unweighted. The first of each pair has mean Z-score as dependent variable; the second has mean productivity as dependent variable. This arrangement is used throughout Table 5. The weighted and unweighted regressions do not differ greatly though arm circumference is on occasions not significant in the unweighted analyses. Only the weighted regressions are discussed here.

In equation 1, using $\bar{z}$ or $\bar{x}$, arm circumferences takes a positive coefficient and is significant at better than the 5% level (10% in the case of $\bar{x}$). With $\bar{z}$ as dependent variable its value is 0.0087. Raising arm circumference by one standard deviation (17.86 mm, see Table 3) raises the Z-score for productivity by

0.16 which implies a rise in productivity itself of about 0.033 m^3/man hour, an increase of 4%[1]. Similar results obtain when $\bar{x}$ is used as dependent variable.

Haemoglobin takes a positive coefficient which is strongly significant. With $\bar{z}$ as dependent variable its value is 0.100, indicating that a one standard deviation rise in haemoglobin (1.32 grams/100 mills; see Table 3) is associated with a 0.132 rise in Z-score implying a rise in productivity of 0.027 m^3/man hour, an increase of 4%. Again similar results are obtained using $\bar{x}$ as dependent variable.

The infection variable is not significant but takes the correct sign, the presence of infection reducing productivity. The presence of infection is estimated to reduce productivity by 0.025 m^3/man hour (.047 m^3/man hour using $\bar{x}$ as dependent variable) but this effect is very imprecisely estimated. Age is weakly significant, individuals over 50 years of age having productivity 0.08 m^3/man hour less than other individuals once the age effects on the other attributes like arm circumference have been allowed for. Age is negatively correlated with AC, H and I - older people are more likely to have small arm circumferences, lower haemoglobin levels and are more likely to have parasitic infections - thus the total effect of age is larger than the age coefficient suggests.

The three dummy variables - S, R and T - are all significant with $\bar{z}$ as dependent variable though R (road) is not significant with $\bar{x}$ as dependent variable. This is a common phenomenon throughout the

---

1) A standard deviation for productivity of 0.210 is assumed. This was the average standard deviation in this study; see Table 6(B).

analysis. Using Z-scores reduces the non-homogeneity of the sample with respect to road and task though not with respect to sex. Thus R and T have smaller coefficients when $\bar{z}$ is used. Female workers have productivities which are about 0.15 m^3/man hour (19%) lower than males once other attributes have been allowed for. Note though that females tend to have larger arm circumferences and lower rates of infection (though lower haemoglobin levels) than males so the difference between male and female productivity is likely to be slightly less than this. The variable T takes a positive coefficient indicating that productivity was higher generally in excavating than in ditching and related activities.

Though the marginal effects of many attributes on productivity have been isolated the overall fit of the equations is not particularly good, squared multiple correlation coefficients (R^2) around 0.3 being obtained. Much of the unexplained variation is probably due to errors in measuring productivity, unmeasured personal attributes and unmeasured climatic and other environmental changes. Using mean productivity ($\bar{x}$) as dependent variable, R^2 is higher but this is because taking Z-scores reduces some of the unexplained variation in productivity which is due to day to day climatic and other environmental changes leaving less variation to be explained by the attributes considered here, particularly R and T.

Equation 2

In equation 2 arm circumference is replaced by weight as a percentage of standard weight for height (w). This variable is not significant though its coefficient has the right sign (+). Using Z-scores as dependent variable the coefficient on w is 0.01. A one standard deviation rise in w (9.6 percentage points; see

too high?

Table 3) produces a 0.096 rise in Z-score implying a 0.02 m^3/man hour rise in productivity, a rise of about 3%. This is in line with equation (1). H, I, A, S, R and T have coefficients of similar magnitudes to those obtained in equation 1.

Equation (1) appears preferable to equation (2) for predictive purposes. However, both (1) and (2) contain the variables age and infection which have ill-determined coefficients and it may be felt that these should be deleted. If A and I are deleted the results labelled equations (3) and (4) of Table 5 are obtained.

Equation 3

Here arm circumference is included and w is excluded as are A and I. AC and H are still significant as are S and T. All coefficients are of similar magnitudes to those obtained in equation 1 and the discussion of that equation applies here.

Equation 4

Here AC is excluded as are A and I while w is included. As in equation (2) the coefficient on w is not significant while the coefficients on H, S and T are. Again coefficients alter little on the exclusion of A and I.

CONCLUSIONS

The sample analysed here relates to productivities of males and females in four activities at two road sites over a period of approximately one month. There is considerable heterogeneity in the sample and much unexplained variation in productivities. Nevertheless it has been possible to isolate and measure the effects on productivity of arm circumference and haemoglobin level and to weakly determine effects for age and presence of parasitic infection. Incidentally differences in productivity between males and females have been measured.

The most informative equations concerning productivity are equations 1(a) and 1(b) of Table 5 reproduced here:

$$1(a)\quad \hat{\hat{z}} = -3.435 - .389A + .0087AC + .100H - .121I - .719S - .461R + .598T$$

$$1(b)\quad \hat{\hat{x}} = -0.191 - .087A + .0017AC + .033H - .047I - .247S - .096R + .380T$$

Converting 1(a) to productivity form using an average productivity of 0.773 and a standard deviation for productivity of 0.210 gives

$$1(a)'\quad P = 0.052 - .082A + .0018AC + .021H - .025I - .152S - .097R + .126T$$

which is broadly similar to 1(b) obtained using productivity directly.

When predicting with these relationships it should be noted that certain of the attributes are related to each other. For example, an individual with a severe parasitic infection may have a low haemoglobin level and small arm circumference. The effect of severe infection is then greater than indicated by the coefficient it will not!

on the infection variable. Similarly dietary supplementation to improve haemoglobin levels may raise arm circumferences so that the effect of such intervention is larger than it might at first appear to be.

Important further work could be done with this data. The following matters deserve attention.

(A) Does the estimated relationship fit for data gathered subsequent to caloric intervention?

(B) Are there effects due to parasitic infections which have not been determined to date? In particular, how important is severity of infection?

(C) Is the effect of haemoglobin level linear or is there a threshold above which changes in H do not affect productivity? If so, then the estimated effect of H for anaemic workers is likely to have been <u>under</u> estimated.

(D) Is the effect of age well-modelled at present?

(E) Are other variables useful determinants of productivity? Among those that might be considered are haematocrit and triceps skinfold measurements.

TABLE 1

DISPOSITION OF SAMPLE BY ROAD, TASK AND SEX

	Road 7		Road 12		Total
	Excavating	Ditching, etc	Excavating	Ditching, etc	
Males	34	7	0	29	70
Females	2	0	5	7	14
Total	36	7	5	36	84

Total: Road 7 = 43 Total: Road 12 = 41

Total: Excavating = 41 Total: Ditching = 43

TABLE 2

DISPOSITION OF SAMPLE BY AGE, INFECTION AND SEX

	Infected		Not Infected	
	Age > 50	Age $\leqslant 50$	Age > 50	Age $\leqslant 50$
Males	0	24	5	41
Females	0	2	0	12
Total	0	26	5	53

Total Infected = 26 Total Not Infected = 58

Total Age > 50 = 5 Total Age $\leqslant 50$ = 79

TABLE 3

MEANS AND STANDARD DEVIATIONS OF VARIABLES

Data	Average of				
	w	AC	H	X	Z
All	83.02 (9.60)	254.79 (17.86)	14.53 (1.32)	0.773 (0.25)	0.098 (0.63)
Road 7	80.56 (6.03)	256.23 (15.97)	14.85 (1.18)	0.911 (0.25)	0.254 (0.61)
Road 12	85.60 (11.82)	253.27 (19.74)	14.18 (1.39)	0.628 (0.02)	-0.650 (0.60)
Excavating	81.84 (7.80)	257.17 (18.08)	14.63 (1.34)	0.944 (0.22)	0.299 (0.62)
Ditching, etc	84.14 (11.02)	252.51 (17.56)	14.42 (1.32)	0.609 (0.14)	-0.093 (0.58)
Males	80.68 (7.75)	253.27 (16.48)	14.77 (1.15)	0.807 (0.26)	0.171 (0.58)
Females	94.72 (9.61)	262.36 (22.81)	13.32 (1.51)	0.603 (0.14)	-0.267 (0.74)

Figures in parentheses are standard deviations.

w = weight as %age of weight for height (%age points)

AC = arm circumference (mm)

H = haemoglobin weight per unit of volume (grams/100 mills)

X = average productivity (m^3/man hour)

Z = average Z-score for productivity (standard deviation units)

TABLE 4

CORRELATION MATRICES

(A) All Data (84 Observations)

	S	R	T	W	A	AC	H	I	X
S									
R	-.33								
T	.01	.72							
W	.55	-.26	-.12						
A	-.11	-.16	-.15	-.14					
AC	.19	.08	.13	.59	-.21				
H	-.41	.26	.08	-.11	-.12	.07			
I	-.16	.09	.12	-.07	-.17	.10	.02		
X	-.30	.56	.67	-.16	-.14	.08	.36	.03	
Z	-.26	.25	.31	-.02	-.17	.23	.37	.03	.72

S = 1 for females, 0 for males

R = 1 for Road 7 , 0 for Road 12

T = 1 for excavation, 0 for ditching, etc.

W = weight as %age of weight for height

A = 1 if age > 50, 0 if age ≤ 50

AC = arm circumference

H = haemoglobin

I = 1 if infected, 0 otherwise

X = average productivity

Z = average Z-score for productivity

(B) Males (70 Observations)

	R	T	W	AC	H	I	X
T	.82						
W	-.07	-.10					
AC	.22	.16	.53				
H	.23	.13	.23	.29			
I	.06	.14	.04	.22	-.08		
X	.55	.73	.05	.22	.33	.00	
Z	.28	.29	.21	.40	.36	-.07	.71

(C) Females (14 Observations)

	R	T	W	AC	H	I	X
T	.41						
W	-.29	-.37					
AC	-.16	.03	.77				
H	-.34	-.07	-.14	-.19			
I	-.17	.00	-.11	-.28	.09		
X	.09	.61	-.33	-.23	-.06	-.25	
Z	-.32	.48	-.06	-.01	.11	-.02	.81

TABLE 5

ESTIMATED RELATIONSHIPS

Equation No.	Dependent Variables	INDEPENDENT VARIABLES									Weighted?	R^2	$\hat{\varepsilon}'\hat{\varepsilon}$
		w	A	AC	H	I	S	R	T	CNST			
1a	Z		-.389^{o} (.229)	.0087* (.003)	.100* (.048)	-.121 (.122)	-.719** (.236)	-.461^{o} (.264)	.598* (.266)	-3.435 (.941)	Yes	-	114.372
1b	X		-.087 (.061)	.0017^{o} (.001)	.033** (.013)	-.047 (.032)	-.247** (.063)	-.096 (.070)	.380** (.071)	-0.191 (.251)	Yes	-	8.132
1c	Z		-.326 (.270)	.0081* (.004)	.115* (.052)	-.135 (.136)	-.555** (.210)	-.342^{o} (.200)	.572** (.186)	-3.577 (1.096)	No	.317	22.731
1d	X		-.081 (.083)	.0006 (.001)	.038* (.061)	-.062 (.042)	-.204** (.064)	-.061 (.061)	.371** (.051)	-0.021 (.337)	No	.596	2.151
2a	Z	.010 (.006)	-.419^{o} (.235)		.121** (.048)	-.087 (.123)	-.737** (.257)	-.417 (.291)	.632** (.274)	-2.378 (.803)	Yes	-	120.563
2b	X	.002 (.002)	-.092 (.062)		.037** (.013)	-.041 (.032)	-.256** (.067)	-.088 (.071)	.388** (.072)	-0.013 (.211)	Yes	-	8.301
2c	Z	.012 (.008)	-.363 (.274)		.120* (.053)	-.106 (.138)	-.620* (.240)	-.308 (.203)	.605** (.191)	-2.575 (.941)	No	.291	23.592
2d	X	.003 (.002)	-.078 (.082)		.037* (.016)	-.061 (.041)	-.236** (.072)	-.058 (.061)	-.378** (.057)	-0.072 (.282)	No	.601	2.125
3a	Z			.0089* (.003)	.113* (.048)		-.627** (.230)	-.420 (.265)	.560* (.267)	-3.743 (.925)	Yes	-	119.430
3b	X			.0016^{o} (.0009)	.037** (.013)		-.218** (.061)	-.084 (.071)	.367** (.071)	-0.252 (.247)	Yes	-	8.506
3c	Z			.0082* (.004)	.127* (.051)		-.466* (.200)	-.292 (.197)	.540** (.184)	-3.871 (1.064)	No	.299	23.350
3d	X			.0005 (.0011)	.042** (.016)		-.172** (.062)	-.044 (.061)	.357** (.057)	-0.087 (.328)	No	.582	2.227
4a	Z	.011 (.007)			.133** (.048)		-.661** (.252)	-.377 (.272)	.603* (.274)	-2.697 (.790)	Yes	-	125.821
4b	X	.002 (.002)			.040** (.013)		-.230** (.066)	-.076 (.071)	.376** (.072)	-.088 (.207)	Yes	-	8.651
4c	Z	.012 (.008)			.132* (.052)		-.542* (.232)	-.258 (.200)	.581** (.189)	-2.894 (.913)	No	.273	24.217
4d	X	.003 (.002)			.041* (.016)		-.207** (.070)	-.042 (.060)	.365** (.057)	-0.156 (.225)	No	.588	2.197

Figures in parentheses are standard errors of estimates of coefficients. $\hat{\varepsilon}'\hat{\varepsilon}$ is the sum (weighted sum in the case of weighted least squares analyses) of squared least squares residuals. R^2 is the multiple correlation coefficient and is not applicable to weighted least squares estimates.

** significantly different from zero at the 1% level
* significantly different from zero at the 5% level
o significantly different from zero at the 10% level

w = weight as %age of weight for height
A = age dummy
AC = arm circumference
H = haemoglobin
I = infection dummy
S = sex dummy
R = road dummy
T = task dummy

TABLE 6

(A) DAILY MEAN AND STANDARD DEVIATION OF PRODUCTIVITY

(m^3/man hour) BY ROAD AND TASK

Road	Task	Date Day	Date Month	Mean Productivity	Standard Deviation of Productivity	No. of Workers
ROAD 12	Excavation	19	6	.359	.172	16
		20	6	.408	.155	21
		21	6	.317	.171	28
		22	6	.706	.261	27
		23	6	.872	.291	4
		27	6	.707	.192	11
		28	6	.720	.181	18
		29	6	.500	.195	17
		30	6	.809	.223	12
		3	7	.607	.143	23
		4	7	.908	.340	30
		5	7	.828	.369	31
		6	7	.818	.226	12
		7	7	.582	.225	17
		8	7	.678	.185	23
		10	7	.802	.232	17
		11	7	.698	.246	21
	Ditching etc.	5	7	.640	.181	20
		6	7	.607	.189	7
		7	7	.751	.106	6

TABLE 6 (continued)

Road	Task	Date Day	Date Month	Mean Productivity	Standard Deviation of Productivity	No. of Workers
ROAD 7	Excavation	28	6	.518	.063	8
		29	6	.595	.090	7
		30	6	.502	.077	5
		1	7	.600	.282	12
		3	7	.556	.107	5
	Ditching, etc.	27	6	.931	.141	37
		28	6	1.350	.405	24
		29	6	.805	.245	22
		30	6	1.067	.173	17
		1	7	1.080	.412	22
		3	7	.815	.248	27
		4	7	.865	.230	24
		5	7	.821	.219	22
		6	7	.825	.255	33
		7	7	.734	.249	30
		8	7	.769	.286	14
		10	7	.547	.155	6
		11	7	.633	.159	3
		12	7	.747	.103	8

TABLE 6

(B) AVERAGES OF STANDARD DEVIATIONS

	Road 7	Road 12	Average by task
Excavating	.124	.224	.201
Ditching, etc.	.234	.159	.221
Average by road	.205	.214	Average for all data .210

APPENDIX

Z-Scores

Consider (I) in vector notation:

$$(I)' \quad x_{tijk} = \alpha' + \alpha_t + \alpha_j + \alpha_k + \beta' D_i + u_{tijk}$$

where D_i is a vector of attributes, β is a vector of coefficients and α has been written as $\alpha' + \alpha_t + \alpha_j + \alpha_k$ where α_t, α_j and α_k are changes in the intercept α induced by day to day environmental changes, changes in road and changes in task respectively. The Z-score for individual i on road j in task k is related to the D_i's by:

$$(AI) \quad z_{tijk} = \frac{-\beta' \bar{D}_{tjk}}{S_{tjk}} + \frac{\beta' D_i}{S_{tjk}} + \frac{u_{tijk} - \bar{u}_{tjk}}{S_{tjk}}$$

Here $\bar{D}_{tjk}$ is the mean vector of attributes of workers working on day t in task k on road j. Least squares analysis of (AI) (or weighted least squares analysis of an averaged version of (AI)) involves regressions of z_{tijk} (or $\bar{z}_{ijk}$) on the D_i. It produces an estimate of the average of the term $\frac{-\beta' \bar{D}_{tjk}}{S_{tjk}}$ as estimated intercept and of $\frac{\beta'}{S_{tjk}}$. There are substantial statistical problems in the analysis of (AI). The properties of the error term are obscure and matters are complicated by the dependence of S_{tjk} on the z_{tijk}'s.

With reasonably large numbers of individuals working on most days and assuming that the attendance of workers does not depend on day to day conditions in such a way that day to day conditions are associated with the attributes measured in D_i, the analysis of (AI) using standard methods may be expected to lead to reasonable predictions for productivity.

The University of Birmingham

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Mrs. Basta for info D836

please file in my Kenya file

ADC/LML

6th February, 1979

Dr. Michael C. Latham,
Division of Nutritional Sciences,
Cornell University,
Savage Hall,
Ithaca,
New York, 14853
U. S. A.

Dear Michael,

Another progress report. I have nearly completed my analysis of the productivity vs. anthropometric attributes relationships though since I have a few loose ends to tie up I cannot provide you with the answers just yet. The analysis has produced some interesting results. Generally weight for height performs poorly but arm circumference seems to take its place quite adequately. The haemoglobin variable is surprisingly significant and the presence of parasitic infection though not significant generally depresses productivity.

The analysis has been something of a nightmare because of the considerable heterogeneity of the data. Nevertheless by judicious use of dummy variables we have been able to pool all the data and achieve what I think are interesting results. I will send them to you when they are complete.

I have not started the analysis of the effect of caloric intervention yet as I do not have the information on
(a) level of caloric supplementation,
(b) number of days attendance by workers.
You might note that I am going to be in Brazil from March 24th to May 12th and possibly to Nepal for July and half of August. It would be most convenient for me if I could do the caloric intervention analysis during May/June. Is this alright with you?

I hope your recent trip to Kenya was enjoyable and successful and look forward to seeing you again.

Best wishes,

Andrew Chesher

Logged - Jan 26, '79

The University of Birmingham

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Telephone 021-472 1301 Extn. 2569

1) cc S Best

ADC/LML

16th January, 1979

Dr. Michael Latham,
c/o Dr. A. Jansen,
P.O. Box 20752,
Nairobi,
KENYA,
East Africa.

Dear Michael,

A short "progress report". We have spent some time re-working the basic data files so that all individuals with 2 or more days data and anthropometric data are included in the analysis. We have also re-defined a few of the variables in the light of our discussion at Heathrow. Consequently, there are no new results to give you but I will communicate again when there are. I believe Mark Sharrock has written to you concerning the information we need before we can examine the effect of caloric supplementation.

I enjoyed meeting you again and hope that your journey to Nairobi was pleasant.

Best wishes,

Yours sincerely,

Andrew Chesher

c.c. Dr. C.G. Harral,
World Bank.

INCOMING CABLE

Mr. Basta
D836

mc

File Basta Kenya file
(for Joy)

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File Kenya (for Joy)

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

January 2, 1979

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

I phoned you as I am leaving for Kenya on January 4. I was told that you would not be back in the office until January 15.

I wanted to touch base with you before Lani and I leave because we will be there for some 10 weeks.

We have arranged to meet on January 5 for a few hours with Mark Sharrock and Andrew Chesher (unless his wife delivers a baby that day!). This I believe will be useful. We will try to meet them for a longer period when we return through London on about March 12, 1979.

I still have not heard whether Peter Hopcraft has accepted the World Bank's offer. Therefore I go to Kenya not knowing whether he is our economic consultant. I can of course see him and find out. But perhaps a cable to me c/o Dr. Jansen, NETROPHELTH, Nairobi would be helpful. My address in Kenya will be c/o Dr. A. Jansen, Medical Research Centre, Box 20752, Nairobi. But most of the time we'll be in the field in Machakos or Kwale so will not get mail that frequently.

As you know on this visit we will be doing the examinations of the 900 or so children for the Ascaris study in Machakos and will be beginning the three new studies on control of hookworm, malaria and schistosomiasis in Kwale District. If time allows we may also do a cross sectional study in a new ecological zone.

With all good wishes for 1979.

Sincerely,

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

cc: Dr. Samir Basta ✓

File Kenya
(for Don)

Cornell University

DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF
HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
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January 2, 1979

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

I phoned you as I am leaving for Kenya on January 4. I was told that you would not be back in the office until January 15.

I wanted to touch base with you before Lani and I leave because we will be there for some 10 weeks.

We have arranged to meet on January 5 for a few hours with Mark Sharrock and Andrew Chesher (unless his wife delivers a baby that day!). This I believe will be useful. We will try to meet them for a longer period when we return through London on about March 12, 1979.

I still have not heard whether Peter Hopcraft has accepted the World Bank's offer. Therefore I go to Kenya not knowing whether he is our economic consultant. I can of course see him and find out. But perhaps a cable to me c/o Dr. Jansen, NETROPHELTH, Nairobi would be helpful. My address in Kenya will be c/o Dr. A. Jansen, Medical Research Centre, Box 20752, Nairobi. But most of the time we'll be in the field in Machakos or Kwale so will not get mail that frequently.

As you know on this visit we will be doing the examinations of the 900 or so children for the Ascaris study in Machakos and will be beginning the three new studies on control of hookworm, malaria and schistosomiasis in Kwale District. If time allows we may also do a cross sectional study in a new ecological zone.

With all good wishes for 1979.

Sincerely,

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

cc: Dr. Samir Basta

INCOMING MAIL UNIT
1979 JAN -9 PM 4:02
RECEIVED

SB's
Kenya file

December 15, 1978

Mr. Juma Mwakuzimu
P.O. Box 58,
Kwale, (Mombasa)
Kenya

Dear Juma;

Thank you very much for your letter. Unfortunately, I did not receive the previous letter you sent me, but I think I do understand what you are referring to. Let me just say that I am very pleased that you are now a teacher in primary school, because of the following reasons:

(a) Your knowledge and experience are being transmitted to young people of your country who will carry this for the rest of their lives, and hopefully help their nation and themselves by it.

(b) Teaching has traditionally led to positions of great importance in East Africa. It has been considered a major stepping stone to political and professional careers.

(c) Time and time again, I have discovered that the vehicle to improved social, health, and agricultural progress for countries such as yours and mine is through teachers and educators.

You can, and I am sure will, reach your career goals of being an accountant or a doctor, for you are still a very young man and opportunities will come to you as they have for any man of your educational background. I am also confident that Dr. Latham, who has such a wide circle of acquaintances in East Africa, Europe and America, will help as much as he can. One suggestion I may offer you is also to get in touch with the American, German, Dutch, Swedish, French and British consulates in Mombasa to ask about their educational and scholarship opportunities. Headquarters of the various churches in Mombasa may also be of help.

The Lathams and I appreciate very much the work you have been doing for us. Much of it would not be possible without you. I hope you are fully aware of the potential contribution you are providing to the betterment of the health situation of your people. Your contribution in may ways is of more potential benefit than the work of many doctors who might have more narrow objectives, and are usually dealing with curative, rather than preventive medicine. Research of this nature, although tedious and intermittent, can lead to the betterment of the lives of many millions of people living within and outside the borders of Kenya. That is why we do it.

Thank you for the good wishes to my wife and me. She joins me in expressing our wishes that 1979 will bring you much, if not more than you desired, and we do hope that we will meet with you again very soon. We have much to talk about.

Please be confident and patient.

Yours very sincerely,

Samir Sanad Basta

cc: Dr. Latham

SSB:wb

File Kenya

FOR IMMEDIATE RELEASE

World Bank

1818 H Street, N.W., Washington, D.C. 20433, U.S.A. • Telephone: (202) 477-1234

BANK NEWS RELEASE NO. 79/29
IDA NEWS RELEASE NO. 79/24

December 7, 1978

WORLD BANK/IDA LEND $105 MILLION TO KENYA

The World Bank and its affiliate, the International Development Association (IDA), will support three projects in Kenya--for rural water supply, agricultural development, and rehabilitation of sugar production facilities. These projects will be assisted by two World Bank loans and one IDA development credit, totaling $105 million.

Rural Water Supply Project

About half a million people, who are among the poorest segments of Kenya's rural population, will benefit from this fourth project by the Government of Kenya to provide safe and reliable water supply in rural areas. The project consists of the construction of 33 rural water supply schemes in various parts of the country; the strengthening of the operation, maintenance, and direct labor sections of the Kenya Ministry of Water Development; and technical assistance for the ministry as well as for the preparation of a study of a fifth rural water supply program.

The World Bank is lending $20 million to help finance this project, which is expected to lead to a reduction in water-borne diseases including diarrhea and cholera, and improve the general health of the people.

The $20 million World Bank loan will cover 75% of the project's total cost, estimated at about $26.8 million. The remainder, about $6.8 million, will be provided by the Government of Kenya.

The World Bank loan is repayable in 20 years, with 5 years of grace, at 7.35% interest per annum.

Narok Agricultural Development

This project will constitute the first phase of a long-term program for the development of mixed farming in the Mau Division of the Narok District of Kenya. It has two major objectives: to promote the development of Narok District, an area of high agricultural potential which has been relatively neglected in the past, and secondly, to increase the production of wheat, an important commodity which Kenya is now obliged to import. Both objectives will be achieved through the strengthening of basic extension services and farmer

.../

NOTE: Money figures are expressed in U.S. dollar equivalents.

training, the improvement of credit services for farmers, and the expansion of rural infrastructure, including feeder and access roads.

The project will benefit almost exclusively individuals with medium-scale farms, that is, those with more than 20 hectares of farm land. The project fits into the overall strategy of the Kenyan government for agricultural development, which calls for parallel and separate efforts to assist small-scale farmers, and medium- and large-scale farmers. This project will revitalize the institutions supplying services to those medium-scale farmers and focus attention directly on their problems.

Further benefits from the project include the protection of Narok's environment through soil and water conservation measures, protection of catchment forests, and a wildlife control program.

The total costs of this project are estimated at $18.8 million. IDA, the soft-loan affiliate of the World Bank, is assisting with a credit of $13 million, while the Canadian International Development Agency (CIDA) will provide a grant of $1.4 million. The remainder of the cost, about $4.4 million, will be financed by the Government of Kenya and farmers participating in the project.

The IDA credit is on the standard term of 50 years, including 5 years of grace, at no interest, except for a charge of 3/4 of 1% per annum to cover IDA's administrative expenses.

Sugar Rehabilitation

The project seeks to reduce Kenya's dependence on imported sugar and also to promote balanced regional economic growth and employment. It supports the Kenyan government's efforts to improve the efficiency and capacity of existing sugar factories. The project will provide new or improved irrigation on a total of 3,540 hectares of sugar cane lands and drainage infrastructure for about 15,000 hectares. Cane production will be improved and expanded on 14,790 hectares of nucleus estate land and 34,550 hectares of outgrower's land in the Nyanza Sugar Belt in western Kenya and at Ramisi on the southern coast. The factories of the sugar companies at Miwani, Muhoroni, and Ramisi will be rehabilitated and expanded. The project will also provide for the improvement and expansion of access roads, for the construction of staff houses, and for staff training and studies.

The project is expected to result in an increase in sugar production of about 109,000 tons per annum by the mid-1980s, thus saving Kenya about $30 million net foreign exchange annually. Wage employment will be provided for about 1,000 persons, while about 10,800 smallholder families will benefit through increased farm incomes.

The World Bank will support this project with a loan of $72 million. Co-financing will be provided by the African Development Bank with a loan of $6 million. The World Bank loan is repayable in 20 years, with 5 years of grace, at 7.35 % interest per annum.

- 0 -

FORM NO. 1121
(5–76)

TECHNICAL DATA

PROJECT: Rural Water Supply

COUNTRY: Kenya

TOTAL COST: $26.8 million

BANK FINANCING: $20 million , repayable in 20 years, with 5 years of grace, at 7.35% interest per annum.

OTHER FINANCING: Government of Kenya, $6.8 million

IMPLEMENTING ORGANIZATION: Water Department
Ministry of Water Development (MWD)
P.O.BOX 49720
Nairobi, Kenya CABLE: WATER, NAIROBI

PROJECT DESCRIPTION: It forms part of the government's fourth rural water supply program and consists of: the construction of 33 rural water supply schemes; the strengthening of the operation, maintenance, and direct labor sections of the Ministry of Water Development; and technical assistance for implementation of the recommendations of the management study aimed at strengthening MWD, and for the preparation of the fifth rural water supply program.

PROCUREMENT: Construction contracts of $300,000 or more, and contracts for equipment and materials of $100.000 or more will be awarded on the basis of international competitive bidding in accordance with Bank guidelines. Equipment and materials supplied under contracts of less than $100,000 and construction contracts of less than $300,000 will be procured through local competitive bidding procedures which are satisfactory.

CONSULTANTS: Consulting engineers will be employed for all medium and large rural water schemes under the project, from the preparation of feasibility studies through supervision of construction The Water Department is currently using about 20 consultants who are acceptable to the Bank.

ECONOMIC RATE OF RETURN: n.a.

ESTIMATED COMPLETION DATE: 1985

FORM NO. 1121
(5–76)

TECHNICAL DATA

PROJECT: Narok Agricultural Development

COUNTRY: Kenya

TOTAL COST: $18.8 million

IDA FINANCING: $13 million, repayable in 50 years, with 10 years of grace, no interest, except 3/4 of 1% for administrativ expenses.

OTHER FINANCING: Canadian International Development Agency, $1.4 million; Government of Kenya, $3.4 million; Farmers, $1 million.

IMPLEMENTING ORGANIZATION: Land and Farm Management Division
Ministry of Agriculture
P.O.BOX 30028
Nairobi, Kenya
CABLE: MINAG, NAIROBI

PROJECT DESCRIPTION: It will be the first stage of a long-term program for development of mixed farming in the Mau Division of the Narok District and will include: development of improved extension services for crops, livestock, and farmer training; improved credit services for mixed farming; seasonal credit for wheat and rapeseed inputs and medium-term credit for farm development; development, upgrading, and maintenance of access and feeder roads; soil conservation measures and development of tree nurseries; a wildlife control program to limit damage to crops by wild animals; studies to establish baseline data on the district, monitoring, and evaluation of project progress, and studies and field trails to prepare projects for the future development of the Narok District .

PROCUREMENT: Procurement of equipment and materials for extension and credit services, soil and water conservation, and the wildlife control program will follow government procurement procedures which are satisfactory. Most contracts for road development and construction works are too small and locations too scattered to attract international bids.

CONSULTANTS: Consultants will be needed for the baseline studies of population, ecology, and resources of the Narok District which will be financed under the CIDA grant to the project. Consultant engineers will also be used for the road development components of the project.

ECONOMIC RATE OF RETURN: 13%

ESTIMATED COMPLETION DATE: 1984

FORM NO. 1121
(5-76)

TECHNICAL DATA

PROJECT: Sugar Rehabilitation

COUNTRY: Kenya

TOTAL COST: $128.4 million

BANK FINANCING: $72 million, repayable in 20 years, with 5 years of grace, at 7.35% interest per annum .

OTHER FINANCING: African Development Bank, $6 million; Government of Kenya, $3.5 million; Miwani Sugar Mills, Ltd., $8.5 million; Chemelil Sugar Company, Ltd., $8.5 million; East African Sugar Industries, Ltd., $14.3 million; Associated Sugar Company, Ltd., $9.2 million.

IMPLEMENTING ORGANIZATION: Kenya Sugar Authority, P.O.BOX 51500, Nairobi, Kenya (CABLE: KENSUGAR, NAIROBI).
East African Sugar Industries Limited, P.O.BOX 47101, Nairobi, Kenya.
Chemelil Sugar Company Limited, P.O.BOX 45854, Nairobi, Kenya.
Associated Sugar Company Limited, P.O.BOX 90134, Mombasa, Kenya
Miwani Sugar Mills Ltd, P.O.BOX 49021, Nairobi, Kenya.

PROJECT DESCRIPTION: It will provide new or improved irrigation on a total of 3,540 hectares of cane lands and drainage infrastructure for about 15,000 hectares. Cane production will be improved and expanded on 14,790 hectares of nucleus estate land and 34,550 hectares of outgrower land at Chemelil, Miwani, and Muhoroni zones in the Nyanza Province sugar belt, and at Ramisi on the southern coast. The factories of the sugar companies at Miwani, Muhoroni, and Ramisi will be rehabilitated and expanded. General management and administration will be improved in all companies, as well as improvement and expansion of sugar roads and tracks, and staff training and studies. The industry's research capability will also be strengthened.

PROCUREMENT: The procurement under the World Bank loan of agricultural vehicles and equipment ($9 million), new sugar factory machinery and equipment ($14.8 million), incremental fertilizers ($4.9 million) and civil works contracts for housing ($7.3 million), irrigation and drainage ($13.2 million) and roads under the responsibility of the Ministry of Works ($2.9 million) would be by international competitive bidding, except for materials and equipment costing less than $100.000 and civil works costing less than $200.000 which would be procured in accordance with local procedures.

CONSULTANTS: Architects and engineering consultants will be employed for irrigation, roads, factories and social facilities under terms satisfactory to the World Bank.

ECONOMIC RATE OF RETURN: 33%

ESTIMATED COMPLETION DATE: 1985

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

Please file in my Kenya file

A DIVISION OF THE NEW YORK STATE COLLEGES OF HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

December 6, 1978

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

I enclose herewith a short Progress Report for our Kenya project. There is not a great deal new to add since we sent you the quite detailed Inception Report. There will be a lot more on which to report in a few months after I have been back in Kenya and the results of the productivity study begin to emerge.

I am most grateful to you for seeing that the December IBRD payment was made in good time.

Sincerely,

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

Enc.

cc: Dr. S. Basta

December 4, 1978

Progress Report

for

The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Kenya: Health, Nutrition and Worker Productivity Studies

Submitted by:

Dr. Michael C. Latham
Professor of International Nutrition and
Principal Investigator

from

Division of Nutritional Sciences
Cornell University
Ithaca, N.Y. 14853, U.S.A.

This is a Progress Report, and as such is designed simply to report on progress made with the Kenya: Health, Nutrition and Worker Productivity Studies since the Inception Report was provided on September 30, 1978. That detailed report (40 pages with 11 tables) gave details of the work undertaken up to August 31, 1978. This report simply summarizes what has been done in the 3 months since then, and provides information on what will be done in the immediate future. Another progress report will be furnished on about June 30, 1979.

Study No. 1 - Nutrition and Worker Productivity Study

As indicated in the Inception Report, the definitive part of this study is being conducted on Road No. 7 (near Kibirigwi) and No. 12 (near Sagana) in Kirinyaga and Muranga Districts respectively. These two roads were begun in mid 1978. Base-line clinical, nutritional status, dietary, stool, and hematological data were collected from approximately 113 workers on Road 7 and 88 workers on Road 12 in June and July 1978. Productivity observations on 60 persons on Road 7 and 64 persons on Road 12 were obtained by Mr. Mark Sharrock. For 28 of these workers, only 1 or 2 days of observations were made (See Table 4 of Inception Report). Preliminary anthropometric data from Roads 7 and 12 as supplied by Ms. June Wolgemuth are included as Tables 1-6.

The road workers were divided into an experimental group and a matched control group. The study group were provided with a mid work day snack or meal to provide approximately 1000 calories per day of participation. The control group received a snack providing about 200 calories per day of participation. Table 7 shows the weight changes after 9 weeks of supplementation.

Beginning in late November and ending in early December final examinations are being made, and final productivity measurements are being collected (again by Mr. Mark Sharrock). Dietary information was collected using the recall method prior to supplementation and again after supplementation began. On a sub-sample more difficult home weighing of foods was performed. These data have not yet been analyzed.

Problems with this study were discussed in the Inception Report. These included considerable instability in the labor force with irregular attendance and major losses; difficulty of recruiting workers so that both males and females, old and young, healthy and infirm are all used; difficulties in obtaining adequately accurate and enough observations of work output on sufficient workers; and failure of subjects always to consume the intended supplements because of poor work attendance. At this time it is not possible to report on how these difficulties will effect the final results.

Our original objective of having an N of 120 was more than met (Total N = 201) but the numbers who participated fully in the intervention and on whom both base-line and final productivity measurements are available will be well below half the original total.

Ms. June Wolgemuth, a nutritionist who is a Cornell University Graduate Research Assistant, and Mr. Andrew Hall, a parasitologist from Cambridge University also a project Graduate Research Assistant, have been resident in Karatina, and devoted full time work during this period to the study in Kenya. The project field management and data collection during the period was largely undertaken by them, and their Kenyan assistants.

Study No. 2b - Evaluation of Practical Means to Control Anemia by the Provision of Iron

These studies are being performed at various road sites in Kwale

District. In July 1978, 3 sites were selected. These were (a) the Quarry (murram) site and (b) Road No. 3 where medicinal iron was provided, and (c) Road No. 7 where two different feeding regimes is being evaluated. Mr. Terry Elliott, a nutritionist who is a Cornell University Graduate Research Assistant, is based in Kwale District, and has devoted full time to these studies. Mr. Hall was responsible for the parasitological studies in Kwale. Base-line data were collected by a team including the Principal Investigator (See Inception Report) in July 1978.

Labor problems on these sites in Kwale have been much less severe than on the highland sites near Karatina. The workers with very few exceptions are adult males. One problem arose when the quarry (murram) site was closed prematurely. A fair proportion of men transferred to a new quarry and were maintained. For the rest, final data were collected, which means that the intervention for some men has been shorter than originally proposed. To increase the N some new subjects were recruited at the new site.

At the quarry site and Road No. 3 the workers were divided into 3 groups. One group receives 600 mg ferrous sulphate each day, a second group receives 600 mg ferrous sulphate plus medicinal ascorbic acid each day, and a third group receives a placebo capsule each day.

On Road No. 7 the workers were divided into 2 matched groups. The one group receives a cold mid work day snack (low in its iron content and with no ascorbic acid), and the second group is receiving a hot mid work day snack containing about 5.7 mg of iron and 42 mg of ascorbic acid (See details in Inception Report). All men found to have hookworm, other intestinal parasites or schistosomiasis at the beginning of the study were treated.

Participation in these studies has been good, and blood has been collected, as intended, for examination. The feeding has proved popular as has the regular provision of first aid and simple treatment. Data are not yet available for analysis.

Study No. 4 - Ascaris Study

In this project examinations of some 900 preschool and primary school children in the villages of Kanzalu and Mwatati are conducted by Drs. Latham, Stephenson and Crompton every January. At that time, one of the three doses of Levamisole (Ketrax) are provided to the children. In May-June and again in September-October under a plan devised by Dr. Stephenson the other doses are provided in house and school visits. Since the Inception Report the third 1978 dose (Dose 6) was provided. The three field workers, Mrs. Esther Ndunda, Ms. Rose Nzuki and Ms. Jennifer Wambua, visited both schools, and all project households. Study children were identified, and their dose of Levamisole given. Mr. Hall supervised this operation, which appears to have gone smoothly. A total of 990 preschool and primary school children received Levamisole in September-October 1978.

Plans for immediate future

At the present time, as indicated, Mr. Sharrock is completing the final productivity measurements, and Ms. Wolgemuth and Mr. Hall are winding up data collection at the sites for Study No. 1. Mr. Elliott is continuing with the supervision of the anemia control projects in Kwale District (Study No. 2b).

Drs. Latham, Stephenson and Crompton will arrive in Kenya on January 6, 1979. On January 5 a meeting between Dr. Chesher (Statistics Consultant), Mr. Sharrock, Dr. Stephenson and Dr. Latham will be arranged in London. In January the three Investigators will concentrate mainly on the annual examinations in Machakos District for Study No. 4 while making a short visit to Kwale in the middle of the month to make arrangements for activities there.

At the end of January and during February three new studies will be initiated to evaluate the feasibility and effectiveness of routine parasitic treatment and prophylaxis of hookworm infection, schistosomiasis and malaria. In late February or early March a part of Study No. 3 (an investigation of health and nutritional status in new ecological areas) will be undertaken. The area chosen and the work done will depend on discussions with officials in the Ministry of Works. Dr. Crompton is expected to remain in Kenya for 6 weeks, and Drs. Latham and Stephenson for 8 to 10 weeks.

TABLE - 1

PRELIMINARY DATA FOR ROAD #7 - ORIGINAL BREAKDOWN OF EXPERIMENTAL AND CONTROL GROUPS

	Total	males	females	WPM*
Experimentals	58 (51%)	45 (39.8%)	13 (11.5%)	23 (20.35%)
Controls	55 (49%)	39 (34.5%)	16 (14.2%)	22 (19.46%)
Total	113 (100%)	84 (74.3%)	29 (25.7%)	45 (39.81%)

*Worker productivity measurements taken

TABLE - 2

INITIAL WEIGHT FOR HEIGHT MEASUREMENTS (EXPRESSED AS PERCENT OF STANDARD) FOR WORKERS ON ROAD #7

% STD WT-HT.	number	proportion
60-64		
M	3	
F	0	
	3	0.027
65-69		
M	4	
F	1	
	5	0.044
70-74		
M	12	
F	2	
	14	0.124
75-79		
M	25	
F	5	
	30	0. 265
80-84		
M	23	
F	5	
	28	0.248
85-89		
M	10	
F	9	
	19	0.168
90-94		
M	3	
F	5	
	8	0.071
95-99		
M	3	
F	1	
	4	0.035
100+		
M	0	
F	2	
	2	0.018
TOTAL	113	100.000

% of Weights below:

85% STD WT.-HT.= 70.8%

80% STD WT.-HT.= 46.0%

TABLE - 3

PRELIMINARY DATA FOR ROAD #12 - ORIGINAL BREAKDOWN OF EXPERIMENTAL AND CONTROL GROUPS

	Total	males	females	WPM*
Experimental	43(48.9%)	21(23.9%)	22(25.0%)	18 (20.5%)
Controls	45(51.1%)	22(25.0%)	23(26.1%)	20 (22.7%)
Total	88(100%)	43(48.9%)	45(51.1%)	38 (43.2%)

*Worker productivity measurements taken

TABLE - 4

INITIAL WEIGHT FOR HEIGHT MEASUREMENTS (EXPRESSED AS PERCENT OF STANDARD) FOR WORKERS ON ROAD # 12

% STD WT-HT.	number	proportion	%STD WT-HT	number	Proportion
60-64			95-99		
M	1		M	0	
F	1		F	3	
	2	0.023		3	0.034
65-69			100+		
M	1		M	0	
F	1		F	7	
	2	0.023		7	0.080
70-74			TOTAL	88	100.000
M	8				
F	2				
	10	0.114			
75-79					
M	13				
F	6				
	19	0.216			
80-84					
M	11				
F	8				
	19	0.216			
85-89					
M	6				
F	11				
	17	0.193			
90-94					
M	3				
F	6				
	9	0.102			

% of Weights below:

85% STD WT-HT.= 59.1%

80% STD WT.-HT.=37.5%

TABLE – 5

PRELIMINARY DATA FOR BOTH ROADS # 7 & # 12 – ORIGINAL BREAKDOWN OF EXPERIMENTAL AND CONTROL GROUPS

	Total	males	females	WPM
Experimentals	101(50.2%)	66(32.8%)	35(17.4%)	41(20.4%)
Controls	100(49.8%)	61(30.3%)	39(19.4%)	42(20.9%)
Total	201(100%)	127(63.1%)	74(36.8%)	83(41.3%)

TABLE – 6

INITIAL WEIGHT FOR HEIGHT MEASUREMENTS FOR ROAD WORKERS ON #7 & #12

%STD. WT.-HT.	number	proportion
60-64	5	0.025
65-69	7	0.035
70-74	24	0.119
75-79	49	0.244
80-84	47	0.234
85-89	36	0.179
90-94	17	0.085
95-99	7	0.035
100+	9	0.045
Total	201	100.0

% of Weight below:

85% STD WT.-HT. = 65.7%

80% STD WT.-HT. = 42.3%

75% " " " = 17.9%

TABLE - 7

WEIGHT CHANGES* OF RURAL ACCESS ROADS WORKERS ON TWO ROADS IN CENTRAL PROVINCE, KENYA

		EXPERIMENTAL GROUP**+	CONTROL GROUP***+
ROAD #7			
number of workers(n)	=	38	34
mean weight change (kg.) ($\bar{x}$)	=	1.052	0.095
std. dev.	=	1.55	3.11
ROAD #12			
n	=	29	36
$\bar{x}$	=	1.580	0.642
std. dev.	=	1.54	1.37
BOTH ROADS			
n	=	67	70
$\bar{x}$	=	1.28	0.376
std. dev.	=	1.56	2.378

p value ? =

*Number of weeks between first and second weights = 15

**Experimental group received 1000 kcal per day

*** Control group received 200 kcal per day

+ Length of supplemental period for both roads = 9 weeks

FORM NO. 75
(1–76)

THE WORLD BANK

ROUTING SLIP	DATE:

NAME	ROOM NO.
~~Mr. Merriam~~	
File	
No problem	
[initials] 12/14	

	APPROPRIATE DISPOSITION		NOTE AND RETURN
✓	APPROVAL		NOTE AND SEND ON
✓	CLEARANCE		PER OUR CONVERSATION
	COMMENT		PER YOUR REQUEST
	FOR ACTION		PREPARE REPLY
	INFORMATION		RECOMMENDATION
	INITIAL		SIGNATURE
	NOTE AND FILE		URGENT

REMARKS:

We supported part of this study by a research grant. No Bank documents or materials were used and only reference to WB is acknowledgements (p. 17 (first article) & back of p. 24 (second article). Is it cleared for publication by American Journal for Clinical Nutrition?

FROM:	ROOM NO.:	EXTENSION:
S. Basta	D836	73597

Submitted to Am J Clin Nutr 11/30/78 Samir Basta

File
Kenya
(SB's file)

ABSTRACT

A longitudinal study of growth in relation to Ascaris infection was conducted in 2 Kenyan villages. Anthropometric, clinical, and stool exams were performed 3 times (I, II, III) at 14 week intervals on 290 children, and 186 of these were included in the study. At visit I, 15% of children were above 90% weight for age, 27% had Ascaris ova in their stools, and mean anthropometric measurements between infected and control children did not differ significantly. All received an anthelmintic drug (levamisole) at visit II. In the 14 weeks between visits I and II (before deworming), children with Ascaris ($n = 61$) did not differ from controls ($n = 125$) in percent expected weight gain. In the 14 weeks after deworming (II-III), previously infected children showed higher percent expected weight gain (129 vs 98%, $p < .025$) than controls. Before deworming, triceps skinfold thickness decreased in Ascaris-infected children vs controls (-1.6 vs 0.3 mm, $p < .0005$). After deworming, skinfold increased markedly in previously infected children vs controls (2.0 vs -1.1 mm, $p < .0005$). Multiple regression analysis showed that Ascaris infection was by far the most important variable explaining decrease in skinfold thickness before and increase after deworming. It appears that even light Ascaris infections may adversely influence nutritional status, and deworming may enhance growth.

RELATIONSHIPS BETWEEN ASCARIS INFECTION AND GROWTH OF MALNOURISHED PRESCHOOL CHILDREN IN KENYA[1,2]

Consultants

L. S. Stephenson, M.N.S., Ph.D.[3], D. W. T. Crompton, M.A., Ph.D., Sc.D.[4], M. C. Latham, M.D., M.P.H., D.T.M.&H.[5], T. W. J. Schulpen, M.D.[6], M. C. Nesheim, Ph.D.[7], and A. A. J. Jansen, M.D.[8]

Ascaris lumbricoides, the common roundworm, is an intestinal parasite which has been estimated to infect about a quarter of the world's population, or 1 billion people (1). The disease is most common, particularly in preschool age children, in the tropics and subtropics, where protein-energy malnutrition (PEM) of childhood is often endemic (2). In some areas, over 80% of the children have *Ascaris* infection (2,3).

The adult worms are found mainly in the jejunal lumen of the small intestine, may have a lifespan of over a year, are relatively large in size (15-35 cm in length) (4), and are known to contain antiproteolytic substances (5). An individual host may harbor over one hundred roundworms at once (6), although lighter burdens are more usual.

Practicing physicians and nutritionists in developing countries often report an association between *Ascaris* infection and malnutrition (6,7), and speculate that *Ascaris* may contribute importantly to PEM (6-8).

Balance studies conducted on relatively small numbers of *Ascaris*-infected children have suggested a lower apparent absorption (8-10) and retention (9,10) of nitrogen and also a lower apparent absorption of fat and d-xylose (9,10) in infected children before, compared with after, deworming. Alterations in mucosal structure have been observed in biopsy samples from infected children; the structure reverted to a more normal form after treatment (10). Trends indicating decreased absorption of protein and fat and abnormalities of the small intestinal mucosa and tunica muscularis in malnourished *Ascaris*-infected piglets have also been reported by us (11,12). In contrast, some other studies using small numbers of infected patients indicated no clear evidence of malabsorption of protein or fat (13,14).

Ascaris infection has also been related to poor absorption of vitamin A in children and adults in India (15,16), and to B_6 deficiency in adult male patients in Egypt (17). A recent cross-sectional survey in Louisiana suggests that *Ascaris* infection in children is significantly associated with low serum albumin and plasma ascorbic acid levels and is weakly associated with low weight for height and signs of riboflavin deficiency (18).

When the present investigation was initiated in 1974, there was little accessible data which showed whether or not *Ascaris* infection affected growth of preschool children in a rural community setting. The study reported here was undertaken to determine the relationships between *Ascaris* infection and the growth of preschool age children in a community where PEM was known from previous studies to be common (19). The study design allowed for the comparison of growth of children before and after deworming with a control group of children who were considered to have remained uninfected throughout the course of the study.

MATERIALS AND METHODS

Location

Two villages in the Machakos District of Kenya were selected for the study. These villages are among those included in a longitudinal health study (the Joint Project Machakos or JPM) being conducted by the Medical Research Centre in Nairobi (20). The two villages were selected because a point prevalance parasitological survey conducted in the JPM area in 1973 had indicated that these two villages had a higher prevalence of Ascaris infection than the other villages, and that other intestinal parasites were not prevalent (21; J. Ouma, personal communication).

Subjects

The mothers living in the two villages were invited to bring their preschool children age 12-72 months to participate in a sequence of 3 examinations or visits at intervals of 14 weeks (I-December 1975, II-March 1976, III-June-July 1976). Three hundred and seventy-five children or about 81% of the preschool population were examined at visit I. Two hundred and ninety children or about 62% of the population attended all 3 examinations.

Examinations, which were conducted at the local primary schools, included anthropometric measurements, a clinical exam, stool collection for parasite ova and cysts, and the collection from the mother of information on factors which might be related to the child's present nutritional and health status. Socioeconomic data on the families were obtained from the JPM study.

Anthropometric and clinical examinations

Anthropometric measurements performed at each visit were weight, mid upper arm circumference, and triceps skinfold thickness. Length was measured at visits I and III only, and length at visit II was extrapolated assuming linear growth (a preschool child between 1 and 6 years of age is not likely to grow more than 2-4 cm in 14 weeks).

Nude weight was measured to the nearest 0.1 kg on a portable Salter spring balance (model 235) with a 25 kg capacity (Salter Export Trading Co., West Bromwich, Staffs, England). Scale calibration was checked regularly. Length was determined to the nearest 0.1 cm using a locally made length board with a stationary headpiece and movable foot piece as described by Jelliffe (22).

Mid upper arm circumference was measured to the nearest 0.1 cm on the left arm, half way between the tip of the acromion process of the scapula and the olecranon process of the ulna. The tape measure used was made of non-stretchable polyvinyl chloride coated fiberglass. Triceps skinfold thickness was measured with Harpenden calipers in triplicate to the nearest 0.1 mm on the left arm where the midpoint had been marked for the arm circumference measurement.

Raw anthropometric values were converted to percent standard values given by Jelliffe (22) and Nelson (23), using: for weight and length, the Harvard Standards of Stuart and Stevenson to 60 mo. and the Iowa Standards for children 61-72 mo; for arm circumference, the standards of Wolanski for children 12-60 mo. and those of O'Brien, Girshik and Hunt for children 61-72 mo; and for triceps skinfold, the standards of Hammond, and Tanner and Whitehouse. Both raw and percent standard values were used in the statistical analysis.

Growth standards for Kenyan children have not yet been established. However, Bohdal's study (24) of healthy "elite" African and Caucasian 4-5 year olds in Kenya indicated that the 2 ethnic groups were very similar to each other and very close to 100% standard values (22) for weight for age (97.9 vs 97.1%), height for age (99.1 vs 98.8%), weight for height (102.2 vs 103.5%), arm circumference for age (98.1 vs 98.9%), and skinfold for age (105.9 vs 111.7%).

Clinical examinations were conducted by an experienced physician-nutritionist. The presence or absence of clinical signs related either to nutritional status or health was recorded at all 3 visits. The physician also asked each mother about her child's present health complaints, drugs her child received at home, and breast feeding history. Simple medications were provided free to sick children. None of the medications commonly given were likely to greatly affect growth.

Stool examinations

Fresh stool specimens were collected at the site from most children, and samples of approximately 1 ml were preserved in Schaudinn's fluid-polyvinyl alcohol fixative (25). For those few children who did not produce a stool, mothers were issued with a plastic container and told to place a fresh stool specimen from the children into this the next morning. Containers were retrieved by fieldworkers from the child's home within 2 days. These stool samples were then fixed in the manner described above. All samples were examined in the laboratory at Cambridge University for the presence of parasite ova and cysts after the use of a modified version of Telemann's method as described by Bayer (26).

Deworming and collection of worms

At visits II and III, each child attending was given a dose of the anthelmintic drug levamisole (trade name Ketrax, Imperial Chemical Industries Ltd., England), a broad spectrum anthelmintic which has been shown to be effective in the treatment of intestinal stages of *Ascaris lumbricoides* and *Enterobius vermicularis* (pinworm) and may also be prescribed for hookworms (*Necator americanus* and *Ancylostoma duodenale*), *Trichuris trichiura* (whipworm), and *Strongyloides stercoralis* (27,28). The drug is reported to be virtually free from side effects (28). The dose used was the recommended 40 mg levamisole hydrochloride (as 5 ml syrup) for children under 60 months of age and 80 mg (as 2 tablets) for children 60 months of age and older. Because all stools were transported to Cambridge University, the results of those collected at visit I were only available 2 weeks before visit II.

If a child had had a stool examination that was positive for Ascaris ova at visit I, the mother was asked at visit II to watch all of the child's stools for $2\frac{1}{2}$ days after the anthelmintic was given and to collect all worms passed in a plastic bag. The number of worms collected per child was counted by project staff. Cooperation of mothers in this task was very good, but it is likely that some worms were passed without notice and escaped collection.

At visit III, 2 project interviewers both asked each mother whether or not her child had passed worms after receiving levamisole at visit II. This was designed to confirm results of worm collections and to discover the existence of any infections of male or immature worms alone. These, because they do not pass ova in the stools, would not have been detected during examination of stool samples.

Dietary and socioeconomic data

A nutritionist obtained limited dietary recall data concerning each child. The authors had access to socioeconomic data obtained in 1973-4 from the families of study children by researchers from the Medical Research Centre in Nairobi. Information on over 70 variables relating to education, and occupation of parents, environmental hygiene of the home, and details of crop harvests and materials possessions was obtained. These data were later condensed, for use in a multiple regression analysis, into scales of similar items using a correlation matrix procedure (the domain sampling model), described by Nunnally (29).

Selection of the Ascaris and control sample

Analyses of the longitudinal effects on growth of *Ascaris* infection and of deworming were determined by selecting, from the total sample, subsamples of children who had attended all 3 visits and who could be defined either as control children (who were not infected with *Ascaris*) or as *Ascaris*-infected children. The *Ascaris* children had evidence of intestinal *Ascaris* infection during the first half of the study but did not appear to have intestinal *Ascaris* infection during the second half, after deworming had taken place.

The control group consisted of children in whose stools *Ascaris* ova had not been seen at visits I, II, and III, and who, according to their mothers, had not passed worms after receiving levamisole at visit II. *Ascaris* group children were those in whose stools *Ascaris* ova had been seen at visit I and who had evidence of being infected at visit II, either because the visit II stool was positive for *Ascaris* ova (74% of cases) or because worms were collected after deworming or because the mother reported that the child had passed worms after levamisole at visit II. *Ascaris* group children then had to have a stool negative for *Ascaris* ova at visit III, after deworming. One hundred and four children who attended at all 3 visits but did not fit into either of these groups and 85 children who attended less than 3 times were not included in the study reported here.

Statistical analysis

The data were processed by computer using Statistical Package for the Social Sciences programs (30). Relationships between growth and *Ascaris* infection were examined by comparing the value of a given parameter in the *Ascaris* group with the same parameter in the control group during the same time period, e.g., change in weight for age in the 2 groups in the period before deworming. It was also necessary to determine whether or not the 2 groups were comparable at the outset of the study in all respects excepting infection with *Ascaris*. Basic analyses were first done using t-tests, analysis of variance, Chi-square and Pearson r statistics. The predictors of changes in skinfold thickness before and after deworming were determined using a general multiple regression procedure.

RESULTS

A total of 186 of the 290 children seen at all 3 visits satisfied the criteria for inclusion in the *Ascaris* and control sample: 61 were *Ascaris*-infected and 125 were controls. The 2 groups were comparable in regard to sex and age distribution (see table 1).

Parasitology

The results of the stool examinations for parasite ova and cysts shown in table 2 indicate that infection of children with intestinal helminths other than *Ascaris* was relatively low in both study groups. Percentage of children infected with each parasite (other than *Ascaris*) did not vary significantly between groups for any of the 3 visits. Hence, the differential influence of parasites other than *Ascaris* on growth was ignored in the analysis.

The number of worms harbored per child prior to deworming at visit II was determined mainly from the number of worms collected, and occasionally from worms seen but not collected, by mothers after administration of levamisole. For example, one worm seen by a mother was subsequently eaten by a chicken. Mean number of worms harbored per child in the Ascaris group from these calculations was 7.1 ± 9.3 (range 0-53). This suggests that worm loads were rather light. These worm counts underestimate the true worm burden, because worms not seen did not get counted. One 3 year old child who was unable to return for visit III and is not included in this study passed over 100 worms.

Anthropometry

The baseline anthropometric data (table 3) indicate the high prevalence of protein-energy malnutrition in both groups of children, with a mean weight for age of approximately 79%, mean length for age of 92%, and mean weight for length of 91-92%. Only 15% of the children in the sample were above 90% weight for age. The baseline data also show that there were no significant differences between the Ascaris and control groups for any of the anthropometric measurements at the start of the study. Thus growth potential in the 2 groups was expected to be very similar.

Changes in weight, arm circumference, and skinfold thickness were calculated for both study groups for 2 periods: before deworming (visit II value minus visit I value) and after deworming (visit III value minus visit II value) (see table 4). In the period before deworming, weight gain did not differ between the Ascaris and control groups, judged by actual weight gain, change in percent weight for age, or percent expected weight gain. Percent expected weight gain is equal to the weight actually gained by a child during a given interval divided by the standard amount of weight he should have gained, converted to a percent.

However, in the period following deworming, children in the *Ascaris* group gained more weight than control children (0.7 vs 0.5 kg, $p < .05$), had a higher percent expected weight gain (129.9 vs 98.2%, $p < .025$), and showed a marginally greater gain in percent weight for age (1.6 vs 0.7 percentage points, borderline $p < .10$).

Changes in triceps skinfold thickness showed highly significant differences between groups. In the period before deworming, *Ascaris*-infected children exhibited a decrease in actual skinfold thickness and in percent skinfold for age while skinfold thickness in the control group children increased significantly (-1.6 vs 0.3 mm, $p < .0005$; -15.6 vs 3.5 percentage points, $p < .0005$). In the period after deworming, this trend was reversed: *Ascaris* group children gained skinfold thickness and control children lost skinfold thickness (2.0 vs -1.1 mm, $p < .0005$; 21.7 vs -10.4 percentage points, $p < .0005$).

Changes in arm circumference were small in magnitude (0.2 cm change or less in each group and time period), were of doubtful nutritional significance, and are not reported here.

Clinical examinations and dietary information

The results of the clinical examinations and the dietary findings on the whole population studied are being reported elsewhere (31). Clinical signs of PEM, ariboflavinosis, anemia, and xerophthalmia were quite common but did not differ significantly between the control and *Ascaris* groups. Similarly, breast feeding practices and dietary findings were similar for the two groups. Breast feeding was almost universally practiced for at least six months, and often much longer.

Multiple regression analysis

The most striking anthropometric effects of Ascaris infection were the decrease in skinfold thickness that occurred while children harbored worms and the subsequent increase in skinfold thickness after deworming. A descriptive multiple regression analysis was therefore performed to determine the degree to which skinfold changes were related to Ascaris infection and the degree to which they were related to other variables in the children's lives. Two equations were calculated: the first, using change in skinfold thickness in mm from visits I to II as the dependent variable, determined the predictors of skinfold thickness change before deworming; the second, using change in skinfold from visits II to III as the dependent variable, determined the predictors of skinfold change after deworming.

Most of the variables studied could theoretically be causally related to nutritional status of preschool children (see figure 1). Thirty-seven variables representing these factors were originally selected as potential predictors of skinfold change (see table 5 for list of variables). A correlation matrix was first computed to ensure that no multicolinearity existed.

Abbreviated results of the regression analysis are presented in table 6. The equations were very successful in accounting for skinfold changes, explaining 60% (equation I) and 64% (equation II) of the variation in skinfold change.

The standardized Beta values or normalized regression coefficients in table 6 indicate the relative importance of each variable listed in explaining the variance in the dependent variable. These equations show that presence of Ascaris infection was by far the most important predictor of skinfold decrease before deworming, and that it was also the most important in predicting increase after deworming. This finding held true in all equations run, from initial to final, in this analysis.

The other 8 relevant predictors of change in skinfold before deworming: Mother's report of the presence of "malaria" (body temperature) at visit I, increasing education of head of household, more acute types of PEM at visit I, presence of "fever" (cold) at visit I, and increasing total calorie score at visit II all predicted increases in skinfold. A report of "malaria" at visit II, an increasing amount of coffee harvested, and a reported presence of cough at visit I predicted decreases in skinfold.

Following deworming, only 4 other variables were significant: village of residence predicted that children in Mwatati gained more in skinfold, and the three other variables, a report of "fever" at visit II, increasing age, and a report of diarrhea at visit III, predicted decreases.

DISCUSSION

The present field study of malnourished children showed that even apparently light loads of intestinal Ascaris infection are associated with a significant decrease in triceps skinfold. Similarly, deworming of Ascaris-infected children was followed by significant growth improvements including increased weight gain and an increase in triceps skinfold thickness. These results indicate that Ascaris infections in the presence of PEM may be detrimental to growth, not only in pigs and hospitalized children, as previously shown, but also in relatively normal children living at home in rural Kenya. The study also suggests that deworming benefits growth in these children.

These findings are, perhaps, not surprising since earlier studies had found disturbances in the absorption of nitrogen, fat, and d-xylose and in the structure of the intestinal mucosa of infected subjects (8-12). Similar findings do not appear to have been demonstrated before in a well controlled field study with such large numbers of infected and control children.

Gupta et al (32) have recently reported that 3 monthly deworming of Ascaris-infected preschool Indian children for a period of 1 year allowed a higher proportion of treated children to gain more than 1 percentage point in weight for age than was the case for children receiving placebos. They also estimated that the 6 tablets of tetramisole (an isomer of levamisole) needed per child per year cost only about 4% as much as a year's supply of food for a supplementary feeding program for the same child.

On the basis of the multiple regression analysis, intestinal Ascaris infection was strongly associated with the highly significant changes in skinfold thickness that occurred during the course of the present study. One might ask why the children in the 2 groups had similar anthropometric measurements at the start of the study. It is likely in this community, with a moderate prevalence of ascariasis, that most children are exposed to infections but that only some children have Ascaris at any one point in time. Anthelmintics may be obtained by parents either from local hospitals and clinics or from village shops. It is highly likely that many children in the control group have, for some part of their lives, had ascariasis. The baseline data collected strongly support the idea that children in both groups did not differ significantly in nutritional or socio-economic status at the start of the study and that both groups were representative of the preschool population in the community.

Seasonal factors related to food availability probably account for the slight deterioration in percent weight for age in both control and *Ascaris*-infected children in the first four month period, and improvement in the second period. But in this second period a significantly greater improvement occurred in those children who had lost their worm burden. In the first period, prior to treatment, the *Ascaris* group lost, and after treatment, gained subcutaneous fat. More difficult to explain is why there was a small gain in skinfold thickness in control children in the first period, and a modest loss in the second period.

Whatever the reasons, the data do show significant improvements in weight and especially in skinfold thickness in children during 4 months after deworming when compared with their growth while harboring roundworms.

Some of the possible mechanisms by which *Ascaris* may affect nutritional status and growth are numerous, including physical irritation and occlusion of the gut mucosa, and secretions of "toxins" and anti-enzymes, and have been summarized by Jelliffe (6) and by Latham (12). The deformed villi and elongated crypts seen in the jejunal mucosa of infected children (10) and by us in infected malnourished pigs (11,12) imply that pathological changes leading to malabsorption may be partially responsible. Confirmation of this may require further laboratory studies in suitable malnourished animals.

Thus, within the limitations of our investigation, we conclude that Ascaris infection might contribute importantly to PEM in young children in developing countries. We believe that control of ascariasis deserves a higher priority in public health and nutrition intervention programs than it is now receiving.

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Footnotes

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Table 1. Village, sex, and age data on subjects in Ascaris and control groups

Statistic[a]	Control No.	Control %	Ascaris No.	Ascaris %	All subjects No.	All subjects %
Total subjects	125	67.	61	33.	186	100.
Village						
Kanzalu	58	46.	20	33.	78	58.
Mwatati	67	54.	41	67.	108	42.
Sex						
Male	73	58.	32	52.	105	56.
Female	52	42.	29	48.	81	44.
Age at Visit I, mo.						
12-23	24	19.	4	7.	28	15.
24-35	26	21.	15	25.	41	22.
36-47	27	22.	17	28.	44	24.
48-59	29	23.	12	20.	41	22.
60-72	19	15.	13	21.	32	17.

[a] No statistically significant association found between Ascaris group and village, sex, or age, using a χ^2 test.

Table 2. Results of stool examinations for parasite ova and cysts at Visit I

Parasite[a]	Group			
	Control		Ascaris	
	n positive	% positive	n positive	% positive
A. lumbricoides	0	0	61	100.0
Hookworms and/or unident. nematode spp.	9	7.2	8	13.1
T. trichiura	1	0.8	2	3.3
Protozoan cysts (Entamoeba spp)	20	16.0	12	19.7

[a] No significant associations between group and infection with parasites other than Ascaris, using chi-square tests.
One control child (0.8%) was judged to have S. mansoni infection; another control child passed ova of E. vermicularis.

Table 3. Anthropometric measurements. Ascaris and control sample, Visits I, II, III

Parameter	Group[a]	n	Visit I $\overline{X} \pm SD^c$	Visit II $\overline{X} \pm SD^c$	Visit III $\overline{X} \pm SD^c$
wt, kg	C	125	12.2 ± 2.7	12.5 ± 2.7	13.0 ± 2.7
	A	61	12.5 ± 2.0	12.8 ± 2.0	13.5 ± 2.0
wt/age, %	C	125	79.6 ± 9.9	78.4 ± 10.0	79.0 ± 10.0
	A	61	79.3 ± 9.6	78.4 ± 9.3	79.8 ± 9.8
length, cm[b]	C	125	90.5 ± 11.3	--	94.2 ± 10.8
	A	61	91.8 ± 9.7	--	95.4 ± 9.3
length/age, %[b]	C	125	92.4 ± 4.3	--	92.2 ± 4.3
	A	61	91.8 ± 4.9	--	91.7 ± 4.8
wt/length, %[b]	C	125	90.8 ± 7.3	--	90.8 ± 7.4*
	A	61	91.7 ± 6.5	--	92.9 ± 7.2
skinfold, mm	C	124	9.3 ± 2.1	9.6 ± 2.2**	8.5 ± 2.0**
	A	61	9.6 ± 2.6	8.0 ± 2.3	10.0 ± 2.3
skinfold/age, %	C	124	96.1 ± 20.8	100.0 ± 21.9**	89.4 ± 20.4**
	A	61	99.8 ± 24.9	84.2 ± 22.1	105.9 ± 22.9

[a] C = control group, A = Ascaris group

[b] Length was not measured at Visit II.

[c] Differences between control and Ascaris groups:

* borderline significant, $p < .10$

** highly statistically significant, $p < .0005$, using t-tests

Table 4. Increases in weight and triceps skinfold measurements before and after deworming. Ascaris and control samples, Visits I-II, II-III

Parameter	Group	n	Before deworming $\overline{X} \pm SD^a$	After deworming $\overline{X} \pm SD^a$
A. original sample				
wt, kg	C	125	0.2 ± 0.5	0.5 ± 0.5**
	A	61	0.3 ± 0.4	0.7 ± 0.4
wt/age, %	C	125	-1.2 ± 3.0	0.7 ± 3.1*
	A	61	-1.0 ± 2.4	1.6 ± 2.7
% expt wt gn	C	125	45.6 ± 83.2	98.2 ± 87.7***
	A	61	50.1 ± 67.6	129.9 ± 91.8
skinfold, mm	C	123	0.3 ± 0.8****	-1.1 ± 1.2****
	A	61	-1.6 ± 1.0	2.0 ± 0.9
skinfold/age, %	C	123	3.5 ± 8.7****	-10.4 ± 13.4****
	A	61	-15.6 ± 10.3	21.7 ± 9.7

[a] t-test results: differences between C and A groups

* borderline significant, $p < .10$

** statistically significant, $p < .05$

*** statistically significant, $p < .025$

**** highly statistically significant, $p < .0005$

Figure 1. Theoretical relationships between child's nutritional status, diet, infection, and social, environmental, and economic variables.
Data were obtained in the present study for all variables enclosed in boxes.

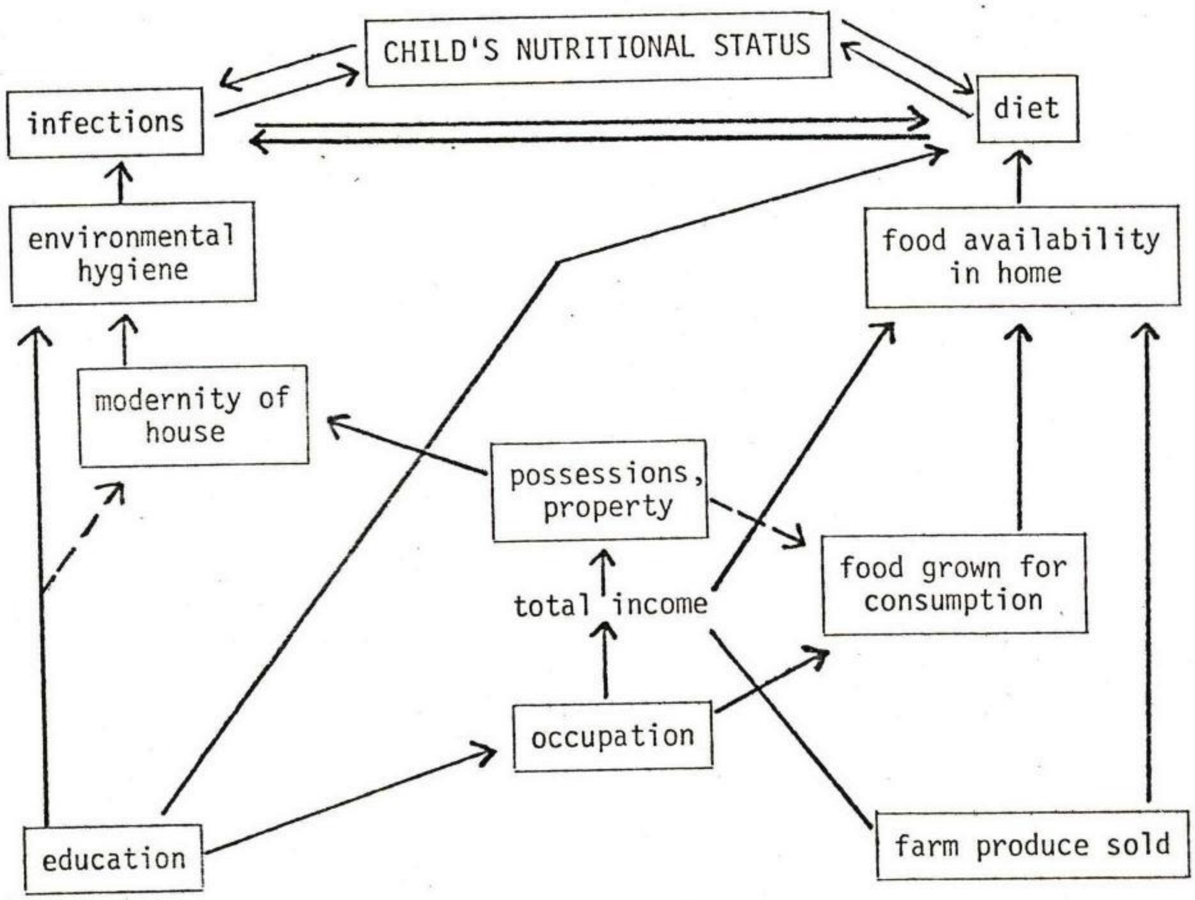

Table 5. Variables used in initial multiple regression equations[a]

Variable	Equation I Before deworming	Equation II After deworming
independent:	increase in skin-fold thickness, Visits I-II, mm	increase in skin-fold thickness, Visits II-III, mm
dependent:		
age of child, mo.	x	x
sex of child	x	x
village of residence	x	x
no. children born alive to mother	x	x
percent of siblings who died in preschool years	x	x
control vs. Ascaris group	x	x
no. of Ascaris passed, Visit II	x	x
hookworm ova in stools at	Visit I	Visit II
protozoan cysts in stools at	Visit I	Visit II
type of PCM at Visit I	x	x
presence of splenomegaly	at Visit I	at Visit II
child had cough	at Visit I, II	at Visit II, III
child had a "fever" (cold)	at Visit I, II	at Visit II, III
child had diarrhea	at Visit I, II	at Visit II, III
child had "malaria" (body temp.)	at Visit I, II	at Visit II, III
total calorie score	at Visit II	at Visit III
total protein score	at Visit II	at Visit III

(continued)

Table 5 continued

Variable	Equation I Before deworming	Equation II After deworming
cleanliness of latrine & kitchen	x	x
cleanliness & adequacy of child's sleeping room[b]	x	x
education of mother	x	x
education of household head	x	x
education of other family members	x	x
level of mother's job	x	x
level of jobs of other family members	x	x
amount of coffee harvested	x	x
amount of farm produce sold (excluding coffee)[b]	x	x
amount of job-related equipment and property	x	x
availability of certain foods[b]	x	x
modernity of house[b]	x	x
is child taken care of by mother	x	x
is the mother married now	x	x
does the father live at home[b]	x	x
does the grandmother live in the home	x	x

[a] Variables with an F value less than 1.0 in each equation were deleted from subsequent equations.

[b] Variable had an F value slightly above 1.0 in an early equation but it lowered the sample size by >30% and was deleted to avoid biasing the sample.

Table 6. Coefficients for final multiple regression equations.
Variables explaining changes in skinfold thickness.

	B	Standard-ized Beta	Standard error B	F	Probability of F
Equation I[a] (N = 175)					
Dependent variable: change in skinfold thickness (mm.), Visits I-II					
Independent variables in order of decreasing importance:					
1. Control vs. Ascaris group	-1.84	-0.72	0.13	189.83	.0005
2. Child had "malaria", Visit I	0.64	0.18	0.18	12.48	.001
3. Education of household head	0.57	0.17	0.18	10.34	.005
4. Type of PCM at Visit I	0.11	0.13	0.04	6.98	.01
5. Child had "fever", Visit I	0.29	0.12	0.14	4.13	.05
6. Child had "malaria", Visit II	-0.26	-0.09	0.14	3.27	.10
7. Amount of coffee harvested	-0.05	-0.09	0.03	3.10	.10
8. Child had cough at Visit I	-0.22	-0.09	0.14	2.39	.14
9. Total calorie score in breakfast, Visit II	0.11	0.08	0.07	2.64	.10
constant (a)	-0.66				
R^2 for Equation I = 0.60					
Equation II[a] (N = 182)					
Dependent variable: change in skinfold thickness (mm.), Visits II-III					
Independent variables in order of decreasing importance:					
1. Control vs. Ascaris group	3.11	0.80	0.18	297.29	.0005
2. Village of residence	0.42	0.11	0.18	5.45	.025
3. Child had "fever", Visit II	-0.46	-0.10	0.22	4.27	.05
4. Age	-0.01	-0.10	0.005	4.55	.05
5. Child had diarrhea, Visit III	-0.46	-0.08	0.27	2.92	.10
constant (a)	-0.67				
R^2 for Equation II = 0.64					

[a] All variables included in final equations had an F value greater than 2.0.

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Samir Basta

Chapter

NUTRITIONAL AND ECONOMIC IMPLICATIONS OF SOIL-TRANSMITTED HELMINTHS WITH SPECIAL REFERENCE TO ASCARIASIS

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> It is difficult for those living in temperate climates with good standards of public health and medical care to realize the impact of disease on rural communities in the tropics. For example, if you happen to be born and grow up in rural Africa, you are liable to harbor four or more different disease-producing organisms simultaneously. And yet as a parent, you must be fit enough to work, or your family will starve. In your village every child at times suffers the paroxysms of malaria fever and you and your wife will mourn the death of one or two children from this disease....But lacking effective remedies, you tend to philosophize in the face of sickness. You make the effort to walk the ten miles to the nearest dispensary when you or your child is ill, but there may be no remedies, and it may be too late....
>
> Dr. David Rowe
> WHO Special Programme for Research and Training in Tropical Diseases (1)

I. TO TREAT OR NOT TO TREAT

There has long been a controversy in the medical literature over whether or not a clinician should provide treatment for common intestinal helminthic infections, particularly when they appear to be light or asymptomatic. A recent statement by H. M. Gilles illustrates what is probably the most commonly held viewpoint: "In non-endemic areas it is justifiable to treat all [intestinal worm] infections however light, while in areas where reinfection is likely to occur, only heavy or moderate infections are worth treating unless simultaneous attempts are made to improve environmental hygiene." (2) On the other hand, Pawlowski recently stated, with reference to *Ascaris* infection, that "intestinal ascariasis should always be treated when diagnosed because it is potentially a very serious infection. The treatment of suspected cases is also recommended...." (3) In the past, when drugs available particularly for hookworm and *Trichuris* infections were somewhat toxic, difficult to administer, and/or not particularly efficacious, discouraging treatment may have been justified. However, recent developments seriously question former conservative viewpoints. These include the appearance of broad spectrum anthelmintic drugs which are relatively safe and inexpensive, the fact that prevalence of soil-transmitted helminths is not rapidly decreasing (4), and a realization that hoped-for large improvements in environmental hygiene have not occurred for a majority of poor families in many developing countries.

II. PREVALENCE AND EPIDEMIOLOGY

Four common soil-transmitted helminths, roundworm (*Ascaris lumbricoides*), hookworms (*Ancylostoma duodenale* and *Necator americanus*), and whipworm (*Trichuris trichiura*) constitute public health problems from the point of view of prevalence. Recent global estimates indicate that *Ascaris* infection is one of the most common parasitic infections in the world, with an estimated 986 million persons or one quarter of the world's population infected (5). Hookworms are estimated to infect about 716 million persons, while *Trichuris* is thought to infect 536 million persons (5).

Transmission of all 4 parasites is through improper disposal of feces from infected persons containing potentially infective ova or larvae which require relatively warm temperatures and moisture for development. Once at the infective stage, eggs of *Ascaris* and *Trichuris* are capable of surviving considerable cold and dehydration. This means that infections tend to be endemic in poverty areas, anywhere sanitation is poor, especially in the warm humid areas of the tropics and subtropics. It may be improbable that light intestinal worm infections cause serious disease in otherwise healthy well nourished persons. However, the vast majority of people infected with intestinal helminths live in developing countries or areas where various forms of malnutrition and other diseases are common. There is increasing evidence not only of synergistic relationships between malnutrition and infections but also between one infection and another. In the case of Ascaris, infections are most common and heaviest in children of preschool age who are also most likely to suffer from or succumb to protein energy malnutrition (PEM), gastroenteritis, respiratory infections, malaria, and a variety of other nutritional, infectious, and parasitic diseases (6).

III. NUTRITION-HELMINTH INTERACTIONS: POSSIBLE MECHANISMS

The helminths discussed here are in excellent physiological positions to be able to interact with the nutritional status of their hosts. The adult forms of Ascaris and the hookworms are commonly located in the jejunum of the small intestine where most nutrient digestion and absorption take place and where antigenic components and toxic or bioactive compounds produced by the worms can be easily absorbed. In addition, hookworms suck blood from the mucosal surface, causing blood loss and tissue destruction. Trichuris, although located primarily in the colon, where they often bury their heads deeply into the colonic mucosa, are in a position to interfere with water and electrolyte absorption.

Intestinal parasites may directly affect nutritional status of a child basically by causing either a decrease in nutrient consumption or a functional increase in the body's nutrient requirements. Any condition causing anorexia, such as general malaise due to larval migration through the tissues or intestinal upset due to presence of adult parasites in the small intestine, would decrease total nutrient consumption.

Increases in nutrient requirements may occur due to a number of factors including (1) interference with absorption at the brush border due to diffuse mucosal damage, physical obstruction by worms, or production of antiproteolytic substances by worms; (2) loss of macronutrients, fluid, and electrolytes through diarrhea and vomiting, and (3) consumption by the worms of nutrients which are needed by the host (7,8). These effects would be much more likely to achieve clinical significance when a child is heavily infected with parasites, has a marginal nutrient intake, and/or already has other debilitating infections. While the above interactions may be logical from a physiologic standpoint, it is complicated and ethically difficult to confirm their occurrence in human clinical studies. Layrisse and Vargas (4) described the dilemma faced by researchers in this way:

> Much has been written on the synergistic interaction between parasitic infection and malnutrition in which malnutrition decreases the capacity of the host to invasion of parasites and, vice versa, the effect of parasitic infection influences the host's nutrition. But although this concept of mutual effect seems very logical, it has not as yet received substantial support due in part to the fact that human parasitic infection flourishes mostly in areas where malnourishment exists since early life and partly because the experimental studies carried out so far have not been entirely satisfactory.
>
> The difficulties confronted for a perusal study of a single parasitic infection in man should also be taken into account. There are environmental influences which can affect either host or parasites, or both, and which vary according to the ecological area under study. It is also important to bear in mind the difficulty in finding populations infected with a single parasite. In many instances, students are forced to work in multiparasitized areas and make a decision which infection is paramount in inducing malnourishment and rule out other less harmful infections. The literature on this topic reflects pathetically all these inconveniences. Controversial results, such as ascribing to a parasite a detrimental nutritional effect by a group of investigators and a nondetrimental effect by others, are not unusual. In other cases, malnourishment effects ascribed to a parasite have been denied after more careful studies.

Well controlled animal studies can provide clear cut evidence of parasitic effects, but it is difficult for the clinician to extrapolate these results for use in the clinical setting.

IV. NUTRIENT-PARASITE INTERACTIONS

A. Ascaris lumbricoides

1. LIFE CYCLE

Adult Ascaris lumbricoides normally live in the small intestine and are most often found in the proximal and mid jejunum at autopsy. The female worms are 20 to over 35 cm in length and about 4-6 mm in diameter, while the males are 15 to 30 cm long and more slender (9).

The female worms produce ova which are passed in the feces of the host. Ascaris are much more prolific in terms of potential ova production than are the other intestinal helminths. One female worm can contain 27,000,000 ova and may pass as many as 200,000 ova per day into the feces (10).

Humans contract Ascaris infection by ingestion of embryonated ova. The ova are passed unembryonated in the feces. In the presence of sufficient oxygen, moisture, and warmth, a larva develops in about 2-3 weeks and becomes infective about one week later. The ova have a tough protein coat and, prior to embryonation, are extremely resistant to drying or to destruction by various chemicals. They have been known to remain viable in the soil for over 10 years. Development generally ceases above $100^{\circ}F$ and below $60^{\circ}F$. Tropical temperatures of about $85^{\circ}F$ are ideal for embryonation, although prolonged direct sunlight is said to kill embryos.

Ova ingested by the host hatch in the small intestine and liberate larvae which pass through the mucosa and are carried to the liver in the enterohepatic circulation. The larvae develop further and roam about in the liver for about 4-5 days, then proceed via the blood stream to the heart and on to the lungs. In the lungs they continue growth, finally break out into the alveoli, pass up the trachea, and are either swallowed or spit out by the host. The swallowed larvae develop in the small intestine where they grow into juvenile and then adult worms of both sexes which mate to produce fertilized ova. Many of the larvae that originally hatched are destroyed or lost and do not become adult *Ascaris*.

The entire process, from ingestion of ova to production of fertilized ova by gravid *Ascaris*, takes about 2 months. Adult *Ascaris* continue to grow in width and length throughout their normal 1-2 year life-span. More detailed information of the life cycle of *A. lumbricoides* is available in various parasitology books (9,11).

2. GENERAL PATHOLOGY AND MORBIDITY OF *ASCARIS* INFECTION

Evidence for pathological effects of *A. lumbricoides* in humans comes mainly from clinical and surgical experiences of practicing physicians in many countries, but in general the pathological processes have been little studied under controlled conditions. Symptoms reported to occur in ascariasis include digestive disorders, colic, nausea, vomiting, respiratory disorders and pneumonitis, restless sleep, and tooth grinding during the night (12). Neurological disorders, including convulsions, and serious allergic manifestations are also reported in the medical literature (13).

Adult *A. lumbricoides* are thought to live peacefully in the lumen of the small intestine, indiscriminately ingesting food particles and other substances, such as barium sulfate from a barium meal, that pass through the GI tract (14). However, it seems likely that adult Ascaris cause a variety of digestive disturbances. To substantiate this view, Lagundoye (15) found that 92% of 53 adult Nigerian hospital outpatients infected with adult Ascaris exhibited a disordered small bowel pattern when a plain abdominal x-ray film was taken. The commonest abnormality seen was coarsening of the mucosal folds, although flocculation and dilution of barium, segmentation, bowel dilatation, and non-obstructive localized intussusception were also seen.

But most published reports on the effects of adult worms deal with surgical or other complications due to wandering of the adults to abnormal sites, such as the liver or pancreas (16,17). These complications include intestinal obstruction, obstructive jaundice, cholangitis, liver abscesses, acute pancreatitis, peritonitis, appendicitis, and others (see table 1). These are discussed in detail by Pawlowski (3).

Ascaris infection in humans is generally thought to cause few if any symptoms in most infected persons (13) and to be rarely fatal. However, in Sri Lanka in 1954, one large hospital reported that ascariasis was the most common cause for admission of inpatients. In 12.8% of cases admitted for ascariasis, the disease was fatal (18). This fatality rate was halved in the following year due to the introduction of piperazine compounds. This mortality rate seems unusually high; the author did not report whether deaths were due primarily to ascariasis or to other causes.

Complications due to ascariasis in the U.S. are relatively rare but are still encountered, particularly in the Southern states. In

1975, Blumenthal and Schultz (19) observed, in 3 rural Louisiana public hospitals, that 21 patients had been hospitalized with intestinal obstruction secondary to Ascaris infection over a 3 year period. They estimated that this incidence approximated 2 cases of obstruction per 1000 infected children.

Regarding symptomatology, it is pertinent to point out that tolerance to and admission of pain are often determined by culture and previous experience. Also, full medical histories are difficult to obtain and may even be dispensed with in overcrowded outpatient clinics where the patrons are mostly illiterate parents with a 2 or 3 year old child who at best has difficulty explaining his symptoms. In any case the idea that ascariasis is either harmless or symptomless may be only medical folklore.

3. NUTRITIONAL STUDIES

The report of a WHO Expert Committee on control of ascariasis (13) cites relationships between Ascaris infection and stunting, general undernutrition, avitaminosis, decreased protein absorption, xerophthalmia, and ascorbic acid deficiency. There is a huge literature available on various aspects of ascariasis, but very few well controlled studies deal with the nutritional effects of Ascaris on the human host. Those that have been conducted chose children who were mostly of school age and therefore less vulnerable to malnutrition than are preschool children. Also, many children studied harbored a number of other gastrointestinal parasites, making assessment of the effects of ascariasis itself difficult.

A few clinical studies of A. lumbricoides infection in children indicate lower apparent absorption and retention of protein and lower apparent absorption of fat and carbohydrate in infected children prior to, as opposed to after, deworming. In the first of these studies, Venkatachalam and Patwardhan (20) found that deworming of 9 hospitalized infected children, who harbored a mean of 26 adult parasites each, caused the mean fecal nitrogen excretion per day to decrease from 1.32 to 0.76 g ($p < .01$). The authors also showed experimentally that neither the improved hospital diet fed nor the ova excreted by Ascaris nor the effects of the drugs used in deworming could have accounted for this change in nitrogen excretion.

They concluded that even moderate burdens of Ascaris could be responsible for nutritionally significant losses of dietary protein in children receiving diets marginal in protein content.

Improvement in protein nutrition after deworming was also noted by Tripathy et al. (21) in 5 hospitalized children harboring a mean of 30 adult Ascaris and receiving relatively low levels of protein in the diet (1.0 - 1.5 g/kg body wt/da). Fecal nitrogen after deworming decreased by a mean of 6.5 percentage points of dietary nitrogen, being 33.5% before and 27% after deworming ($p < .01$). The same authors (22) also found, in 3 other Ascaris-infected children harboring over 48 worms each, that the decrease in nitrogen excretion after deworming was accompanied by an increase in nitrogen retention.

More important from the standpoint of energy balance, Tripathy et al. (21) found that 4 of 5 infected children exhibited mild to moderate steatorrhea. Fecal fat excretion decreased in all 5 children after deworming (9.9 vs 2.3% of dietary fat, $p < .001$). They also found impaired d-xylose absorption in 3 of the 5 children prior to treatment, which improved slightly in 2 cases immediately after deworming. They reported generalized mucosal damage in small intestinal biopsies taken prior to deworming and postulated that mucosal damage was responsible for the defects in absorption. Degree of mucosal damage had decreased in biopsies taken after deworming.

On the other hand, Teotia et al. (23) found that only 1 of 5 *Ascaris*-infected children exhibited fat malabsorption, but severity of infections was not measured. Also, Bray (24), in a nitrogen balance study in 4 children (ages 7-10 yrs), found no consistent differences in nitrogen absorption or utilization prior to and after deworming. The children studied exhibited wide variations in severity of *Ascaris* infection, in clinical signs of malnutrition, and 1 subject also harbored *Ancylostoma*.

Recently 2 clinical studies in India have indicated that *Ascaris* infection may interfere with vitamin A absorption. Mahalanabis et al. (25) determined vitamin A absorption in *Ascaris* infected adults and 12 healthy controls. Over 70% of infected patients had malabsorption of vitamin A, judging from serum levels after a radioactive dose. In addition, 7 of 23 infected patients who received a d-xylose absorption test had abnormally low values (below 20% of dose excreted in urine in 5 hr). Immediately after deworming, vitamin A absorption improved in 13 of the 14 patients re-tested, and d-xylose absorption increased in all 5 patients re-tested.

Sivakumar and Reddy (26) demonstrated that 6 *Ascaris* infected children absorbed less of a test dose of vitamin A from the gut than did 5 control children (80 vs 99%, $p < .01$). Percent of the radioactive label excreted in the urine did not vary between groups, hence the infected children retained less vitamin A than did controls (68 vs 82%, $p < .01$). None of the children had steatorrhea, since stool fat content was less than 5 g/24 hr. Two of the infected children were re-tested 2 months after deworming; vitamin A absorption improved from 83-86% to 95-96%. Only trace amounts of the vitamin A label were found in excreted worms, indicating that sequestering of the vitamin by the worms could not have caused the defect in absorption. The authors concluded that ascariasis may be aggravating vitamin A deficiency in areas where xerophthalmia is common.

In one of the few published studies relating ascariasis to preschool child growth, Gupta and co-workers (27) reported from India that deworming of malnourished preschool children every three months in villages where Ascaris was common resulted in increased weight for age after 8 months of study, compared to non-treated controls. Children 6-48 mos old in 2 villages were given tetramisole every 3 months for a year, and control children in 2 other villages received a placebo; children in all 4 villages received food supplements, immunizations, and simple medical care.

When children whose stools had been positive for Ascaris ova were considered, 13 treated children gained over one percentage point in wt/age during the year and only 2 lost over one percentage point. In the placebo group, 16 children gained but 27 children lost over one percentage point (Chi-square $p < .01$). The authors concluded that periodic deworming should be an integral part of a supplementary feeding program or a child health care package where roundworm is a severe problem. They also pointed out that the 6 tablets of tetramisole needed per child per year cost only about 4% as much as a year's supply of supplementary food for the same child.

In 1975-76, an investigation was undertaken in Kenya to measure the effects of Ascaris infection on growth, nutritional status, and health of preschool age children (28,29). The study was conducted in 2 Kenyan villages where 186 children aged 12-72 months were examined 3 times at 14 week intervals and anthropometric, clinical, and stool exams were performed. At visit I, 85% of the children were below 90% weight for age by the Harvard standard, 27% had Ascaris ova in their stools, and mean anthropometric measurements between infected and control children did not differ significantly. All children received an anthelmintic (levamisole) at visit II; mean number of worms collected was approximately 7 per infected child.

In the 14 weeks between visits I and II (before deworming) children with Ascaris ($n = 61$) did not differ from controls ($n = 125$) in weight gain or percent expected weight gain. In the 14 weeks after deworming (II-III) previously infected children showed higher weight gain (0.7 vs 0.5 kg, $p < .05$) and percent expected weight gain (130 vs 98%, $p < .025$) than controls. Before deworming, triceps skinfold thickness decreased in Ascaris-infected children vs controls (-1.6 vs 0.3 mm, $p < .0005$). After deworming, skinfold increased markedly in previously infected children vs controls (2.0 vs -1.1 mm, $p < .0005$). Multiple regression analysis showed that Ascaris infection was by far the most important variable of 37 possible health, nutritional and socioeconomic variables explaining decrease in skinfold before and increase after deworming. Thus it was concluded that even light Ascaris infections adversely influence nutritional status, and deworming enhances growth.

Cross-sectional nutrition parasite surveys in the U.S. have recently found _Ascaris_ infection in children from Louisiana to be associated with low serum albumin and plasma ascorbic acid levels and weakly associated with low weight for height and with signs of riboflavin deficiency (30). Also, _Ascaris_-infected preschoolers on Hilton Head Island, South Carolina more frequently had serum vitamin A levels below 20 μg/100 ml than did non-infected children (43 vs 21%), but the association was not statistically significant (31).

In short, _Ascaris_ infection has been linked to deficiencies or malabsorption of calories, protein, fat, carbohydrate (d-xylose), vitamin A, riboflavin, and Ascorbic Acid. These findings deserve further study, particularly in preschool age children in areas where poor growth and development are common.

B. Hookworms

"Hookworm is never spectacular like some other diseases, but is essentially insidious; year after year, generation after generation, it saps the vitality and undermines the health and efficiency of whole communities" (9). The life cycles of the human hookworms are grossly similar to that of _Ascaris_ except that man contracts the infection from infective larvae which penetrate the skin or oral cavity, rather than from ingestion of ova. Details of the life cycles, epidemiology, diagnosis, and drug treatment are well described elsewhere (9,32). The adult parasites live mainly in the upper small intestine and are 7-12 mm in length; their lifespan may be 5 years or longer. An individual can harbor over one thousand adult hookworms at once.

The relationships between hookworm and human nutritional status have been more thoroughly studied than is true for the other soil transmitted helminths and are discussed in detail by Layrisse and Roche (33), Layrisse and Vargas (4), and Banwell and Shad (32). The worms feed by biting off pieces of the mucosal surface, which causes bleeding into the gut, and also by actively sucking the host's blood. Daily blood loss due to hookworm infection had been estimated to vary from 2-3 ml in light infections to about 100 ml in heavy infections. Studies with infected humans have determined, using radioisotopic techniques, that Necator causes a blood loss of approximately 0.03 ml per day per worm or 2 ml per day per 1000 Necator ova found per gram of feces. The daily blood loss is generally greater per worm with Ancylostoma, being approximately 0.20 ml per worm or 4 ml per 1000 ova per gram of feces.

Perhaps 40-60% of the hemoglobin iron lost into the gut lumen is reabsorbed farther down the GI tract (4), but iron losses can be considerable and hookworms are an important cause of iron deficiency anemia in humans when the dietary iron absorption is not sufficient to replace both that lost through normal iron losses plus those due to the parasites. Layrisse and Roche, in a classic field study in over 1100 rural Venezuelans, demonstrated that hemoglobin level correlated inversely with number of hookworm ova per gram of feces (33,34).

Human hookworm infection may also be responsible for severe hypoproteinemia due to serum albumin loss and a protein losing enteropathy (32). In uncomplicated hookworm infection, macro- and micronutrient absorption for those nutrients studied is said to be adequate, except for an impairment of folic acid absorption (4). Some workers have reported malabsorption and mucosal injury in infected subjects, but others have not and have suggested that the mucosal changes seen were actually caused by factors other than hookworms, eg., poor diet or tropical sprue (4, 35-37).

When considering treatment of hookworm infection, one must realize that a majority of patients and particularly children living in endemic tropical and subtropical areas are likely to be presently or potentially malnourished to some degree, are likely to be exposed to many other infections, and are likely to have infrequent access to medical care. Provided that the drugs are available, it may be wiser, even in presumably light infections, to treat rather than to assume that the infection is harmless.

C. Trichuris trichiura

Trichuris is contracted by ingestion of infective ova, as is Ascaris, and causes blood loss from the gut, as do the hookworms. The adult Trichuris worms are 30-50 mm in length and live for up to 3 to 5 years or perhaps longer. They attach themselves to the mucosa in the colon, usually in the cecum and appendix. Infections can consist of only a few to over a thousand worms. Signs and symptoms of heavy infections may resemble those of hookworm infection and may include loss of appetite, abdominal discomfort, nausea, diarrhea, blood streaked stools, weakness, weight loss, eosinophilia, and anemia (9). Rectal prolapse can occur in severe or chronic cases (9). Further details of interest to physicians and other researchers are available elsewhere (4,9,38).

Recent reviews indicate the role of Trichuris in causing blood loss, but it appears that other possible relationships between the worms and malnutrition have not been extensively studied in humans. Layrisse et al (39) determined blood loss in 9 Trichuris infected children using Cr 51 and reported that the children lost about 0.005 ml of blood per worm per day, or about 0.25 ml per 1000 ova per gram of feces. They estimated that infections of more than 800 worms can induce iron deficiency anemia in children. While Trichuris do not cause the degree of blood loss that hookworms do, the symptoms attributed to them (loss of appetite, diarrhea, weight loss) suggest that they may negatively influence nutritional status of malnourished children through a number of mechanisms, even when infections are light. Previously, the most effective treatment for trichuriasis was the difficult and time-consuming hexylresorcinol retention enema. Under these conditions, it was not surprising that light infections were not treated. An effective and reportedly safe drug, mebendazole, is now available (38), and perhaps it is time to re-consider treatment of lighter infections and to continue research on interactions between Trichuris and malnutrition in children.

V. ECONOMICS OF ASCARIASIS

From the foregoing discussion one can see that some relationships between human malnutrition and intestinal helminths have been studied. However, with the possible exception of hookworm anemia, very little of a quantitative cause and effect nature is actually known. The economic implications of intestinal parasites on the family and society have been studied much less with a few notable exceptions (40). Yet the cost of a disease relative to other diseases and to available financial resources is important in determining whether or not the medical care system chooses to prevent and control the disease.

In the past, treatment of lighter infections of Ascaris, hookworm, and Trichuris has been discouraged using the following justifications:

1. Light loads are "asymptomatic" (and therefore presumably harmless).
2. The children will just get reinfected anyway.
3. Environmental hygiene and health education are the true answers to control.
4. It costs nothing, economically speaking, to ignore light infections.
5. To treat light, presumably harmless infections uses scarce health resources that are better spent on diseases with higher mortality rates.

In view of recent research into nutritional and economic implications of ascariasis in particular, a review of these arguments is now in order. It may be true that light Ascaris infections are asymptomatic, though this depends upon the amount of discomfort a person is used to experiencing. But field studies have now shown that deworming of infected malnourished children improves weight gain (27-29). While it is true that treated children often get reinfected in endemic areas, the fact that treatment may improve growth, even if only for a short period, justifies treatment, particularly in preschool children, who are most vulnerable to growth failure and protein energy malnutrition.

It is true that a general rise in the standard of living and that significant improvements in environmental hygiene should prevent transmission of soil-transmitted helminths. This has been the gospel put forth for decades. But for millions of people in rural areas, environmental sanitation has not improved markedly, and the prevalence of intestinal parasites in many communities has hardly decreased. A recent study in Iran (41) illustrated that improved sanitation by itself may be unlikely drastically to lower prevalence of Ascaris and hookworm infections. Three villages in Iran were supplied with either improved sanitation alone (one latrine per family plus a clean village water supply), treatment alone (piperazine for Ascaris infection and bephenium for hookworm infection given alternately every 3 months), or both. Four years later, the reduction in rates of Ascaris infection for the different methods were: sanitation, 28%; treatment, 84%; and both, 79%. For hookworm, reduction rates were: sanitation, 4%; treatment, 73%; and both, 69%. Thus even after a four year period, sanitation alone did little to decrease prevalence of both parasites while treatment decreased prevalence by 70% or more.

Provision and usage of latrines and safe water supplies and health education are of course essential parts of community development and can drastically reduce transmission of many diseases, particularly those due to certain bacteria and viruses. However, in the short term, it is questionable whether increased usage of latrines by itself can be expected greatly to lower the prevalence of Ascaris infection. Recent village studies in Kenya showed that most older children and adults used latrines, but that some young preschool children did not, partly because they could not use a pit latrine properly and partly because they were too young to understand the need for proper feces disposal (29). Mothers can encourage their children to use a latrine as early as possible. But the average rural Kenyan mother may have 2 or 3 preschool children to care for and is responsible for cultivation of all food crops, food preparation, and for fetching the entire family's supply of water and firewood on foot. Thus it is unrealistic to expect her to ensure that every stool passed by all of her children ends up in a latrine. Fecal contamination of the environment by young children cannot help but continue.

Spread of ascariasis is further complicated by the prolific ova production of the female worms. Only one contaminated stool that is passed in the yard contains enough ova to theoretically infect an entire village for years.

One adult female Ascaris may produce about 200,000 ova per day, and each ovum, if embryonated and swallowed by a human, can produce one adult worm. Ova are extremely hardy and can survive for more than a year in the soil, if not destroyed by sunlight, radiation, or dessication. If one young child harbors only 10 adult worms, 5 of which are female, the number of ova passed in his stools per day is on the order of 1,000,000, and yearly ova output is about 365,000,000. Thus even if all older family members religiously use a latrine and the youngest preschool child uses the latrine at least 90% of the time, that one child, if only lightly infected, can deposit up to 36,500,000 Ascaris ova per year in the soil around the family dwelling. These ova can obviously be spread from dwelling to dwelling by movement of animals or people, or possibly by wind and rain, or on contaminated food. So even if availability and use of latrines becomes near perfect, Ascaris ova will remain in large numbers in the environment. This is also true for the other soil transmitted helminths, although their reproductive capacities are much lower per worm than is that of Ascaris.

The other health education technique that can be used to prevent Ascaris infection is to promote thorough hand washing before eating. This of course is already being done, but large quantities of clean water are simply not available to many rural families. And even when access to water is not a problem, it is at best difficult to convince very young children that they should not put unwashed hands in their mouths.

The fourth assumption about nontreatment of mild infections is that lack of treatment involves no economic costs. But there clearly are costs attached to the mere existence and persistence of a disease. In Kenya in 1976 minimal economic costs incurred due to Ascaris infection were estimated for the entire country (29). These computations included costs to the medical care system and to private citizens. The results were as follows. Health care costs were estimated from inpatient and outpatient statistics from government hospitals where a primary diagnosis of ascariasis was made. These were extrapolated to include mission hospitals (but not rural health centres or dispensaries). From this the cost of health care was estimated to be $180,000 in 1976, excluding anthelmintic drugs. Figures were obtained on anthelmintic drugs purchased by the government, and the cost of these was estimated to be $160,000. The general public were estimated to have purchased $195,000 worth of anthelmintic drugs from retail stores in 1976. Ascaris infected Kenyans seeking treatment in hospitals were estimated to have spent $199,000 because of lost work time and transport costs resulting from their trips to the hospital. Based on the assumption that absorption and utilization of calories in food in those infected with Ascaris is reduced by only 2.8% of total calories, then the retail value of this food lost to Kenyans was estimated to be $4,400,000 in 1976. The total of these economic costs of Ascaris is over $5,000,000 in a single year for a country with 10 million persons, and these estimates are quite conservative.

The fifth and strongest argument against treating light intestinal worm infections is that to do so would use up scarce health care funds which should be used to prevent and treat diseases with higher child mortality rates, such as PEM, gastroenteritis, and malaria. Since Gish and Walker (42) have estimated that many developing countries spend only $2 per capita per year on health care, this point is well taken. On the other hand, diseases such as PEM and gastroenteritis are much more complicated and expensive to treat and control than is Ascaris infection. And since ascariasis may inhibit growth in malnourished children, treatment and prevention of ascariasis may very well have a beneficial effect on the prevalence of PEM and its associated diseases.

VI. DRUG TREATMENT PROGRAMS

Thus, despite efforts to improve health knowledge, sanitation, and health care, Ascaris, hookworms, and Trichuris are still very prevalent and, because of their ubiquitous natures, very likely to persist or even increase in prevalence. Substantial improvements in education, housing, sanitation, and the economic situation are being made in many areas, but these improvements are unlikely to occur fast enough to stay or decrease the prevalence of soil-transmitted helminths in general, and

Ascaris in particular, in the next 10 years. This is especially true if the only weapons used are health education and symptomatic treatment after diagnosis in hospitals.

Given that significant fecal contamination of the environment is destined to continue, the remaining approach to decrease ascariasis is to decrease the likelihood that those feces contain helminth ova. For _Ascaris_ in particular, this can be done by periodic mass anthelmintic treatment of persons in areas where _Ascaris_ is prevalent. In the past, anthelmintic drugs, especially the more toxic ones, have only been given to a person after a stool examination has shown which parasites the person has. Development of less toxic drugs, coupled with the realization that most _Ascaris_ infested persons never get a stool examination and hence never receive drug treatment, has caused a number of physicians to suggest mass treatment programs as an alternative (43). In mass treatment, an anthelmintic is periodically given to all persons in a vulnerable group in an area where certain parasites are known to be common. This approach has important medical and economic advantages over other methods of control:

(1) time and cost of stool examinations are saved

(2) for the same amount of money, many more persons can be treated than is possible in conventional health care facilities

(3) the person administering the drug needs very little if any genuine medical training

(4) prevention and cure in one delivery system are combined in that present effects of the disease are temporarily

arrested and fecal contamination is temporarily halted in all infected persons.

This mass treatment approach is likely to be the only way significantly and economically to decrease Ascaris infection and prevalence of 3 other soil transmitted helminths within the next 10 years.

The three main components of a mass treatment program are (1) choice of target groups, (2) choice of drug, and (3) choice of delivery system.

Regarding target groups, it seems that preschool children are the most likely to suffer from effects of ascariasis and are also most likely to promote transmission of the disease to others. Hence they probably require frequent deworming, perhaps 2-3 times per year at the outset. Prevalence surveys in some areas also show that Ascaris and other soil-transmitted helminths are extremely prevalent in school-aged children and adults. If cost permits, they too should receive routine anthelmintic therapy, although less often than preschoolers, e.g. once per year or every 2 years.

Regarding choice of drug, one can either opt for the traditional less expensive piperazine compounds, or one can choose the more expensive broad spectrum anthelmintics. The author feels that the preferable choice, for Kenya in particular, is a broad-spectrum type drug for a number of reasons:

(1) Prevalence studies show that the soil-transmitted helminths tend to co-exist. Cases of multiple parasites are often common. If one is going to treat and help prevent Ascaris, one might as well also be treating and helping prevent hookworm, Trichuris, and Strongyloides at the same time. This cannot be done using piperazine compounds alone.

(2) The major difficulty and a significant proportion of the cost of a mass treatment program is likely to be choice and development of the delivery system, rather than choice and purchase of drugs. It is sensible to combat all 4 soil-transmitted helminths with a single delivery system.

(3) Although the cost per dose of the broad-spectrum anthelmintics is greater than the cost of piperazine compounds, the cost per dose of bephenium, used in treatment of hookworm, is greater than the cost per dose of levamisole, a broad spectrum drug that reportedly lowers individual worm burdens of hookworm, *Trichuris* and *Strongyloides* as well as virtually eliminating *Ascaris*. In the long run, it is probably cheaper to treat and prevent all 4 diseases at once than to deal with them separately.

VII. CONCLUSIONS

There is a great need for more applied research to determine the relationships between nutrition, particularly childhood malnutrition, and intestinal parasitic infections. Nevertheless, it is clear that hookworm infection can cause iron deficiency anemia and that *Ascaris* infection is associated with poor growth in malnourished children. Periodic deworming of children using a mass treatment approach is highly recommended to control soil-transmitted helminths in areas where parasites and protein energy malnutrition are highly prevalent. The main aims of treatment should be to reduce parasite loads below the level of clinical significance for the individual child (2) and to reduce future environmental contamination with infective feces for the sake of the community.

Acknowledgements

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TABLE 1

Manifestations of ascariasis

ALLERGIC ACTION OF THE ADULT AND LARVA:

(a) Substances from adult: - allergic phenomena among laboratory workers

(b) Substances from larva: - cutaneous signs: urticaria, erythematous lesions
- blood eosinophilia
- Loffler's syndrome

(c) Associated infections: - complications due to *Strongyloides stercoralis* and *Escherichia coli*
- cryptogenetic and malignant eosinophilia
- cutaneous, ophthalmic and visceral larva migrans due to the migration of the larvae

ACTION OF THE ADULT ON THE INTESTINAL TRACT:

(a) Nutritional disorders and enterocolitis of the diarrhoeal type

(b) Surgical forms:

Intestinal subocclusions and occlusions caused by mass of *Ascaris*--Intussusception (in children), volvulus, hernial strangulation (penetration of *Ascaris* into the loop involved)

Acute mesenteric adenitis

Penetration into the appendiceal lumen or into intestinal diverticulum

Postoperative troubles due to movement of *Ascaris* (colic, peritonitis, fistula)

WANDERING OF THE ADULT:

(a) From mouth, nose, lacrimal fossa or through Eustachian tube to the middle ear

(b) Through glottis (glottal oedema) to trachea or bronchi

(c) Into bile ducts: obstructive jaundice, gall-stones, cholangitis, liver abscess

(d) Into pancreatic duct: acute haemorrhagic or purulent pancreatitis

(e) Migration across tissue walls from intestine to peritoneal cavity and elsewhere

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Taken from Control of Ascariasis (13).

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November 21, 1978

Dr. Samir S. Basta
Nutrition Division
The World Bank
1818 H Street N.W., Rm D-836
Washington, D. C. 20433

Dear Samir:

Enclosed is a copy of the monograph on economic aspects of ascariasis we're submitting to the J. Trop. Pediat., to keep you posted on publication activities.

Thanks very much for your comments on the Inception Report. I'll add some explanatory paragraphs in the First Progress Report to reply to the points you brought up.

Best wishes from both of us.

Sincerely,

Lani S. Stephenson/dd

Lani S. Stephenson, Ph.D.
Research Associate

LSS:dd

Enc.

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November 21, 1978

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Dr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

To keep you abreast of our publication activities, attached is a copy of the monograph on economic aspects of ascariasis (mostly excerpted from my PhD thesis) which we are submitting to the Journal of Tropical Pediatrics.

Reports from Andrew Hall and my field workers in Kenya say that the Ascaris control project is going very well in terms of drug delivery. We're now preparing the First Progress Report.

Best wishes from Michael and I.

Sincerely,

Lani S. Stephenson/dd

Lani S. Stephenson, Ph.D.
Research Associate

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Enc.

COSTS, PREVALENCE, AND APPROACHES FOR CONTROL OF *ASCARIS* INFECTION IN KENYA

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I. INTRODUCTION

Ascaris lumbricoides, the human roundworm, is one of the most common intestinal parasites in the world. It has been estimated to infect about one quarter of the world's population, or one billion people (Peters and Gilles, 1977). It is common in preschool aged children and often coexists with protein-calorie malnutrition throughout the tropics and subtropics (Control of Ascariasis, 1967).

Adult *Ascaris* worms, which live in the lumen of the small intestine, are about the size of large earthworms. A single infection can consist of from one to hundreds of adult parasites. The disease is chronic in nature, a single infection lasting for up to two years if untreated. Reinfection in endemic areas is common, so that children and adults may have some degree of *Ascaris* infection for most of their lives. Intestinal obstruction or blockage of a bile duct are complications which occur, especially in cases of massive infestation. The habitual migrations of the immature parasites through the liver and lungs of infected persons may possibly cause liver damage and respiratory disease, as *Ascaris suum* larvae are well known to do in pigs (Chandler and Read, 1961; Pawlowski, 1978).

Practicing physicians in developing countries speak of the often strong association between *Ascaris* infection and protein-calorie malnutrition in preschool children, and many have speculated that *Ascaris* may contribute importantly to preschool child malnutrition (Jelliffe, 1953; Venkatachalam and Patwardhan, 1953; da Silva, 1957). Yet health officials in many developing countries consider ascariasis to be of little or no public health importance (Control of Ascariasis, 1967). Ascariasis, in endemic areas, is often considered something that is barely worth treating, for the children will "just get it back again" (Gilles, 1976). Because of these feelings, few large scale programs have been undertaken to prevent and control Ascaris infection.

It would not be surprising if large worm burdens were responsible for significant growth retardation in children. Of greater public health importance is the question of whether small or moderate worm burdens also retard growth and in this way contribute to protein-calorie malnutrition. Evidence of poor growth and development is found in about two thirds of the children in most developing countries. Ascariasis may be present in over 50 percent of these children.

A review of the literature, as well as the studies of Ascaris infected children reported here, indicate that even light Ascaris infections may have detrimental effects on growth of malnourished preschool children. In addition, a detailed study of the economic aspects of Ascaris infection in Kenya shows that ascariasis is a costly disease and may be cheaper to prevent than to treat.

II. ASCARIS AND NUTRITION

Few well controlled studies of the effects of Ascaris infection on child nutritional status have been conducted, but there are good reasons to believe that it can aggravate protein-calorie malnutrition (Jelliffe, 1953). The WHO Expert Committee Report on control of ascariasis (1967) cites relationships between Ascaris infection and stunting, general undernutrition, avitaminosis, decreased protein absorption, xerophthalmia, and ascorbic acid deficiency as being of possible nutritional importance.

There are some clinical studies of A. lumbricoides infection in children which report lower apparent absorption and retention of protein and lower apparent absorption of fat and carbohydrate in infected children prior to, as opposed to after, deworming. In 1953, Venkatachalam and Patwardhan found that deworming of 9 hospitalized infected children, who harbored a mean of 26 adult parasites each, caused the mean fecal nitrogen excretion per day to decrease from 1.32 to 0.76 g ($p < .01$). They concluded that even moderate burdens of Ascaris could be responsible for nutritionally significant losses of dietary protein in children receiving diets marginal in protein content.

An improvement in protein nutriture after deworming was also noted by Tripathy et al. (1972) in 5 hospitalized children harboring a mean of 30 adult ascarids and receiving relatively low levels of protein in the diet (1.0-1.5 g/kg body wt/da). Fecal nitrogen after deworming decreased by a mean of 6.5 percentage points of dietary nitrogen, being 33.5% before and 27% after deworming ($p < .01$). The same authors (1971) also found, in 3 other Ascaris-infected children harboring over 48 worms each, that the decrease in nitrogen excretion after deworming was accompanied by an increase in nitrogen retention.

More important from the standpoint of energy balance, Tripathy et al. (1972) found that 4 of 5 infected children exhibited mild to moderate steatorrhea. Fecal fat excretion decreased in all 5 children after deworming (9.9 vs 2.3% of dietary fat, $p < .001$). They also found impaired d-xylose absorption in 3 of the 5 children prior to treatment, which improved slightly in 2 cases immediately after deworming. They reported generalized mucosal damage in small intestinal biopsies taken prior to deworming and postulated that mucosal damage was responsible for the defects in absorption. Degree of mucosal damage had decreased in biopsies taken after deworming.

Two clinical studies recently reported from India have shown that *Ascaris* infection may interfere with vitamin A absorption. Mahalanabis et al. (1976) determined vitamin A absorption in *Ascaris* infected adults and 12 healthy controls. Over 70% of infected patients had malabsorption of vitamin A, judging from serum levels after a radioactive dose. In addition, 7 of 23 infected patients who received a d-xylose absorption test had abnormally low values (below 20% of dose excreted in urine in 5 hr). Immediately after deworming, vitamin A absorption improved in 13 of the 14 patients re-tested, and d-xylose absorption increased in all 5 patients re-tested.

In 1975, Sivakumar and Reddy demonstrated that 6 *Ascaris* infected children absorbed less of a test dose of vitamin A from the gut than did 5 control children (80 vs 99%, $p < .01$). Percent of the radio-label excreted in the urine did not vary between groups, hence the infected children retained less vitamin A than did controls (68 vs 82%, $p < .01$). None of the children had steatorrhea, since stool fat content was less than 5 g/24 hr. Two of the infected children were re-tested 2 months after deworming; vitamin A absorption improved from 83-86% to 95-96%. Only trace amounts of the vitamin A label were found in excreted worms, indicating that sequestering of the vitamin by the worms could not have caused the defect in absorption. The authors concluded that ascariasis may be aggravating vitamin A deficiency in areas where xerophthalmia is common.

Gupta and co-workers (1977), in one of the few published studies relating ascariasis to preschool child growth, reported that deworming malnourished preschool children every 3 months in Indian villages where Ascaris was common resulted in increased weight for age after 8 months of study, compared to non-treated controls. Children 6-48 mos old in 2 villages were given tetramisole every 3 months for a year, and control children in 2 other villages received a placebo; children in all 4 villages received food supplements, immunizations, and simple medical care.

When children whose stools had been positive for Ascaris ova were considered, 13 treated children gained over one percentage point in wt/age during the year and only 2 lost over one percentage point. In the placebo group, 16 children gained but 27 children lost over one percentage point (Chi-square $p < .01$). The authors concluded that periodic deworming should be an integral part of a supplementary feeding program or a child health care package where roundworm is a severe problem. They also pointed out that the 6 tablets of tetramisole needed per child per year cost only about 4% as much as a year's supply of supplementary food for the same child.

In 1975-76, the authors undertook a study in Kenya to measure the relationships between Ascaris infection and growth, nutritional status, and health of preschool age children (Latham et al., 1977; Stephenson et al., 1978). The study was conducted in 2 Kenyan villages where 186 children aged 12-72 months were examined 3 times at 14 week intervals and anthropometric, clinical, and stool exams were performed. At visit I, 85% of the children were below 90% weight for age by the Harvard standard, 27% had Ascaris ova in their stools, and mean anthropometric measurements between infected and control children did not differ significantly. All children received an anthelmintic (levamisole) at visit II; mean number of worms collected was approximately 7 per infected child. In the 14 weeks between visits I and II (before deworming) children with Ascaris ($n = 61$) did not differ from controls ($n = 125$) in weight gain or in percent expected weight gain. In the 14 weeks after deworming (II-III) previously infected children showed higher weight gain (0.7 vs 0.5 kg, $p < .05$) and percent expected weight gain (130 vs 98%, $p < .025$) than controls. Before deworming, triceps skinfold thickness decreased in Ascaris-infected children vs controls (-1.6 vs 0.3 mm, $p < .0005$). After deworming, skinfold increased markedly in previously infected children vs controls (2.0 vs -1.1 mm, $p < .0005$). Multiple regression analysis showed that Ascaris infection was by far the most important variable of 37 possible health, nutritional and socioeconomic variables explaining decrease in skinfold before and increase after deworming. Thus it was concluded that even light Ascaris infections adversely influence nutritional status, and deworming improves growth.

In sum, Ascaris infection has been related in human studies to deficiencies or malabsorption of calories, protein, fat, carbohydrate (d-xylose), vitamin A, riboflavin, and ascorbic acid. These findings deserve further study, particularly in preschool age children in areas where poor growth and development are common.

III. ECONOMIC STUDY OF *ASCARIS* INFECTION IN KENYA

A. Purposes of the economic study

The study of the economic aspects of ascariasis had 2 basic purposes: to estimate the cost of ascariasis in Kenya in 1976, both in terms of health care system costs and in terms of costs to private citizens; and to design and estimate costs of a feasible program to control *Ascaris* infection in Kenya. To estimate the costs of *Ascaris* infection, data were compiled from various sources. All available studies on the prevalence of *Ascaris* infection were located, and an overall prevalence estimate was made for Kenya. Current expenditures for the treatment and control of ascariasis were estimated using available hospital, government, and other statistics on (a) patient care costs, (b) costs of anthelmintics to hospitals and to private citizens, and (c) work time and travel expenses incurred by hospital patients. Finally, total food losses due to malabsorption were estimated from previously published data on malabsorption in *Ascaris*-infected children. A potentially feasible program to control ascariasis in Kenya was designed and its costs for drugs estimated using knowledge of local cultural habits and of the adequacy of communication and health care system operations.

B. Results of the economic study

1. Prevalence of *Ascaris* infection in Kenya

Data on prevalence of Ascaris in different parts of Kenya were compiled from several sources including surveys published in the sicentific literature, Ministry of Health reports, unpublished surveys done by medical students at the University of Nairobi, and results from the authors' studies in Machakos and Kwale Districts.

The overall prevalence of Ascaris infection in Kenya was estimated from surveys on prevalence of intestinal parasites undertaken in areas of high population density: (a) southeastern Kenya, (b) central Kenya, and (c) western Kenya. When available, data for prevalence of other soil-born helminthic infections (hookworms, Trichuris trichiura, and Strongyloides stercoralis) are also presented (Table I).

a. Southeastern Kenya

The densely populated area of southeastern Kenya lies within the Coast Province, near the large port city of Mombasa. Available data indicate a moderately high prevalence of Ascaris and hookworm and also a high but variable prevalence of Trichuris infection. In the study of worker productivity of adult male roadworkers in Kwale (Latham and Brooks, 1977; Arnold et al., 1978), stool analysis by D. W. T. Crompton and co-workers showed that one quarter of men had Ascaris infection, while 66% had hookworm and 45% had trichuriasis. Data were not available for children, but prevalence rates for Ascaris infection in preschool children are likely to be higher than 25%. The other evidence for high prevalence of intestinal helminths in Coast Province comes from hospital laboratory internal reports of stool examinations (Maina, personal communication). Reports from the provincial hospital and the larger district hospitals show that 10-30% of stools analyzed were positive for Ascaris ova, while 10-60% showed evidence of hookworm and up to 14% were positive for Trichuris ova (Table I). These data are for all patients on whom stool examinations were done and probably underestimate the prevalence of Ascaris infection in preschool children.

b. Central Kenya

The densely populated areas of central Kenya consist of 3 parts: part of the Eastern Province, inhabited mainly by members of the Kamba tribe, part of the Central Province, inhabited mainly by the Kikuyu tribe, and the capital city of Nairobi itself. Studies in these 3 areas show a generally high prevalence of Ascaris infection. Prevalence of ascariasis in Eastern Province seems greater in ecological zones with more rainfall, e.g. 28% of children 1-16 years old had Ascaris positive stools in a wet sublocation (Kambusu) compared to only 3% in a dry area (Katitu). Prevalence of hookworms is fairly high regardless of rainfall, with 12-33% of children infected (Kinyanjui, 1973).

The authors' data on prevalence of Ascaris in Kambusu sublocation in 6-72 mo. old children also shows 27% of children infected with Ascaris, with no difference in prevalence between sexes (Stephenson et al., 1977; Latham et al., 1977). It is worth noting that of all children infected with Ascaris, 12% also had hookworm and 5% had Trichuris infection. These cases of multiple parasitosis are common in other parts of Kenya also, and support the need for broad-spectrum anthelmintics which can attack more than one parasite at the same time.

Table I. Summary of prevalence surveys and hospital statistics for selected soil-born helminths in Kenya.

Reference	Area.	Subjects	No. stools examined	% positive for: Ascaris	Hook-worm	Trich-uris	Strongy-loides
a. Southeastern Kenya							
Latham/Brooks, 1977 Arnold et al., 1978	Coast Province Kwale District	adult male roadworkers	119	23.	66.	45.	-
Coast Province Hospital Statistics 1971-6	Coast Province General and District hospitals	hospital patients	87,222	12.	16.	4.	1.6
b. Central Kenya							
Kinyanjui, 1973	Eastern Province Machakos District 5 sublocations	children 1-16 yr	789	12.	19.	2.	-
Latham et al. 1977	Eastern Province Machakos District Kambusu sublocation	children 6-72 mo	375	27.	7.	2.	0
Kungu, 1970	Eastern Province Machakos District Mitaboni Location Miambuni sublocation	children 0-9 yr pregnant women	209 11	3.	1.	0	0.5
Korte, 1966	Central Province Mwea-Tebere Mahigaine, Kirogo	children 1-16 yr	264	15.	-	-	-
Korte, 1972	Central Province Mt. Kenya Warazo village	children 6 mo-6 yr	113	13.	-	-	-
Bell, 1956	Central Province Meru District	hospital patients all ages		18.	-	-	-

Table I. continued

Reference	Area	Subjects	No. stools examined	% positive for: Ascaris	Hook-worm	Trich-uris	Strongy-loides
Nairobi Public Health Labs, 1973-5	Nairobi	children 5-7 yr	2,419	38.	3.	2.	0.3
Rijpstra, 1975	Nairobi	primary school children	250	60.	22.	38.	1.0
c. Western Kenya							
Mubisi, 1973	Western Province	children 0-4 yr	277	29.	18.	6.	2.2
	Busia District	children 5-9 yr	210	44.	34.	14.	5.2
	S. Teso, Bukhayo	pregnant women	22	27.	18.	14.	0
Onjua, 1972	Nyanza Province	children 0-4 yr	160				
	Siaya District	children 5-9 yr	128	66.	43.	22.	0
	East Gen Location	pregnant women	20				
Mwangi, 1971	Nyanza Province	children 0-4 yr	228				
	Kisumu District	children 5-9 yr	146	46.	14.	22.	1.7
	Dunga & Pandpieri	pregnant women	28				
Gondi-Awor and Ndinya-Achola, 1972	Nyanza Province	children 0-4 yr	287	22.	18.	6.	0
	Kisumu District	children 5-9 yr	270	38.	15.	11.	0.7
	Kolwa Location	pregnant women	36	31.	28.	6.	2.8
Kinoti, 1971	Nyanza Province Kisumu District Kano Plain and Nyakach	primary school children	1,191	39.	28.	9.	1.4
Ministry of Health Annual Report, 1968	Nyanza Province Kisumu District Ahero Plains	primary school children	1,000	31.	4.	1.	1.7
Western Kenya Hospital Statistics 1967-74	Nyanza Province Gen'l. Hospital, Busia & Kakamega District Hospitals	hospital patients	166,415	17.	11.	2.	1.0

There are parts of Eastern Province where Ascaris and other intestinal helminths are rare. Kungu (1970) found only 3% of children and pregnant women in Mitaboni location to be infected with Ascaris. This is more likely to occur in very dry areas. It should be mentioned that prevalence surveys, done only at one point in time, are likely to underestimate the percent of a population who will suffer a given infection during an entire year.

It should also be mentioned that stool examinations do not always detect lighter infections of hookworm or Trichuris. Thus the prevalence of these two parasites is very likely greater than that shown in most of these studies. Also, accurate detection of larvae of Strongyloides requires a special technique (the Baermann technique) not routinely used in most stool exams. The prevalence of this parasite is likely to be greatly underestimated. Since hookworms and Trichuris both suck blood from the host's intestinal tract, and heavy Strongyloides infection has been known to cause a severe malabsorption syndrome (O'Brien, 1975), these underestimations, although not quantifiable, must be kept in mind. Ascaris produces many more ova per worm than the other 3 parasites and is quite easy to detect by any standard examination method (Rijpstra, 1975). Thus prevalence figures for Ascaris should be reasonably precise for a given point in time.

Information for the Central Province comes from 3 studies. A stool survey of families in the Mwea-Tebere irrigation scheme (Korte, 1966) showed that 15% of children 1-16 years old had Ascaris positive stools, with a higher prevalence in preschool children (23%) than in children over 7 years (12%). A study of 113 children 6 mo. - 6 years of age showed 13% infected (Korte, 1972), while a study in Meru quoted 18% of persons as being infected with Ascaris (Bell, 1956).

Good data on prevalence of intestinal parasites are available for children in Nairobi primary schools and show a disturbingly high prevalence of Ascaris, hookworm, and Trichuris infections. In 1973-75, stool examinations were done by the city public health laboratories on 2,419 children aged 5-7 years attending 16 primary schools in the Nairobi area (Danee and Cross, personal communication). Overall prevalence of Ascaris infection was 38%, with up to 70% of children in a given school infected. Three percent of all children had hookworm, with up to 10% infected in one school.

Another excellent study (Wijers, Kinyanjui, and Rijpstra, 1972) in two primary schools in Nairobi was conducted to investigate the relationship of different social factors to the prevalence of soil transmitted helminths. Their data show a number of important epidemiological points. First, although 82% of school children in a relatively poor area had Ascaris infection, as many as 40% of children attending a school in a prosperous area were also infected. Overall prevalence of Trichuris infection was extremely high (38%), and hookworm infection was also quite common (22%). Second, a breakdown of prevalence by age group for children attending the prosperous school shows that the percent of children infected did not vary markedly by age either for Ascaris, hookworms, or Trichuris. Percent of boys vs. girls infected also did not vary strikingly for the 3 parasites.

Third, prevalence is broken down by major tribal group and by length of residence in Nairobi. Prevalence of Ascaris infection is lowest, although not low, in the Kamba (30%) and is 47-51% in the other 3 tribal groups. Prevalence of hookworm and Trichuris infections are highest in the 2 groups originating in western Kenya (Luo and Luhya tribes) with infection rates of one-third and one-fourth of children, respectively. The authors also determined whether length of residence in Nairobi affected prevalence of parasites. None of the differences in prevalence by length of residence are statistically significant and generally indicate that length of residence in Nairobi alone, does not drastically effect likelihood of being infected with Ascaris, hookworms, or Trichuris. Prevalence data for preschool children living in the Nairobi area were not available but are likely to be very similar to results for their 5-6 year old siblings.

One cannot help but be concerned by the high rates of helminth infection in these Nairobi schools, since these children theoretically do have the good access to medical care that children in rural areas often lack. The crowded living conditions that inevitably occur in any inner city are likely to cause these prevalence rates to increase with time, unless effective widespread deworming programs are undertaken.

c. Western Kenya

The densely populated areas of western Kenya consist of 2 adjacent provinces on the shores of Lake Victoria: Western Province to the north, and Nyanza Province to the south. Six different prevalence surveys for intestinal helminths in children have been done in these areas; all indicate a high prevalence of Ascaris infection and a variable but often high prevalence of hookworm and Trichuris infections also. Data from stool examinations in hospitals reconfirm these results. The single prevalence survey done in Western Province shows that 36% of subjects (mostly children) had Ascaris positive stools, while 25% had hookworm, 9% had Trichuris, and 3% had Strongyloides. Multiple infections occurred in 15% of cases; 67% of multiple infections were a combination of Ascaris and hookworm (Mubisi, 1973).

The 5 surveys done in Nyanza Province show that Ascaris is very common in both Siaya District and in Kisumu District. A survey by Onjua in 1972 in Siaya District showed that 66% of 160 subjects (mostly children 0-9 yr) harbored Ascaris, while 43% had hookworm and 22% had Trichuris. Eighty-three percent of subjects had at least one helminth infection and 33% had both Ascaris and hookworm infection.

The 4 studies in Kisumu District indicated that Ascaris, hookworms, and Trichuris commonly infected preschool and primary school children and pregnant mothers. In Dunga and Pandpieri villages, 46% of subjects (mostly children) had Ascaris, 14% had hookworm, and 22% had Trichuris (Mwangi, 1971). In Kolwa Location, results were 30% Ascaris, 17% hookworms, and 8% Trichuris, with Ascaris and Trichuris most prevalent in 5-9 year olds, and hookworm most prevalent in pregnant women (Gondi-Awor and Ndinya-Achola, 1972). A large study in 27 primary schools in Kano Plain and Nyakach showed results similar to those in some Nairobi primary schools: 39% Ascaris, 28% hookworm, and 9% Trichuris (Kinoti, 1971). Multiple infections occurred in 114 or 23% of children. Of those, 58 or one-half were Ascaris + hookworm and another one-third were some combination of Ascaris and/or hookworm and/or Trichuris. Prevalence of hookworm went up from 22%

in class I to 31% in class IV but at least one-fifth of students in each class were infected. The last prevalence study in Kisumu District was undertaken in 1,000 primary school children in Ahero Plains and indicated that 31% of subjects had *Ascaris*, but only 4% or fewer were found to have the other 3 intestinal helminths (Ministry of Health Annual Report, 1968). Results of stool examinations for parasite ova at Kakamega District Hospital (Western Province) and Nyanza Province General Hospital confirm results of prevalence surveys (Aseso and Ochieng, personal communication). They show that 15-25% of all stools examined are positive for *Ascaris* ova and that 7-15% exhibit hookworm ova.

d. Overall prevalence estimate

In general, the previous prevalence surveys reveal a high prevalence of *Ascaris* infection in the densely populated areas of Kenya, especially in children in Western Kenya and in Nairobi. They show that *Ascaris* infection is generally common in children of all age groups, of both sexes, and of all the major tribal groups studied. The few studies in adults and the hospital data seem to indicate that, in endemic areas, relatively high percentages of adults are also infected with *Ascaris*.

Since the studies mentioned above have not used random samples in entire provinces and because several districts have not been surveyed, it is not possible to estimate the prevalence of *Ascaris* infection in Kenya with much precision. The many studies which are reviewed here do show considerable consistency which provides a feeling of confidence in making estimates of prevalence of *Ascaris* infection.

The data show that 20-80% of children are Ascaris-infected in different densely populated areas and in most studies the percentage is 30% ± 10%. Since 48% of the population of Kenya (1969) consists of children under 15 years of age and adults are also heavily infected, it seems probable that approximately 25% of all Kenyans are infected with Ascaris at any point in time. These figures gave the following approximations:

Year	Population of Kenya*	Estimate: % infected with Ascaris	Estimate: No. infected with Ascaris
1969 (census)	10,942,705	25%	2,736,000
1976 (projected)	13,900,000	25%	3,475,000
1981 (projected)	16,500,000	25%	4,125,000

*Figures for 1969 taken from Statistical Abstract 1973, Republic of Kenya, Central Bureau of Statistics, Ministry of Finance and Planning. Figures for 1976 and 1981 projected assuming population growth rate of 3.5% per annum.

If these estimates are reasonable, and the prevalence of ascariasis does not increase, then $3\frac{1}{2}$ million Kenyans are now infected with Ascaris and over 4 million may be infected by 1981.

2. Current expenditures for treatment and control

a. Health care system - patient care costs

Documented expenditures by the health care system itself can be divided into 2 categories: expenses for actual patient care, and expenses for anthelmintics themselves. Expenses for actual care of patients were estimated from the number of patients seen with Ascaris infection in all Kenyan government hospitals. Data were taken from the annual Returns of Diseases published by the Ministry of Health for 1960-1968. More recent returns are not available.

Approximately 2.0% of all outpatients and 0.5% of all inpatients in Kenyan government hospitals in the 1965-1968 period had a primary diagnosis of ascariasis. The percent of all hospital patients with *Ascaris* infection was obviously higher than this, but these figures were not available. *Ascaris* patients, as a percent of all patients with infectious and parasitic diseases, constituted approximately 8.0% of outpatients and 2.1-2.5% of inpatients (1965-1968). Ascariasis is increasing as a primary diagnosis, considering both percent of total outpatients (1960 - 1.0% vs. 1968 - 2.1%) and percent of outpatients with infectious or parasitic diseases (1962 - 5.5% vs. 1968 - 9.2%). This may be partly due to increasing accessibility of health services or to improved laboratory diagnoses. These trends imply that the health care system is going to be asked to take care of higher percentages of *Ascaris*-infected patients in the future. This may be especially true if control programs to halt the spread of infection are not successfully undertaken.

Costs for patient care of those whose primary diagnosis was *Ascaris* infection were estimated using actual number of out- and inpatients seen in 1966 and using projected figures for out- and inpatients for 1976. Projected figures assumed that the total number of outpatients and inpatients has increased since 1966 at approximately the same rate as the population of Kenya (3.5% per annum). Number of patients with *Ascaris* as a primary diagnosis was calculated 2 ways for outpatients for 1976: (a) assuming 1966 figures are still correct, e.g. 2.0% outpatients, and (b) assuming percent of patients has increased by one percentage point, to 3.0% in the last 10 years, as it did from 1960 to 1968. Cost per outpatient, excluding medication, was estimated at $0.50 U.S., while cost per inpatient was estimated at $5.00 U.S. per day times 7 days in hospital ($35 per inpatient). Since slightly over half of hospital facilities in Kenya are government hospitals and the other half are mission or private hospitals, this figure was then doubled to yield estimates for all of Kenya. Figures for mission hospitals were not included.

The estimates for number of outpatients treated at rural health centres and dispensaries were not available and are not considered in the estimations of total outpatients treated per year. Many Kenyans seek treatment from rural health centres. There were 1,484 health centres and dispensaries in Kenya in 1967; and the number has been expanding rapidly. Thus the estimates of costs of outpatient care here are likely to be much lower than actual figures.

Results of these estimates are shown in Table II. According to these figures, approximately $124,000 (994,000/=) was spent in all Kenyan hospitals in 1966 on patient care for those whose primary diagnosis was <u>Ascaris</u> infection. These costs were likely to have risen to as much as $180,000 (1,440,000/=) in 1976. These figures do not include costs of surgery for intestinal obstruction or other complications of <u>Ascaris</u>. No estimate has been made of the prevalence or cost of respiratory disease resulting from <u>Ascaris</u> as it migrates through the lungs. A large proportion of respiratory disease may be due to this cause. Respiratory infections are one of the 4 main causes of child mortality in Kenyan hospitals (Grounds, 1964).

Table II. Estimates of patient care expenditures for *Ascaris*-infected patients, Kenya Government Hospitals and all Kenyan hospitals, 1966 and 1976.

Year	Total patients	Percent with Ascaris	No. with Ascaris	Government[1] Hospital cost $US	KS	All Hospitals cost $US	KS
A. Outpatients[2]							
1966	3,103,596	1.9	59,408	$29,704	237,632/=	$59,408	475,264/=
1976 (projected)	4,374,000	2.0	87,480	$43,740	349,920/=	$87,480	699,840/=
1976 (projected)	4,374,000	3.0	131,220	$65,610	524,880/=	$131,220	1,049,760/=
B. Inpatients							
1966	187,766	0.5	927	$32,445	259,560/=	$64,890	519,120/=
1976 (projected)	264,800	0.5	1,324	$46,340	370,720/=	$92,680	741,440/=
C. Outpatients and inpatients combined							
1966	3,291,362		60,335	$62,149	497,192/=	$124,298	994,384/=
1976 (assumes 2% of outpatients with *Ascaris*)	4,638,800		88,804	$90,080	720,640/=	$180,160	1,441,280/=

[1] Cost per outpatient used: $0.50 US
Cost per inpatient used: $35. US
$1 = approximately 8/= (Kenya shillings)

[2] Does not include outpatients treated at over 1500 rural health centres and dispensaries in Kenya.

Comparing these projections of patients treated in 1976 with estimated number of Kenyans infected with *Ascaris* in 1976 provided in the prevalence studies, one sees that only 2.6% of all cases of ascariasis in Kenya would be recorded as having a primary diagnosis of *Ascaris* infection. Even if 5 times that many hospital patients were not recorded as having a primary diagnosis of *Ascaris* but were treated for the infection in hospital, then still over 85% of cases of *Ascaris* in Kenya would not be treated in hospital facilities. This leaves several million cases untreated to spread the infection to future hospital patients.

	Estimated number of *Ascaris*-infected persons in Kenya	Estimated number treated at hospitals*	Estimated percent treated (primary diagnosis)
1976	3,475,000	88,804	2.6%

* with primary diagnosis of *Ascaris*.

b. Health care system - cost of anthelmintics

The second major and quantifiable health care system expenditure caused by *Ascaris* infection is cost of anthelmintic medications prescribed by hospitals and physicians. There are 11 preparations effective in treatment of ascariasis available to physicians in Kenya (African Mims, 1975). Eight "traditional" anthelmintics, almost all piperazine based, have been available for over 20 years. They are cheap, effective, and have a low incidence of side effects. Unfortunately, few are useful in cases of mixed infections unless *Enterobius vermicularis*, an annoying but relatively harmless parasite, is present. The three recently developed "broad-spectrum" anthelmintics are all very effective in *Ascaris* treatment and will also lower a host's burden of hookworms and/or Trichuris and/or Strongyloides. Levamisole and pyrantel pamoate have a relatively low incidence of side effects and have been used in mass treatment programs. Most drugs act only on worms present in the gut. Thiabendazole is one compound which kills larvae migrating in the internal organs of the body, as well as worms in the gut. Thiabendazole does have a relatively high incidence of unpleasant side effects. All the broad spectrum drugs are more expensive per dose than piperazine compounds.

Estimates of expenditures by the health care system on anti-Ascaris anthelmintic drugs were made by the author from records of purchases by 2 main outlets for hospital drugs for fiscal year 1975-76. The first, Central Medical Stores, stocks scheduled drugs available for purchase by all government and mission hospitals located outside the Nairobi area. It does not sell to private doctors or private hospitals, nor does it necessarily supply all anthelmintics used by mission hospitals. Central Medical Stores purchased \$125,000 (995,000/=) worth of drugs effective in treatment of Ascaris infection in fiscal years 1975-76 (Nanusi, personal communication). Seventy-five percent of these purchases were for piperazine.

The second major purchaser of hospital drugs in Kenya is the Hospital Pharmacy at Kenyatta National Hospital in Nairobi. It purchased \$2,600 (21,000/=) worth of anti-Ascaris drugs in fiscal 1975-76 (Haria, personal communication). The total of these two figures was arbitrarily increased by 25% to cover anthelmintics used by private practitioners and hospitals plus some mission hospitals. The total spent in fiscal 1975-76 on anti-Ascaris anthelmintics then comes to \$160,000 (1,275,000/=).

c. Private citizens - retail purchase of anthelmintics

The total expenditure on *Ascaris* infection by the health care system (excluding rural health centres and dispensaries) has been documented above. A second cost of *Ascaris* is the cash expenditure by the families in which infections occur, and the cost of work time, travel, and lost nutrients. Such "costs" of *Ascaris* were estimated as follows:

(1) purchase of anthelmintics in retail stores,

(2) work time lost, travel expenses for trips to hospitals,

(3) food that is eaten but unabsorbed by the host due to the interference of *Ascaris* infection.

Each of these three items will be discussed separately. The authors tried to obtain information on the quantity of anthelmintic drugs sold to retail stores in Kenya by writing to the manufacturers. The results of this exercise were not usable because of incomplete responses. The other approaches used were to determine availability and price of drugs by going to small retail stores in different areas and to ask selected samples of mothers whether or not they bought anthelmintics for their children. The results of the rather limited survey of stores indicates that anti-*Ascaris* drugs, both piperazine compounds and broad-spectrum compounds, are widely available in the local retail stores or dukas in many parts of Kenya. Store surveys were conducted in 3 major areas: Machakos District, Eastern Province; in the City of Nairobi; and in Western Kenya, in both Western and Nyanza Provinces. A number of important conclusions concerning availability of anthelmintics emerged:

1. Both piperazine-based and broad-spectrum anthelmintics seem to be easily available to families in all of these areas. All stores visited at random stock at least one anti-Ascaris drug; some in Western Kenya were reported to stock up to 6 different brand names.

2. Prices of the same medicine differ considerably from one store to another, even within the same area.

3. Price per dose varies markedly between drugs. The price differences between piperazine and broad-spectrum drugs in shops is less than that of the wholesale or bulk prices to hospitals of these compounds. Piperazine tablets are not necessarily cheaper than are levamisole tablets in some shops in Western Kenya. Both are sold for approximately -/50 or $.06 US each, whereas Central Medical Stores buys piperazine for -/04 or $.005 US per tablet compared to retail bulk prices for levamisole of about -/40 or $.05 US per tablet.

4. It is disturbing that some of the medicines available in retail stores are either outmoded, or considered too toxic for modern hospital use. Others are sold unlabelled and some go by names not listed in the African pharmacopoeia.

Information on actual purchases of anthelmintics was obtained by asking mothers in 2 densely populated areas of Kenya (Western Kenya and Machakos District) what they did to treat roundworm infection (or when their child passed a "roundworm" or Ascaris in his stool). Results showed that anti-Ascaris drugs are commonly purchased in retail stores. Thirty percent of 363 preschool children in the Ascaris growth study in Machakos District had received at least one dose of worm medicine in their lives. The facts that 27% of these same children had stools positive for Ascaris ova at one point in time and that

38% had been known to pass a roundworm in their stools previously, imply that most mothers respond to worms passed by buying an anti-*Ascaris* drug, which is easily available at a local store. It is important to note that the percent of people in a group infected with *Ascaris* is likely to be a good deal higher than the percent who actually pass a worm in their stools in a given year. The worms live for 1-2 years and may not pass out of the body until they die. When mothers of lower socioeconomic status in Western and Nyanza Provinces were asked what they did for *Ascaris* infection, 11 of 13 (85%) said they bought "modern" (manufactured) medicine from the local store.

Rough estimates of the percent of the Kenyan population purchasing anthelmintics and total retail costs of these in a given year were made as follows. It was assumed that 15% of all Kenyan preschool children, 10% of school-aged children, and 5% of adults purchase 1 dose or tablet of an anti-*Ascaris* anthelmintic each year. It was further assumed that the dose purchased increases with age, so that each preschool child receives one tablet, each school child receives 2 tablets, and each adult receives 3 tablets. (These are in fact the approximate recommended doses for levamisole.) This means 15% of the total population of Kenya would receive 1 tablet per year. Total expenditures on anthelmintics are calculated, both for 1969 and 1976, assuming retail price per tablet to be 0/75 ($.09 US). This figure is half way between the two most commonly quoted prices of 0/50 and 1/00. These assumptions reveal the following estimations:

Year	Population of Kenya	X 15% (one tab./year)	Total cost per year 0/75 per tablet KS	US$
1969 (census)	10,942,705	1,641,406	1,231,045/=	$153,882
1976 (projected)	13,900,000	2,085,000	1,563,750/=	$195,469

Thus it seems likely that Kenyans spent about $195,000 (1,560,000/=) in 1976 on purchases of anti-Ascaris anthelmintics. If routine deworming programs were available to Kenyans, these costs could essentially disappear.

d. Private citizens - work time lost and travel expenses

Other important expenses incurred by private citizens infected with Ascaris who seek treatment in health care facilities are time lost from work and cost of transport from home to the hospital. Reasonable minimum estimation of the magnitudes of these losses can be made by considering number of patients treated for Ascaris, a representative wage for unskilled work in Kenya, and feasible costs for transport. These estimations were made for outpatients and inpatients (at government hospitals only) whose primary diagnosis was ascariasis for 1966 and 1976. For outpatients, it was assumed that each outpatient lost 1/2 a day of work by coming to a hospital for treatment. If the outpatient was a child, still the adult accompanying the child would lose work time. For inpatients, it was assumed that 1/2 of the patients were adults and suffered 7 days work loss by being in the hospital. The minimum wage figure used was 7/= ($0.88 US) per day, which applied only to unskilled laborers.

Transport costs were taken from a survey of costs at a Ugandan district hospital and quoted by Maurice King in Medical Care in

Developing Countries (1966). This survey showed that an average outpatient spent 2/50 ($0.35) and an average inpatient spent 7/80 ($1.09) in getting to the district hospital. These figures are then doubled to give transport costs both to and from the hospital. These figures are over ten years old and, because of inflation, are likely to be underestimates. The availability and costs of transport in more densely populated areas of Uganda and Kenya were quite similar in the mid 1960's.

Estimates using number of patients from the Return of Diseases for government hospitals were then doubled to yield figures for all Kenyan hospitals because about half the hospitals are non-government. These figures do not include visits to rural health centres or dispensaries and clearly underestimate number of patients treated in Kenya. Results of these computations are presented in Table III. Thus Kenyans with a primary diagnosis of ascariasis were estimated to have lost or spent $199,000 (1,600,000/=) in 1976 as a result of work not done and transport costs to the hospital.

e. Private citizens - total food unabsorbed

A third important loss suffered by Kenyans infected with Ascaris is the loss to their bodies of nutrients not properly absorbed due to the presence of Ascaris. Workers in India and Colombia have found that Ascaris infection caused decreased absorption of protein, fat, and carbohydrate in children that reverted to normal soon after children were dewormed (Venkatachalam and Patwardhan, 1953; Tripathy et al., 1971, 1972). These changes occurred even in children with relatively light Ascaris loads (10-40 worms per child). It is

Table III. Estimates of work loss and transport costs incurred by *Ascaris*-infected patients, Kenya Government Hospitals and All Kenyan Hospitals, 1966 and 1976.

Year	No. with Ascaris	Estimated adults with Ascaris (50%)	Work loss	Transport costs:	Cost Government hospitals KS	Cost Government hospitals US$	Cost all hospitals KS	Cost all hospitals US$
A. Inpatients			49/= per patient	15/60 per patient				
1966	927	464	22,736/=	14,461/=	37,197/=	$ 4,650	74,394/=	$ 9,299
1976 (projected)	1,324	662	32,438/=	20,654/=	53,092/=	$ 6,636	106,184/=	$ 13,273
B. Outpatients[1]			Work loss (3/50 per patient)	5/= per patient				
1966	59,408	-	207,928/=	297,040/=	504,968/=	$63,121	1,009,936/=	$126,242
1976 (projected)	87,480	-	306,180/=	437,400/=	743,580/=	$92,948	1,487,160/=	$185,895
C. Outpatients and Inpatients Combined[1]								
1966			230,664/=	311,501/=	542,165/=	$67,771	1,084,330/=	$135,541
1976 (projected)			338,618/=	458,054/=	796,672/=	$99,584	1,593,344/=	$199,168

[1] Patients attending rural health centres and dispensaries are not included in these estimates.

important to remember that nutrients consumed by an infected person but not properly utilized due to the presence of Ascaris are essentially wasted. In areas like Kenya, where protein calorie malnutrition is widespread, these food losses take on special importance.

The previous studies mentioned suggest that all 3 macronutrients are significantly less well absorbed in ascariasis which indicates a decrease in total calories absorbed. Simple estimations of total food losses were made from the studies of fat and carbohydrate absorption in 7 Colombian children with heavy loads of Ascaris (mean of 66 worms per child). Tripathy et al. (1971, 1972) stated that malabsorption of fat occurred in their Ascaris infected subjects, which was equal to 5% of total calories consumed. They also showed that carbohydrate absorption, using d-xylose as a test carbohydrate, was only about 70% as high while children harbored worms compared to absorption of the same compound after deworming. The typical Kenyan diet, being high in starchy foods, is likely to derive about 70% of total calories from carbohydrate, 15% from fat, and 15% from protein. If 30% of carbohydrate calories are lost due to infection with 66 worms, then approximately 21% of the total caloric intake is lost due to non-absorption of carbohydrate. Then in children with a heavy load of 66 worms, 26% of total calories are lost due to heavy worm infection (5% of dietary calories lost as fat plus 21% lost as carbohydrate).

The average worm burden in all infected persons in Kenya is unknown but is very likely to be much lower than 66 worms per person. We assume that 7 worms per person, the figure we found in infected children in Machakos, is a realistic figure for the average Ascaris infected Kenyan. If we then assume that the percent of calories lost is proportional to size of worm burden, the average Kenyan with 7 worms would lose 2.8% of total calories per day due to lack of absorption.

Total calorie intakes in Ascaris-infected persons were estimated using the 1974 Recommended Dietary Allowances of the NAS-NRC, for specific age groups. It was assumed that one-half of Ascaris-infected Kenyans are children aged 0-15 years and that their mean age is 7.5 years; their daily RDA for calories is 2,400. The other half of Ascaris-infected Kenyans, who are over 15 years of age, are assumed to have a mean age between 23 and 50 years and to be 1/2 males, 1/2 females, with 1/3 of the females either presently pregnant or lactating. Then the daily RDA for this second group is also approximately 2,400 calories. From this estimate of total calorie intake per day was calculated the yearly consumption and loss of calories by infected Kenyans.

Total calories lost were converted to total food loss by assuming that the average Kenyan receives 75% of his food by weight from the most common staple food, maize meal, which cost KS 1/20 ($0.15 US) per kilogram in 1976. The other 25% of food was assumed to come from foods that cost twice as much per kilogram as does maize meal (e.g. beans, milk, meat, vegetables). It was further assumed that these other foods together supply the same number of calories per kilogram as does maize meal. The total retail value of the unabsorbed food was then determined. Step-by-step calculations are presented in Table IV. These estimations suggest that as many as 23,500,000 kg

Table IV. Estimation of total food loss due to lack of absorption in *Ascaris*-infected Kenyans, 1976.

Theoretical calorie intake per day for an average Kenyan[1]		Estimate of number of Kenyans infected with *Ascaris*, 1976[2]		Total calorie intake per day of *Ascaris*-infected Kenyans		Total calories lost per day due to *Ascaris* infection in Kenya			
2,400 Kcal	X	3,475,000	=	8,340,000,000 Kcal	X 2.8%	233,520,000 Kcal	÷	3,620 Kcal/kg maize meal[3]	=

Total kg of food unabsorbed per day due to *Ascaris*				Total kg food unabsorbed per year due to *Ascaris*		Cost of 1/50 per kg of food[4] (75% costs 1/20 25% costs 2/40)		Total retail value of food unabsorbed per year due to *Ascaris*	Per capita retail value of food unabsorbed per year due to *Ascaris*, infected Kenyans only
64,508 kg	X	365 days per year	=	23,545,420 kg	X		=	35,318,130/= $4,414,766	10/16 $1.27

[1]Recommended Dietary Allowances, 1974

[2]Estimated in earlier section

[3]Maize meal, 96% extraction, B. S. Platt, Tables of Representative Values of Foods Commonly Used in Tropical Countries, MRC special report series no. 302, London: H. M. Stationery Office, 1962.

[4]Retail price of commercial maize meal, 1976

of food per year are consumed but not utilized by Ascaris-infected Kenyans. The total retail value of this lost food is an estimated $4,400,000 (35,300,000/=).

Two points must be considered in these figures. Firstly, it must be remembered that this calculation does not include protein losses, which can also be substantial but are much harder to quantify in dollar terms. Venkatachalam and Patwardhan (1953) estimated that deworming of 9 children with an average load of 26 worms per child allowed an increased absorption of 3.5 grams of protein per day. If protein intakes are low or if dietary protein is not well balanced, this difference can be very important. Secondly, these calculations refer to a relatively lightly infected population. In places where mean worm burdens are higher, calorie losses may also be higher. Higher average worm burdens and higher calorie losses are most likely to occur in crowded urban slums and in refugee camps without adequate sanitation. These are precisely the places where food may be hardest to come by (Brown, 1972).

f. Caloric value of skinfold losses

The most striking anthropometric change that occurred in the Ascaris-infected children in the authors' study in Kenya was the loss of skinfold thickness prior to deworming and the gain in skinfold thickness after deworming. The authors attempted to equate the loss of skinfold thickness seen with caloric value of the fat lost per day by the body.

The assumptions made were the following:

1. The triceps skinfold, calculated as a percent of standard

for age, is a representative measure of total body fat. Thus if a child's triceps skinfold thickness is 90% of standard, his body contains 90% of the standard fat content for age.

2. The total body fat of a non-obese preschool child is equal to approximately 20% of the child's weight. The following calculations were then made:

(1) The Ascaris-infected children weighed an average of 12.5 kg at Visit I, and their skinfold thickness as a percent of standard for age was 99.8 or 100%. The total fat content of the average body would then be 12.5 kg x 20% or 2.50 kg of total body fat.

(2) Between Visits I and II, the Ascaris-infected children lost 15.6% of skinfold thickness, while the control children gained 3.5 percentage points. The net loss in percent skinfold in the Ascaris-infected children was then 15.1 + 3.5 or 19.1%.

(3) The actual loss of body fat in the Ascaris-infected children would then be 2.50 kg total body fat x 19.1% or 0.48 kg of fat lost.

(4) The calorie equivalent of this fat loss is 0.48 kg x 9000 kcal/kg of body fat or 4320 kcal.

(5) This loss of calorie stores occurred over a duration of 14-1/2 weeks or 102 days. The daily loss of fat reserves was then 4320 kcal ÷ 102 days or 42 kcal lost per day.

(6) The theoretical calorie requirement for children of this age group (1-6 yr) is 1550 kcal/day (Recommended Dietary Allowances of the NAS-NRC, 1974). The percent of dietary calories lost per day due to Ascaris infection was 42 kcal/day ÷ 1550 kcal/day or 2.7% of calories lost per day. This figure of 2.7% of calories lost agrees

extremely well with the estimation of 2.8% of calories lost, calculated in the previous section from the studies by Tripathy et al. It is timely to re-emphasize that this figure of 2.7-2.8% calorie losses refers only to people with average worm burdens on the order of 7 worms per person.

Table V presents a summary of total estimated costs to Kenya of ascariasis for 1976. The total expenditures incurred by hospital facilities and families due to ascariasis come to over $5,000,000 in a single year.

3. Feasible programs to control ascariasis

The design and execution of a successful program to control ascariasis is dependent first on there being public concern and awareness of the problem and secondly on there being a feasible and acceptable method of control.

a. Current beliefs and practices

An "Opinions About Worms" questionnaire was used by the authors in Kenya to collect information about mothers' experiences with *Ascaris* infection and also about latrine usage. The questionnaire was administered to 180 mothers of 309 preschool children in Machakos District and to 13 poor mothers of 84 children of all ages in Western Kenya. Responses to the questions for Machakos District are shown in Table VI and reveal a number of important facts:

(1) Most mothers in these areas where *Ascaris* is endemic recognize the parasite on sight and have definite beliefs about what it does to their children. Sixty to ninety percent of mothers in each area studied say that *Ascaris* retards the growth and health of their children. No mother questioned believed that *Ascaris* was benign or beneficial.

Table V. Estimated costs of ascariasis in Kenya, based on 25% prevalence, 1976.[1]

Category	Cost KS	Cost US$
A. Health care system - all Kenyan hospitals		
1. Patient care*	1,441,280	180,160
2. Drugs	1,275,705	159,462
Subtotal	2,716,985	339,622
B. Family costs		
1. Retail purchase of drugs	1,563,750	195,469
2. Lost wages, transport*	1,593,344	199,168
3. Food unabsorbed	35,318,130	4,414,766
Subtotal	38,475,224	4,809,403
Total Cost	41,192,209	5,149,025
Per capita cost, *Ascaris*-infected Kenyans only[1]	11/85	$1.48

[1]Estimated number of Kenyans infected with *Ascaris* in 1976 is 3,475,000.
*Does not include patients attending rural health centres and dispensaries.

Table VI. Answers to "Opinions About Worms" questionnaire by mothers of preschool children, 1976.

Question: Where does this child defecate most frequently?

Response:	Children No.	Children %
1. in latrine	147	47.6
2. diaper ("nappie")	10	3.2
3. outside, pieces put in latrine	68	22.0
4. outside, not near house	17	5.5
5. in yard near house	67	21.7
Total	309	100.0

Question: How do children get worms?

Response:	Mothers No.	Mothers %
1. don't know	73	40.6
2. from "eating soil"	42	23.3
3. from "soil"	51	28.3
4. from pregnant mother eating soil	5	2.8
5. from contaminated food	4	2.2
6. from rotten or green food (mangoes)	5	2.8
Total	180	100.0

Question: How does having worms affect the child? (open-ended responses divided into 4 categories)

Responses relating to:	Mothers No.	Mothers %
A. Activities of worms in the body		
1. none mentioned	135	75.0
2. worms eat child's food	28	15.6
3. worms eat child's blood	9	5.0
4. worms eat child's food and blood	4	2.2
5. worms can suffocate child (by vomit and aspiration of worm)	4	2.2
Total	180	100.0
B. Worm effects on child's appetite		
1. none mentioned	166	92.2
2. decrease appetite	4	2.2
3. increase appetite	10	5.6
Total	180	100.0
C. Worm effects on stomach itself		
1. none mentioned	115	63.9
2. cause stomach ache or trouble	44	24.4
3. cause stomach or body to swell	19	10.6
4. "harm intestines"	2	1.1
Total	180	100.0

(continued)

Table VI continued

	Mothers No.	Mothers %
D. Worm effects on general growth, health		
1. none mentioned	72	40.0
2. growth slows	49	27.2
3. grows weak	45	25.0
4. make child sick	13	7.2
5. make child get other diseases	1	0.6
Total	180	100.0

(2) Most mothers in both areas will take steps themselves to rid their children of obvious Ascaris infection, either through purchase of anthelmintics at retail stores or by taking the child to a health care facility. Both these measures require time and expense on the mother's part. Thus control of Ascaris is clearly a "felt need" of people in these areas.

(3) Health education concerning transmission of Ascaris is desirable in both areas of Kenya. In Machakos, 40% of mothers said they did not know how children got Ascaris; 50% correctly said they came from "soil" or "eating soil." In Western Kenya, 5 of 13 mothers thought children could "inherit" Ascaris from an infected pregnant mother.

(4) Latrines are available in most households in both areas surveyed. High percentages of children in both areas use the latrine, e.g. 83% of children of all ages in the Western Kenya survey were reported to defecate in the latrine and 70% of preschool children in the Machakos survey either use the latrine or the child defecates in the yard and the pieces are carried to the latrine. In both Machakos and Western Kenya, there were indications that the younger preschool children (1-2 years) often did not use the latrine even though one was available and was used by the older family members. Some mothers in Machakos indicated that they felt their youngest toddlers were "too young to use the latrine." This is an important point in terms of spread of infection since toddlers, who spend more time crawling and sitting on the ground and tend to put many objects in their mouths, are (a) more likely to contract heavier loads of intestinal helminths

which in turn produce higher amounts of worm ova in the stools, and (b) more likely to spread the infection by defecating on the ground that all family members come into contact with.

b. Control approaches

It seems clear from the foregoing discussion that programs to control ascariasis are desirable for the health of Kenyans and that they are desired by Kenyans. Control refers to reducing the percent of Kenyans infected and to lowering worm burdens in individuals. This is especially important for the most nutritionally vulnerable groups, i.e., preschool children and pregnant and lactating women.

The two methods most likely to help control ascariasis are:

(1) health education, to decrease further fecal contamination of the environment through proper feces disposal and to prevent ingestion of ova by encouraging food hygiene and thorough washing of hands before eating;

(2) drug treatment programs, to reduce number of ova in the stools which are not properly disposed of, to improve nutritional status of previously infected persons, and to encourage commitment of the people to proper feces disposal by showing that the health care system will do its part in decreasing prevalence of Ascaris.

c. Health education

It goes without saying that encouragement of latrine construction and use is important in long-term control of ascariasis and the many other soil-transmitted infections. Kenya has made great headway in this regard and is to be congratulated for its many past and continuing efforts. However, in the short term, it is questionable whether increased usage of latrines <u>alone</u> can be expected to lower drastically the prevalence of <u>Ascaris</u>. The reasons for this are as follows:

(1) It appears that the people most likely not to use available latrines are the younger preschool children, who are simply too young to understand that feces spread disease and who may be physically and mentally too young to use properly the cement or earth pit latrines now available. Mothers can surely be encouraged to have their children learn to use the latrine as early as possible. But it is unrealistic to expect the average Kenyan mother with 2-3 preschool children, crops to cultivate, food to cook, water to fetch, and clothes to wash, to be able to make sure that <u>every</u> stool passed by her children every day ends up in a latrine. Feces disposal may be especially complicated since gastroenteritis is extremely common. Fecal contamination by these children cannot help but continue. This will become more serious as the number and percent of Kenyans under 5 years of age increases.

(2) The number of ova produced per day by one adult female <u>Ascaris</u> is huge. Thus only one contaminated stool that is passed in the yard contains enough ova to theoretically infect an entire village for years. One adult female <u>Ascaris</u> may produce about 200,000 ova per day, and each ovum, if embryonated and swallowed by a human, can produce one adult worm. Ova are extremely hardy and can survive for more than a year in the soil, if not destroyed by sunlight, radiation, or dessication. If one young child harbors only 10 adult worms, 5 of which are female, the number of ova passed in his stools per day is on the order of 1,000,000, and yearly ova output is about 365,000,000. Thus even if all older family members religiously use a latrine and

the youngest preschool child uses the latrine at least 90% of the time, that one child, if only lightly infected, can deposit up to 36,500,000 Ascaris ova per year in the soil around the family dwelling. These ova can obviously be spread from dwelling to dwelling by movement of animals or people or possibly by wind and rain, or on contaminated food. So even if availability and use of latrines becomes near perfect, Ascaris ova will remain in large numbers in the environment. This is also true for the other soil transmitted helminths, although their reproductive capacities are much lower per worm than is that of Ascaris.

The other health education technique that can be used to prevent Ascaris infection is to promote thorough hand washing before eating. This is already being done, yet Ascaris survives. There are two difficulties that interfere with this practice. One is that large quantities of clean water are simply not available to families in many parts of Kenya. Great progress is being made in this regard, but development is a slow process and it is likely that many Kenyans will still not have adequate access to clean water 10 years from now. The second problem again centers on the young preschool child. Even when access to water is no problem, it is at best difficult to convince very young children that they should not put unwashed hands in their mouths.

Thus, despite Kenya's many efforts to improve health knowledge, sanitation, and health care, Ascaris is still very prevalent and, because of its ubiquitous nature, very likely to persist or even increase in prevalence. Substantial improvements in education, housing, sanitation, and the economic situation are being made in Kenya, but these improvements are unlikely to occur fast enough to stay or decrease the prevalence of soil-transmitted helminths in general, and _Ascaris_ in particular, in the next 10 years. This is especially true if the only weapons used against _Ascaris_ are health education and symptomatic treatment after diagnosis in hospitals.

d. Drug treatment programs

Given that significant fecal contamination of the environment is destined to continue, the remaining approach to decrease ascariasis is to decrease the likelihood that those feces contain _Ascaris_ ova. This can be done by periodic mass anthelmintic treatment of persons in areas where _Ascaris_ is prevalent. In the past, anthelmintic drugs, especially the more toxic ones, have only been given to a person after a stool examination has shown which parasites the person has. Recent development of less toxic drugs, coupled with the realization that most _Ascaris_ infested persons never get a stool examination and hence never receive drug treatment, has caused a number of physicians to suggest mass treatment programs as an alternative (Brown, 1972). In mass treatment, an anthelmintic is periodically given to all persons in a vulnerable group in an area where certain parasites are known to be common. This approach has important medical and economic advantages over other methods of control:

(1) time and cost of stool examinations are saved,

(2) for the same amount of money, many more persons can be treated than is possible in conventional health care facilities

(3) the person administering the drug needs very little if any genuine medical training,

(4) prevention and cure in one delivery system are combined in that present effects of the disease are temporarily arrested and fecal contamination is temporarily halted in all infected persons.

This mass treatment approach is likely to be the only way significantly and economically to decrease Ascaris infection and prevalence of 3 other soil transmitted helminths in Kenya within the next 10 years.

The three main components of a mass treatment program are (1) choice of target groups, (2) choice of drug, and (3) choice of delivery system.

Regarding target groups, it seems that preschool children in the densely populated areas of Kenya are the most likely to suffer from effects of ascariasis and are also most likely to promote transmission of the disease to others. Hence they probably require frequent deworming, perhaps 2-3 times per year at the outset. Prevalence surveys also show that Ascaris and other soil-transmitted helminths are prevalent in school-aged children and adults. They too should receive routine anthelmintic therapy, although less often than preschoolers, e.g. once per year or every 2 years.

Regarding choice of drug, one can either opt for the traditional less expensive piperazine compounds, or one can choose the more expensive broad spectrum anthelmintics. The authors feel that the preferable choice for Kenya is a broad-spectrum type drug for a number of reasons:

(1) Prevalence studies show that the soil-transmitted helminths

tend to co-exist in the densely populated areas of Kenya. Cases of multiple parasites are often common. If one is going to treat and help prevent Ascaris, one might as well also be treating and helping prevent hookworm, Trichuris, and Strongyloides at the same time. This cannot be done using piperazine compounds alone.

(2) The major difficulty and a significant proportion of the cost of a mass treatment program is likely to be choice and development of the delivery system, rather than choice and purchase of drugs. It is sensible to combat all 4 soil-transmitted helminths with a single delivery system.

(3) Although the cost per dose of the broad-spectrum anthelmintics is greater than the cost of piperazine compounds, the cost per dose of bephenium, used in treatment of hookworm, is greater than the cost per dose of levamisole, a broad spectrum drug that is reported to lower individual worm burdens of hookworm, Trichuris and Strongyloides as well as virtually eliminating Ascaris. In the long run, it is probably cheaper to treat and prevent all 4 diseases at once than to deal with them separately.

An estimation of drug costs for a mass treatment program for the whole of Kenya was prepared for 1976, making the following assumptions:

1. The drug of choice is levamisole. Its retail bulk price per tablet in Kenya from a large local pharmacy in 1976 was -/40 ($.05 US). It is assumed that levamisole could be obtained for a program of this size at a price 30% lower, or -/28 ($.035 US) per tablet.

2. It is assumed that the population of Kenya in 1976 was approximately 13,900,000 with the proportion falling in each age group similar to that in the 1969 census, i.e. 15% 1-4 years of age, 29% 5-14 years of age, and 52% 16 years of age and over.

3. Concerning dosage, children 1-4 years receive 1 tablet 2 times per year, children 5-14 receive 2 tablets once a year, and persons 15 years and over receive 3 tablets once every 2 years. Children under 12 months of age are not treated. Results of the computations are:

Age group	Estimated no. of Kenyans, 1976	Cost per person per year (-/28 per tablet)	Total drug cost per year KS	US$
1-4 yr	1,946,000	0/56	1,089,760/=	$136,220
5-14 yr	4,031,000	0/56	2,257,360/=	$282,170
15+	7,228,000	0/42	3,035,760/=	$379,470
Total			6,382,880/=	$797,860

The total cost of drugs for this program, as described, would be approximately $800,000 using 1976 figures. It will be recalled that the estimated economic cost of ascariasis was over $5,000,000. Neither the total cost of the drug treatment program nor the total benefits to be derived from the program have been accurately estimated. The cost of the drug treatment program does not include cost of a delivery system. The benefits do not include full present costs of treating patients in Kenya's many rural health centres and dispensaries. This is likely to be higher than the figures included here for hospitals. The benefits also do not include possible substantial benefits for treatment of hookworm, <u>Trichuris</u>, and <u>Strongyloides</u> infections. Heavy hookworm infection has been shown to cause a decrease in productivity of unskilled adult workers by 15-20% (Basta and Churchill, 1974). This is not to mention decreased hospital and other treatment costs that could also be expected to occur with a routine deworming program.

Throughout the calculations of losses of food, time, money, etc. resulting from Ascaris, rather conservative figures have been used. Maximum losses calculated in terms of present dollar values might lead to a cost benefit ratio of 1 to 10 or more. This is without including the other very large benefits of simultaneously controlling other intestinal parasites which were not a part of the present study but which would be part of a future parasite control program.

The most difficult and potentially most costly part of an ascariasis control program is the delivery system. An ineffective delivery system ensures project failure. An overly expensive one saps scarce health care resources needed to combat diseases with higher mortality rates. A number of possible means for drug distribution were discussed with public health personnel in Kenya, and one approach, using primary schools as distribution points, is now being attempted in Kanzalu and Mwatati villages.

The first problem to consider is whether taking worm medicine routinely is desirable and acceptable to Kenyans. The authors' experiences with mothers and children in Machakos District and with adult male roadworkers in 2 other areas of Kenya indicate that people are generally aware of roundworms, don't care for them, and are more than happy to take anthelmintics, especially if provided free. Thus it appears that little if any initial consciousness-raising is needed for program acceptance.

The problem then becomes one of informing people about the distribution of the drug and making it available to them. Concerning information at the village level, local chiefs and school officials could easily inform villagers at local meetings that medicine will be distributed and why. Signs could also be posted in hospitals, dispensaries, health centres, and at the local retail stores (dukas) which are so common throughout the densely populated areas of Kenya. In urban areas, radio messages could be used as well, although these may be less likely to reach the poor who would benefit most from the program.

Concerning actual dispensing of drugs, the authors feel that local primary schools in Kenya offer great promise. Primary school education is strongly encouraged and desired, and most areas have a number of primary schools within walking distance of most homes. Education is basically free for the first 3 years, so that even poor children can and do attend. In addition, primary school officials are among the most respected members of a village. School children can be dewormed easily at school, since only 2-3 hours at most are needed for 1 person to treat over 300 children. Using the local school as a meeting place, school children can inform their mothers and preschool siblings to come to the primary school on a specific date to receive treatment.

In implementing a new program, it is desirable to work, whenever possible, within the existing health care system of a country. In this regard, presently employed local health inspectors, using existing transport, might take charge of distributing medication to primary schools. In heavily infected areas, routine deworming may also be advisable, especially for preschool children, at hospitals, outpatient clinics, health centres, and dispensaries.

The distribution system using primary schools is now being tested and seems quite promising. Such a program should be beneficial because it combines immediate relief of treatment with longer term prevention and control. Not only does treatment temporarily decrease fecal contamination with helminth ova and larvae, it also provides school teachers with tangible examples for classroom use of why environmental and personal hygiene is important for all members of a family.

IV. DISCUSSION AND CONCLUSIONS

The present economic study on costs of ascariasis in Kenya estimated conservatively that *Ascaris* infection was costing Kenyans about \$5,000,000 in 1976, while the price of a broad spectrum anthelmintic (excluding the delivery system), provided to all Kenyans would cost less than 1/5 of that or \$800,000. Thus not only is *Ascaris* infection detrimental to health and well-being of children; it can also be a very costly disease, and drugs that could effectively lower worm burdens are relatively inexpensive. Various possible delivery systems for anthelmintics can be used but will vary from country to country.

But is an attempt to control ascariasis using anthelmintic treatment worth the effort? Some would argue that it is not, since *Ascaris* infection is thought to be relatively harmless in most cases. This is simply not true, especially in preschool children in endemic areas. The results of the present nutritional study and of those cited in the review of the literature show that ascariasis is linked not only to poor growth and PCM but also to malabsorption of macronutrients and vitamin A. It is true that *Ascaris* infection alone is a less important cause of morbidity and mortality than are PCM, gastroenteritis, or respiratory infections. However, these latter diseases are much harder and much more expensive to prevent and to treat than is ascariasis. Also, there are strong indications that *Ascaris* infection aggravates both PCM and respiratory infections. A significant proportion of persons treated for respiratory complaints in developing countries may have these symptoms due to migration of parasites through the lungs.

Some practitioners feel that *Ascaris* infection is not worth treating in endemic areas unless environmental hygiene is simultaneously improved. Discussion was presented here to show that treatment of *Ascaris* infection is actually a form of prevention, in that deworming kills the ova-producing adult worms. It is probable that *Ascaris* and other intestinal helminths will in time virtually disappear from poor tropical areas with improvements in personal hygiene, increased latrine use, and greater availability of safe water supplies.

Suggestions for these improvements are all too easily and flippantly made, especially by those who are privileged and relatively affluent. But urban and rural development and the reduction of poverty are objectives which are difficult to achieve. The gap between rich and poor in the world continues to widen. More education, money, and services for the poor requires sustained commitment from the governments and the peoples concerned, and will be assisted by more international assistance, but will clearly take many years to achieve.

Such improvements will clearly not reach the estimated one billion *Ascaris*-infected people in the near future. We cannot afford to ignore common childhood diseases which are presently treatable and preventable, as Ascaris infection is, and which are increasing child morbidity and mortality and hence impeding economic and social development. We can no longer tell them to wait for a rise in the standard of living to solve their health problems.

Periodic deworming of all preschool age children in areas where Ascaris infection and PCM co-exist and are prevalent is highly desirable to help promote the health and the economic well-being of infected families and of future generations. The data presented here suggest that it would also be economic to do so.

Acknowledgements

This paper is published with the kind permission of Dr. E. N. Mngola, Director of Medical Services, Ministry of Health, Kenya.

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WORLD BANK / INTERNATIONAL FINANCE CORPORATION

File Kenya or chron, file...

OFFICE MEMORANDUM

TO: Mr. Emmerich M. Schebeck, Chief, AGRNU DATE: November 14, 1978

FROM: Samir S. Basta, Nutrition Expert, AGRNU

SUBJECT: Back-to-Office Report: University of California Workshop on Nutrient Intake, Work Output and Physical Activity, San Diego - Oct. 30-Nov. 3

1. The workshop dealt primarily with the relationship between energy intake, work output and the physical and mental performance that comprise several ranges of human activities. This was part of a series of workshops recently funded by a grant from the US Congress, addressing the overall question of the effects of food energy intake on the ability of individuals to function in their own societies. The meetings focused on (a) the effects of marginal rather than severe food energy restriction since mid-moderate malnutrition is widespread throughout the world and relatively few data exist on the consequences of this condition; (b) energy restriction rather than specific nutrient deficiencies was emphasized in light of the fact that research dealing with food energy deficits will necessarily entail consideration of the various nutrients - so the purpose was to focus on the more general problem of food energy intake. Seventeen participants from U.S. and foreign institutions took part (see annex).

2. Most of the earlier workshops did not debate whether or not a relationship exists between moderate malnutrition and the particular function, but accepted this as given for the purposes of the workshop and proceeded to discuss research approaches for the elucidation of the relationship. This workshop, however, discussed and recognized that while, obviously, severe energy deficits will curtail activities and that theoretically there should be effects of moderate restriction, there is still very little evidence for this as regards calories. The establishment of this relationship therefore figured into the research questions.

3. Another important issue was whether there is an effect of nutrition on productivity under different ecosystems, and if so if incremental changes in energy intake can become self-sustained by the populations in these systems. An important concern of some of the participants was that the workshop should not imply that the outcome of increased productivity by means of increased energy intake will always have beneficial results for all segment of a population (i.e. there may be negative economic, social and biological ramifications for the target groups as well as for non-target groups). The purpose of the workshop was also to plan ways of providing data as to whether incremental changes in energy intake will have observable effects on activity and work performance.

4. The other workshops addressed research ethics in a general way. The participants of this workshop felt that there were certain ethical questions specific to the topic of activity/work output. Consideration was to be given in the research design to possible negative ramifications of any actual productivity research project.

5. I chaired the group on field studies, and provided information from our various studies on nutrition and productivity to illustrate the importance of collecting sufficient background information on political, socio-cultural,

economic factors before starting any studies. I also made some reference to the need for standardizing laboratory equipment to actual field use. The participants expressed much interest in our earlier and ongoing studies and seemed to accept that because of these we had a more varied and practical experience to provide, than most universities and institutes (with the exception of Dr. Viteri's INCAP).

6. I also discussed with Dr. Latham his future work plan for our Kenya studies (RES 671-73). He provided me with a copy of a letter he had just sent us and in which he satisfactorily answered the points I had raised earlier in my October 15 letter to him.

7. Although an economist (C Bliss, Nuffield College, Oxford) took part in this workshop, the meeting would have benefitted from more economists or agricultural economists being present especially those dealing with national economic implications of reduced or increased productivity in different sectors. The meetings as such were therefore mainly oriented to answer methodological issues in work physiology - as such I found it rewarding, but a more multi-disciplinary representation would have been more beneficial.

8. It is worthwhile to stress again that the meeting revealed that there was to date no significant evidence to link marginal food (caloric) intakes to productivity. Indeed one participant (Dr. Katerina Borer) provided some evidence from her laboratory that marginally undernourished small mammals performed more efficiently in work output tests than controls fed recommended energy intakes. Obviously more research is needed, but policy makers should be aware of these controversies.

9. Individual and more detailed papers on each of these topics are on file in my office.

cc: Messrs. van der Tak, PAS
Yudelman, AGR
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Davis, AGR
Donaldson, AGR
Berg, AGR
Hamann, AGRNU
Greene, AGRNU
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King, DED
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ANNEX

PARTICIPANTS FOR WORKSHOP ON NUTRIENT INTAKE AND WORK OUTPUT AND PHYSICAL ACTIVITY

October 30 - November 3, 1978
La Jolla, California
(corrected version)

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EMS
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The World Bank / 1818 H Street, N.W., Washington, D.C. 20433, U.S.A. • Telephone: (202) 393-6360 • Cables: INTBAFRAD

November 8, 1978

Professor Michael C. Latham
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Dear Michael:

I saw Mark Sharrock and Andrew Chesher while passing through London ten days ago, and I have sent (under separate cover) the Kenya productivity data which Mark asked me to convey to you. I regret that through a misunderstanding a copy of these data earlier sent to me was not forwarded to you. This serves to underscore the sensibility of your suggestion that all future correspondence should be addressed to you, and copied to the Bank, with which we, of course, agree. Samir Basta will be the correspondent as well as chief spokesman for the Bank, but because the subject is one of deep personal interest to me and I may occasionally be able to assist somehow, I am asking that everyone send a copy of correspondence to me as well as a separate copy to Samir.

I have received your letters of October 11, 12, 16, 23 and 25 addressed to me and also your letter of October 27 to Samir. I have not had an opportunity to review these with Samir (nor am I likely to, given the extremely hectic nature of our calendars over the next two or three months), but from a hasty review it appears to me that you are sorting out matters very well by yourself. Let me record the following quick comments:

(1) We appreciate the spirit of mutual cooperation and will do our best to assist where we can without encumbering you with too much interference.

(2) After reflecting on your letters and my talks with Sharrock I am exploring ways and means of strengthening his effort this month by providing for an engineering assistant of proven ability and dependability through Scott Wilson.

(3) Although Andrew Chesher is always extremely effective, I doubt that the best use of his time is in the field in this case. Rather I would propose the following:

(i) In December (which is about as soon as he could get to it) Chesher should undertake statistical analyses of (a) the "before" data on a cross-sectional basis and (b) as soon as it is available (possibly also in December) the "after" data as well. Presumably Mark Sharrock will carry back to U.K. the needed anthropometric data as well as the productivity data.[1/]

(ii) You should spend possibly half a day (or a bit more) with Chesher and Sharrock in London on your way to Kenya in January. Andrew does need to have a better understanding of many complementary matters, e.g. the accuracy of measurements for caloric/dietary variables and anthropometric parameters compared to measures of productivity. He also has some comments on Mark Brooks' earlier analyses (copy enclosed herewith) which you may wish to discuss with him. I am sure further discussions will give Andrew a much better understanding of the different facets of the study.

(4) With respect to any further studies on productivity vs. calories, I am now virtually convinced that another road construction effort would be fruitless; unless Mark Sharrock should learn something new and much more promising, I think we should abandon the roads proposal in favor of an agricultural activity.

(5) I do hope that you would be able to identify an agricultural undertaking which would prove feasible for study within context of the present study and budget.

(6) If (5) should materialize, presumably Mark Sharrock would not be the appropriate person, and presumably you would want to get a specialist in agricultural work studies to setup and monitor the productivity studies. Possibly something could be worked out with the University of Nairobi, supplemented if necessary by a specialist from Cornell. I doubt that we would have any significant additional funds[2/] for this, but surely there is some scope for reallocation within the existing budget.

(7) Two separate, small points on your Inception Report (pp.20-22):

(i) Why was Road No. 7 selected for the part (a) study (bottom page 20)? According to Table 6, that site has only limited anemia incidence. Would not the Murram Quarry or better yet Road No. 3 be better for this particular study component?

1/ Let me reiterate that I am sympathetic to June Wolgomuth's interest in using her work in this project for a doctoral dissertation. I trust that Cornell University would not consider any analyses done by Chesher or others under the present project as preempting her claim to originality.

2/ We are however, prepared to reimburse you reasonable costs for repairs to the Range Rover, and I will shortly be sending you another letter on this matter. All operating costs and any insurance required (I am checking this out now) will, of course, have to come from your existing contract budget as originally provided.

(ii) The cold snack (group 1, pp. 21-22) is not only inferior nutritionally, it costs more and has lower worker receptivity -- thus we would never consider it in the real world. Some other more realistic diet alternatives should be considered.

I trust you may find some of these comments helpful, and the remainder hopefully are harmless. Do let us know (address to Samir with copy to me) what your intentions are as far as item (3) is concerned, as we will have to confirm arrangements soon for whatever amount of Chesher's time we want.

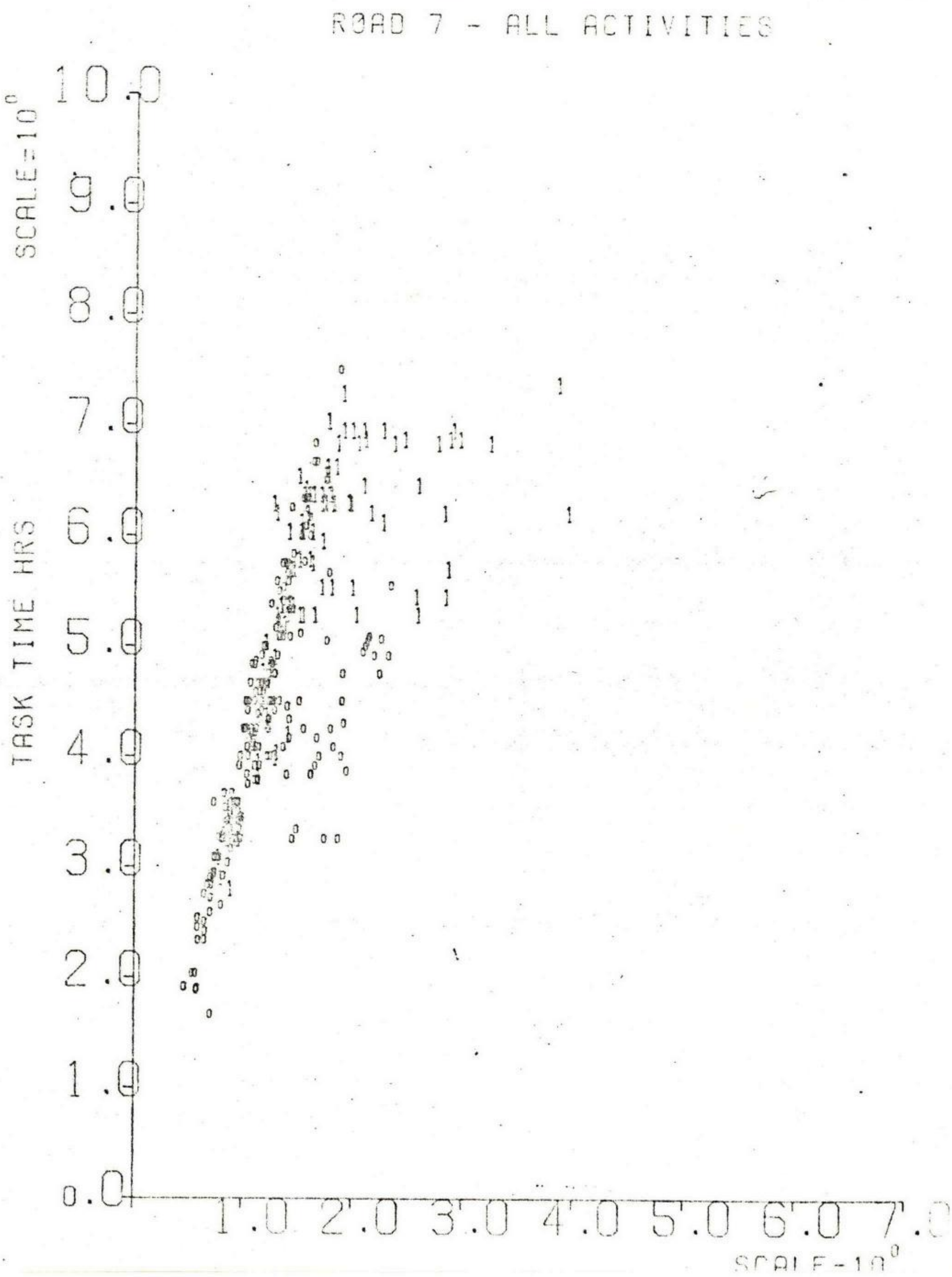
Sincerely yours,

Clell G. Harral
Highway Design & Maintenance Adviser
Transportation Department

CGHarral:phm

cc: Messrs. S. Basta, B. Coukis

SCOTT WILSON KIRKPATRICK & PARTNERS Consulting Civil & Structural Engineers Transportation & Environmental Planners	SKETCH		Job No	Sheet No GRAPH KHN	Revis
	Revision	Suffix			
		Date			
Date 15-OCT 79	Initials	Checked	Job		



FORM NO. 75
(9-78)

THE WORLD BANK

ROUTING SLIP	DATE: Nov. 7

NAME	ROOM NO.
~~Mr. Botta~~	
FILE	
KENYA	

	APPROPRIATE DISPOSITION		NOTE AND RETURN
	APPROVAL		NOTE AND SEND ON
	CLEARANCE		PER OUR CONVERSATION
	COMMENT		PER YOUR REQUEST
	FOR ACTION		PREPARE REPLY
✓	INFORMATION		RECOMMENDATION
	INITIAL		SIGNATURE
	NOTE AND FILE		**URGENT**

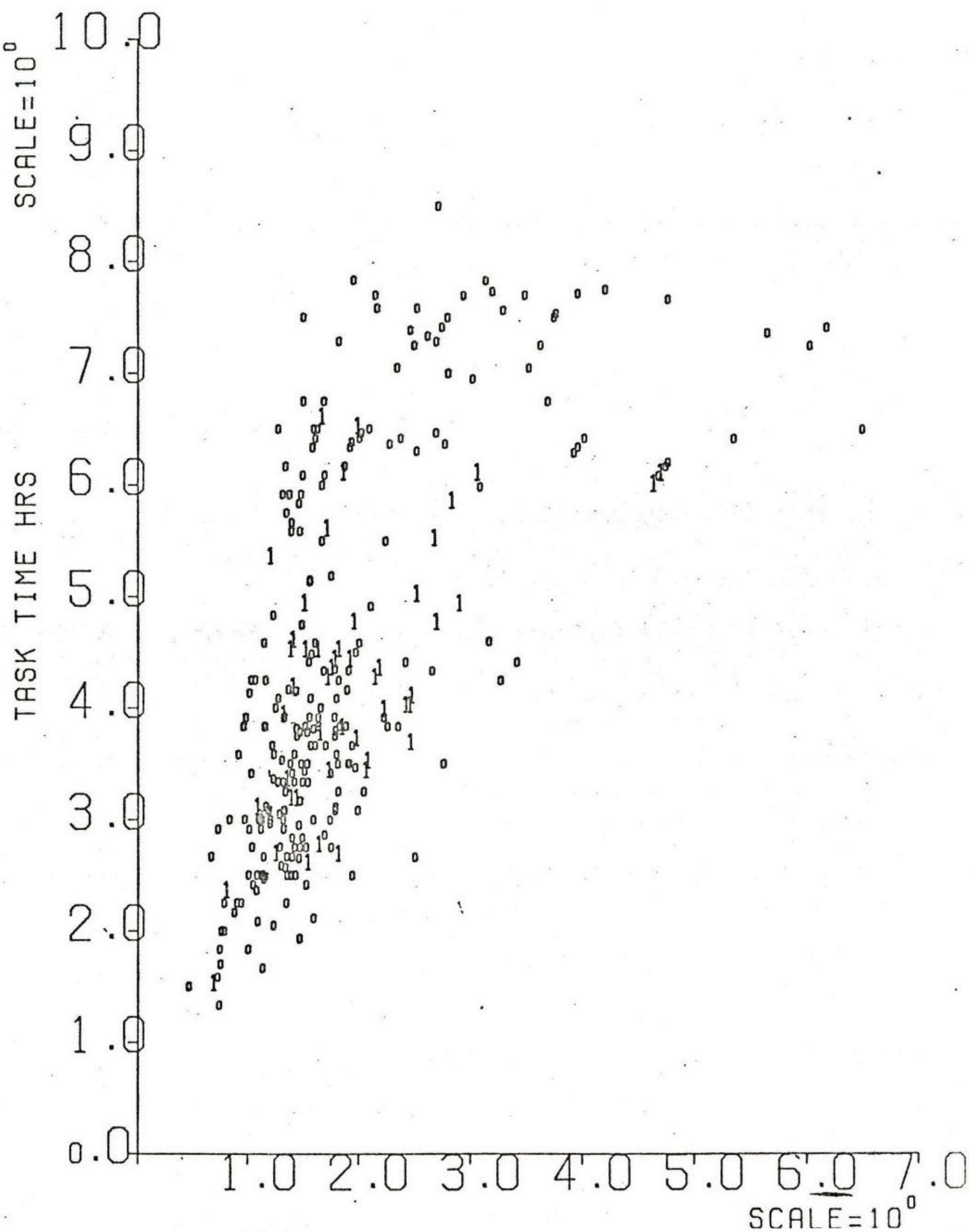
REMARKS:

FROM:	ROOM NO.:	EXTENSION:
C. Harral	E535	72097

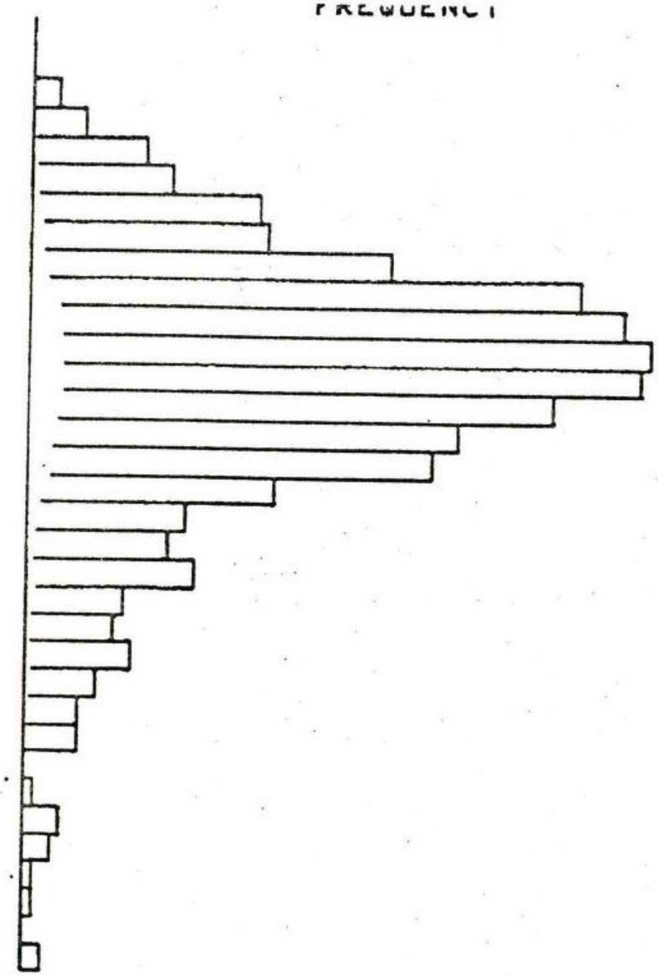
SCOTT WILSON KIRKPATRICK & PARTNERS Consulting Civil & Structural Engineers Transportation & Environmental Planners	SKETCH	Job No	Sheet No GRAPH KHN	Revision
	Revision	Suffix		
		Date		

Date	Initials	Checked	Job
18-OCT 78			

ROAD 12 - ALL ACTIVITIES



FREQUENCY

0	- ∞	0.0	
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3	.06250	.1250	
6	.1250	.1875	
13	.1875	.2500	
16	.2500	.3125	
26	.3125	.3750	
27	.3750	.4375	
41	.4375	.5000	
63	.5000	.5625	
68	.5625	.6250	
71	.6250	.6875	
70	.6875	.7500	
60	.7500	.8125	
49	.8125	.8750	
46	.8750	.9375	
28	.9375	1.000	
18	1.000	1.062	
16	1.062	1.125	
19	1.125	1.187	
11	1.187	1.250	
10	1.250	1.312	
12	1.312	1.375	
8	1.375	1.437	
6	1.437	1.500	
6	1.500	1.562	
0	1.562	1.625	
1	1.625	1.687	
4	1.687	1.750	
3	1.750	1.812	
1	1.812	1.875	
1	1.875	1.937	
0	1.937	2.000	
2	2.000	∞	

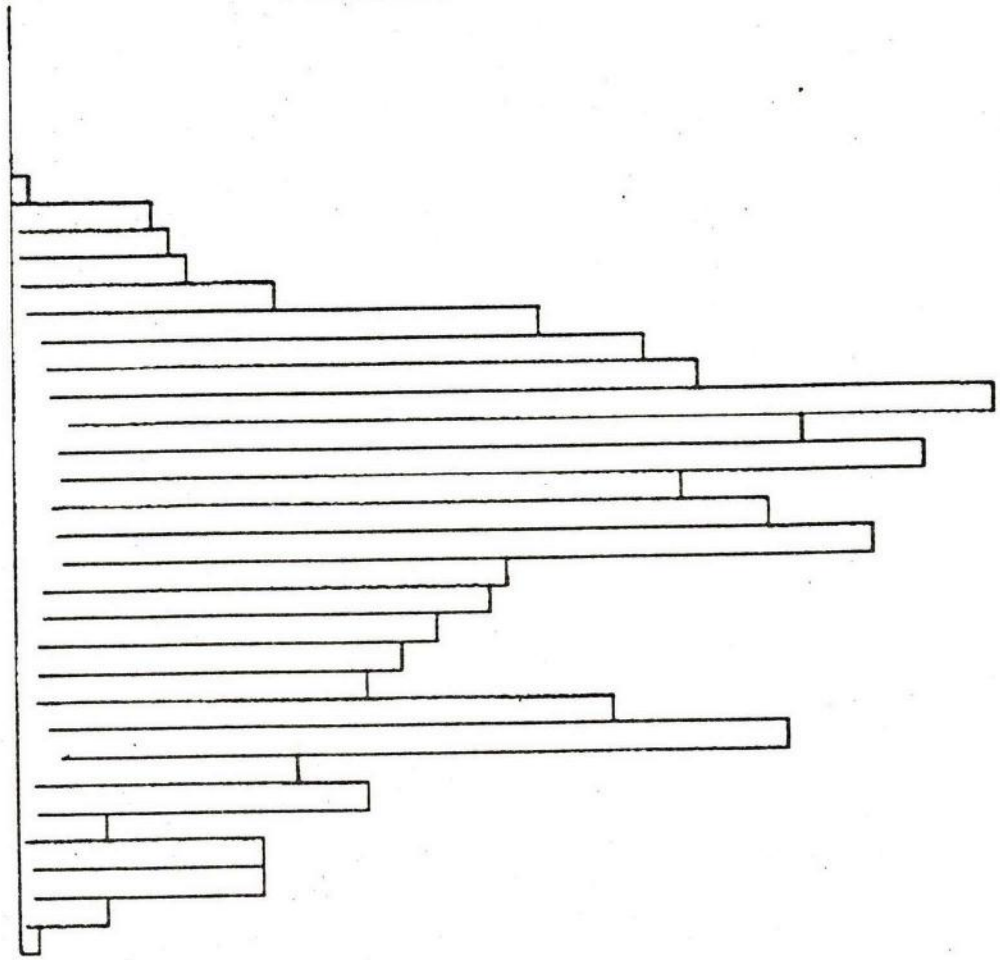
Both Roads
All Productivit

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1100	.1100
MAXIMUM	2.170	1.900
AVERAGE	.7479	.7439
STANDARD DEVIATION	.3153	.3067
NUMBER OF POINTS	705	703

$FINISHED?

FREQUENCY

Ø	- ∞	Ø.Ø	
Ø	Ø.Ø	.25ØØ	
Ø	.25ØØ	.5ØØØ	
Ø	.5ØØØ	.75ØØ	
Ø	.75ØØ	1.ØØØ	
Ø	1.ØØØ	1.25Ø	
1	1.25Ø	1.5ØØ	
8	1.5ØØ	1.75Ø	
9	1.75Ø	2.ØØØ	
1Ø	2.ØØØ	2.25Ø	
15	2.25Ø	2.5ØØ	
3Ø	2.5ØØ	2.75Ø	
36	2.75Ø	3.ØØØ	
39	3.ØØØ	3.25Ø	
56	3.25Ø	3.5ØØ	
45	3.5ØØ	3.75Ø	
52	3.75Ø	4.ØØØ	
38	4.ØØØ	4.25Ø	
43	4.25Ø	4.5ØØ	
49	4.5ØØ	4.75Ø	
28	4.75Ø	5.ØØØ	
27	5.ØØØ	5.25Ø	
24	5.25Ø	5.5ØØ	
22	5.5ØØ	5.75Ø	
2Ø	5.75Ø	6.ØØØ	
34	6.ØØØ	6.25Ø	
44	6.25Ø	6.5ØØ	
16	6.5ØØ	6.75Ø	
2Ø	6.75Ø	7.ØØØ	
5	7.ØØØ	7.25Ø	
14	7.25Ø	7.5ØØ	
14	7.5ØØ	7.75Ø	
5	7.75Ø	8.ØØØ	
1	8.ØØØ	∞	

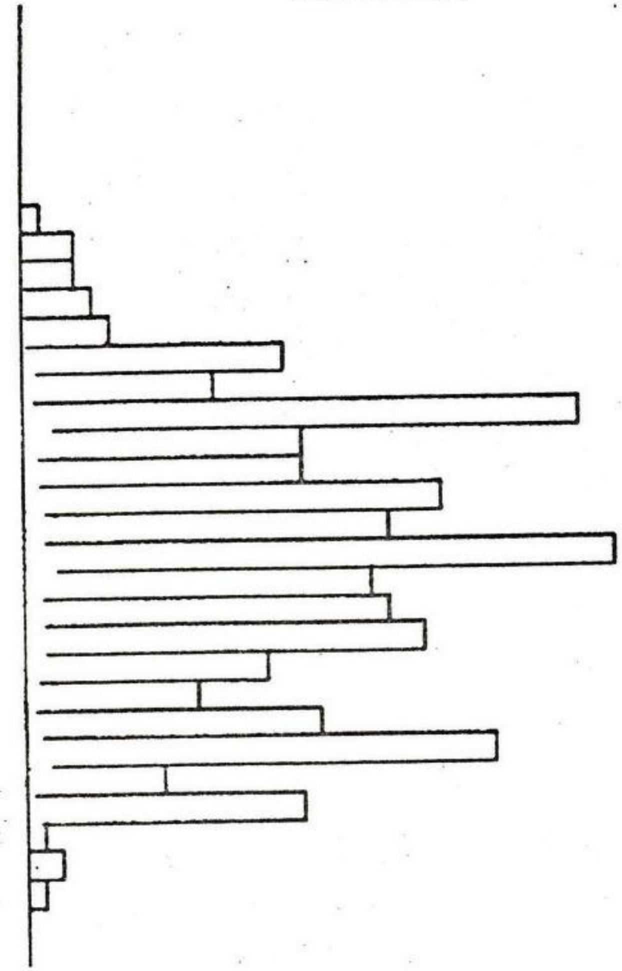


STATISTICS OF	ALL DATA	Ø.Ø TO 8.ØØØ
MINIMUM	1.333	1.333
MAXIMUM	8.5ØØ	7.916
AVERAGE	4.481	4.476
STANDARD DEVIATION	1.484	1.477
NUMBER OF POINTS	7Ø5	7Ø4

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.2500
0	.2500	.5000
0	.5000	.7500
0	.7500	1.000
0	1.000	1.250
0	1.250	1.500
1	1.500	1.750
3	1.750	2.000
3	2.000	2.250
4	2.250	2.500
5	2.500	2.750
15	2.750	3.000
11	3.000	3.250
32	3.250	3.500
16	3.500	3.750
16	3.750	4.000
24	4.000	4.250
21	4.250	4.500
34	4.500	4.750
20	4.750	5.000
21	5.000	5.250
23	5.250	5.500
14	5.500	5.750
10	5.750	6.000
17	6.000	6.250
27	6.250	6.500
8	6.500	6.750
16	6.750	7.000
1	7.000	7.250
2	7.250	7.500
1	7.500	7.750
0	7.750	8.000
0	8.000	∞



Read 7

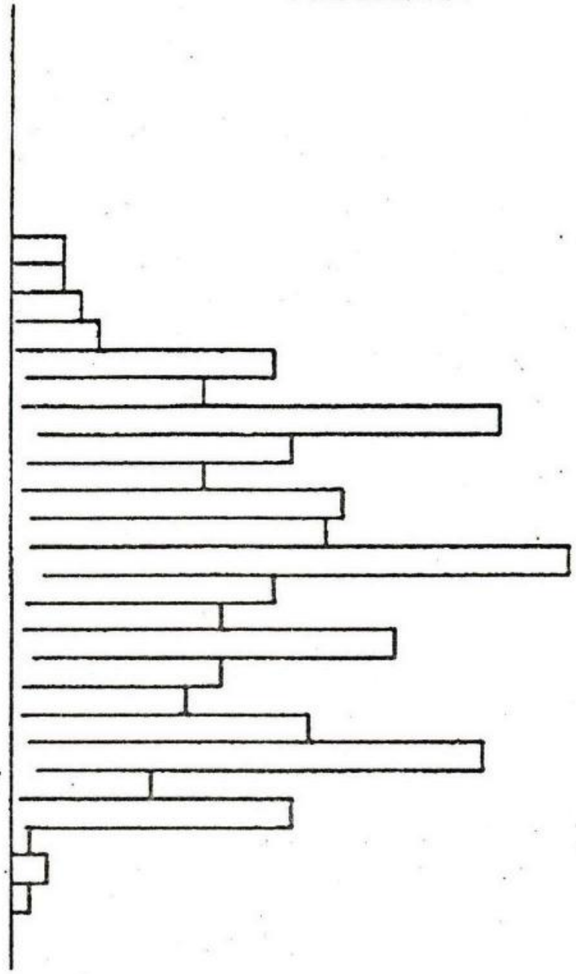
3① Task times, All tasks

STATISTICS OF	ALL DATA	0.0 TO 8.000
MINIMUM	1.666	1.666
MAXIMUM	7.500	7.500
AVERAGE	4.666	4.666
STANDARD DEVIATION	1.260	1.260
NUMBER OF POINTS	345	345

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.2500
0	.2500	.5000
0	.5000	.7500
0	.7500	1.000
0	1.000	1.250
0	1.250	1.500
0	1.500	1.750
3	1.750	2.000
3	2.000	2.250
4	2.250	2.500
5	2.500	2.750
15	2.750	3.000
11	3.000	3.250
28	3.250	3.500
16	3.500	3.750
11	3.750	4.000
19	4.000	4.250
18	4.250	4.500
32	4.500	4.750
15	4.750	5.000
12	5.000	5.250
22	5.250	5.500
12	5.500	5.750
10	5.750	6.000
17	6.000	6.250
27	6.250	6.500
8	6.500	6.750
16	6.750	7.000
1	7.000	7.250
2	7.250	7.500
1	7.500	7.750
0	7.750	8.000
0	8.000	∞



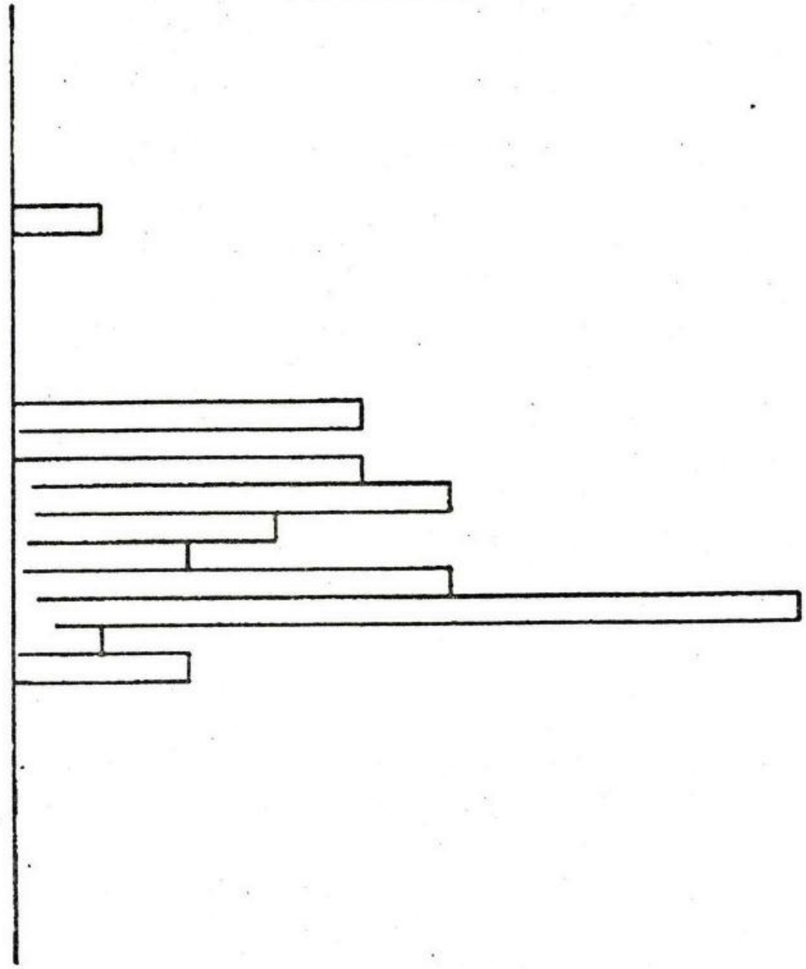
Road 7
Excavation
Task Times

STATISTICS OF	ALL DATA	0.0 TO 8.000
MINIMUM	1.883	1.883
MAXIMUM	7.500	7.500
AVERAGE	4.699	4.699
STANDARD DEVIATION	1.301	1.301
NUMBER OF POINTS	308	308

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.2500
0	.2500	.5000
0	.5000	.7500
0	.7500	1.000
0	1.000	1.250
0	1.250	1.500
1	1.500	1.750
0	1.750	2.000
0	2.000	2.250
0	2.250	2.500
0	2.500	2.750
0	2.750	3.000
0	3.000	3.250
4	3.250	3.500
0	3.500	3.750
4	3.750	4.000
5	4.000	4.250
3	4.250	4.500
2	4.500	4.750
5	4.750	5.000
9	5.000	5.250
1	5.250	5.500
2	5.500	5.750
0	5.750	6.000
0	6.000	6.250
0	6.250	6.500
0	6.500	6.750
0	6.750	7.000
0	7.000	7.250
0	7.250	7.500
0	7.500	7.750
0	7.750	8.000
0	8.000	∞

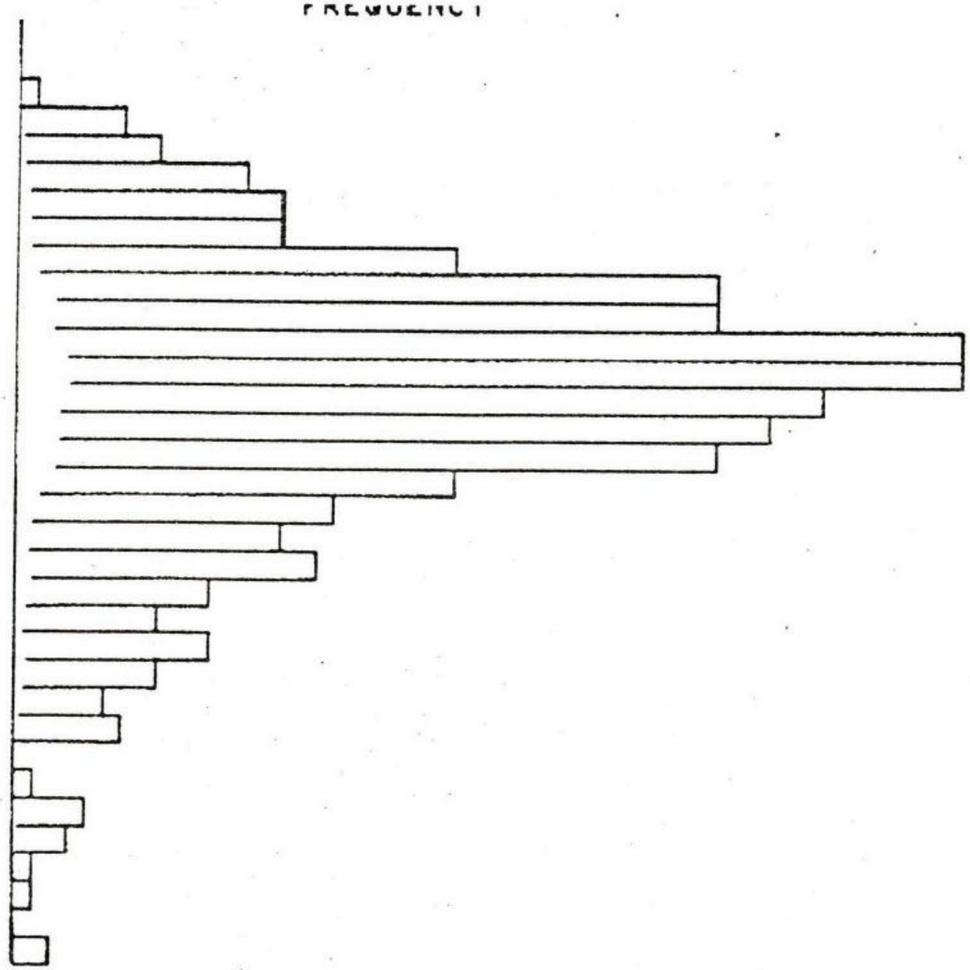


Road 7
Ditching & Sloping
Task times

STATISTICS OF	ALL DATA	0.0 TO 8.000
MINIMUM	1.666	1.666
MAXIMUM	5.666	5.666
AVERAGE	4.408	4.408
STANDARD DEVIATION	.8166	.8166
NUMBER OF POINTS	36	36

$FINISHED?

FREQUENCY



0	- ∞	0.0
0	0.0	.06250
1	.06250	.1250
6	.1250	.1875
8	.1875	.2500
13	.2500	.3125
15	.3125	.3750
15	.3750	.4375
25	.4375	.5000
40	.5000	.5625
40	.5625	.6250
54	.6250	.6875
54	.6875	.7500
46	.7500	.8125
43	.8125	.8750
40	.8750	.9375
25	.9375	1.000
18	1.000	1.062
15	1.062	1.125
17	1.125	1.187
11	1.187	1.250
8	1.250	1.312
11	1.312	1.375
8	1.375	1.437
5	1.437	1.500
6	1.500	1.562
0	1.562	1.625
1	1.625	1.687
4	1.687	1.750
3	1.750	1.812
1	1.812	1.875
1	1.875	1.937
0	1.937	2.000
2	2.000	∞

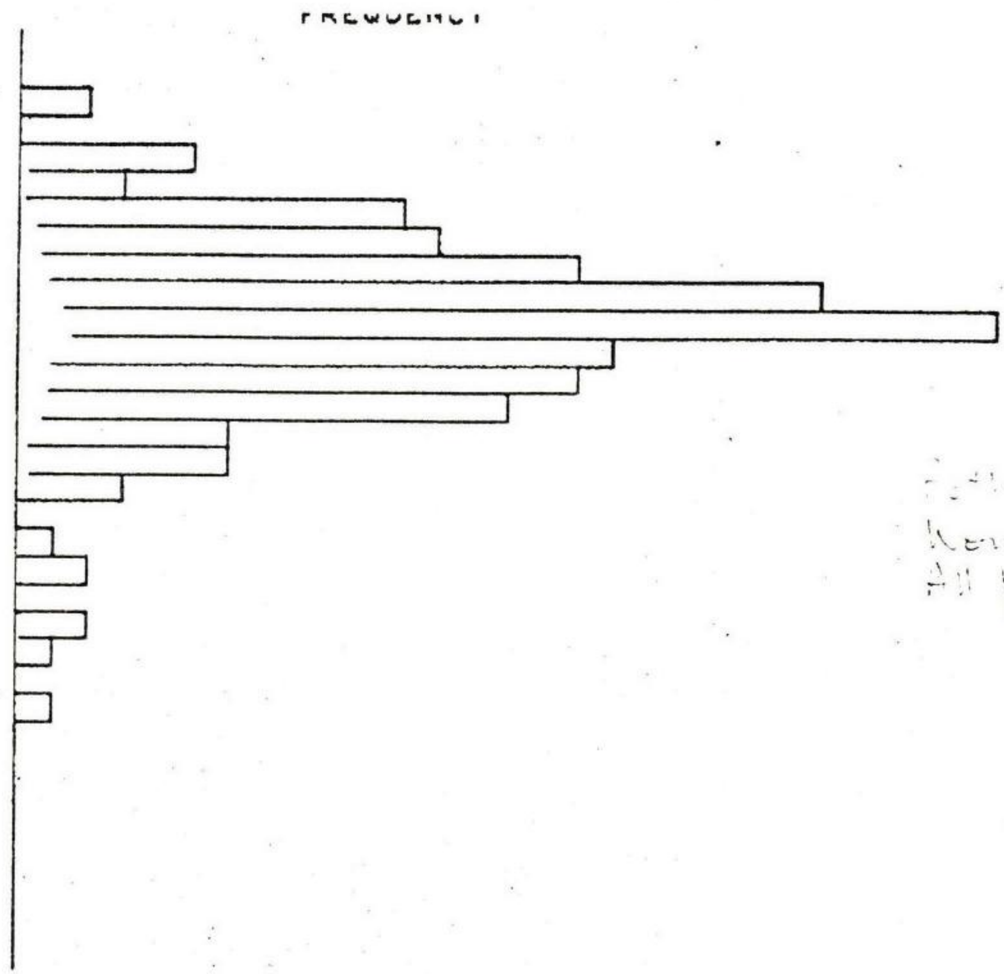
Both Races

All Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1210	.1210
MAXIMUM	2.170	1.900
AVERAGE	.7915	.7864
STANDARD DEVIATION	.3279	.3177
NUMBER OF POINTS	536	534

$FINISHED?

Ø	- ∞	Ø.Ø	
Ø	Ø.Ø	.Ø625Ø	
2	.Ø625Ø	.125Ø	
Ø	.125Ø	.1875	
5	.1875	.25ØØ	
3	.25ØØ	.3125	
11	.3125	.375Ø	
12	.375Ø	.4375	
16	.4375	.5ØØØ	
23	.5ØØØ	.5625	
28	.5625	.625Ø	
17	.625Ø	.6875	
16	.6875	.75ØØ	
14	.75ØØ	.8125	
6	.8125	.875Ø	
6	.875Ø	.9375	
3	.9375	1.ØØØ	
Ø	1.ØØØ	1.Ø62	
1	1.Ø62	1.125	
2	1.125	1.187	
Ø	1.187	1.25Ø	
2	1.25Ø	1.312	
1	1.312	1.375	
Ø	1.375	1.437	
1	1.437	1.5ØØ	
Ø	1.5ØØ	1.562	
Ø	1.562	1.625	
Ø	1.625	1.687	
Ø	1.687	1.75Ø	
Ø	1.75Ø	1.812	
Ø	1.812	1.875	
Ø	1.875	1.937	
Ø	1.937	2.ØØØ	
Ø	2.ØØØ	∞	



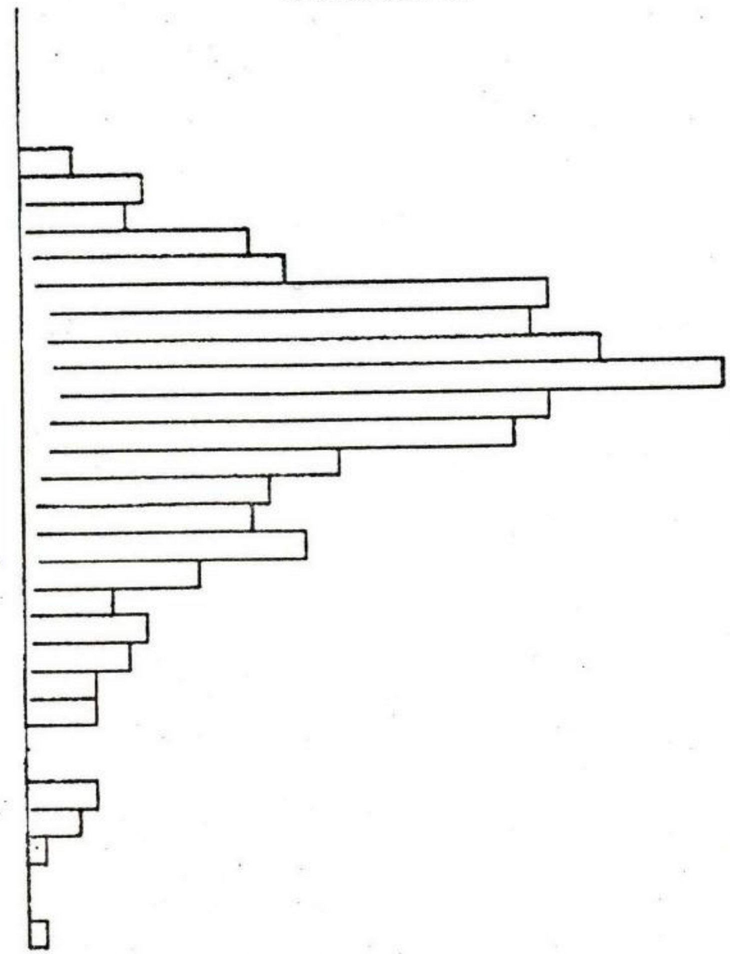
[illegible]
Women
All productivities

STATISTICS OF	ALL DATA	Ø.Ø TO 2.ØØØ
MINIMUM	.11ØØ	.11ØØ
MAXIMUM	1.49Ø	1.49Ø
AVERAGE	.6Ø98	.6Ø98
STANDARD DEVIATION	.2213	.2213
NUMBER OF POINTS	169	169

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
3	.2500	.3125
7	.3125	.3750
6	.3750	.4375
13	.4375	.5000
15	.5000	.5625
30	.5625	.6250
29	.6250	.6875
33	.6875	.7500
40	.7500	.8125
30	.8125	.8750
28	.8750	.9375
18	.9375	1.000
14	1.000	1.062
13	1.062	1.125
16	1.125	1.187
10	1.187	1.250
5	1.250	1.312
7	1.312	1.375
6	1.375	1.437
4	1.437	1.500
4	1.500	1.562
0	1.562	1.625
0	1.625	1.687
4	1.687	1.750
3	1.750	1.812
1	1.812	1.875
0	1.875	1.937
0	1.937	2.000
1	2.000	∞



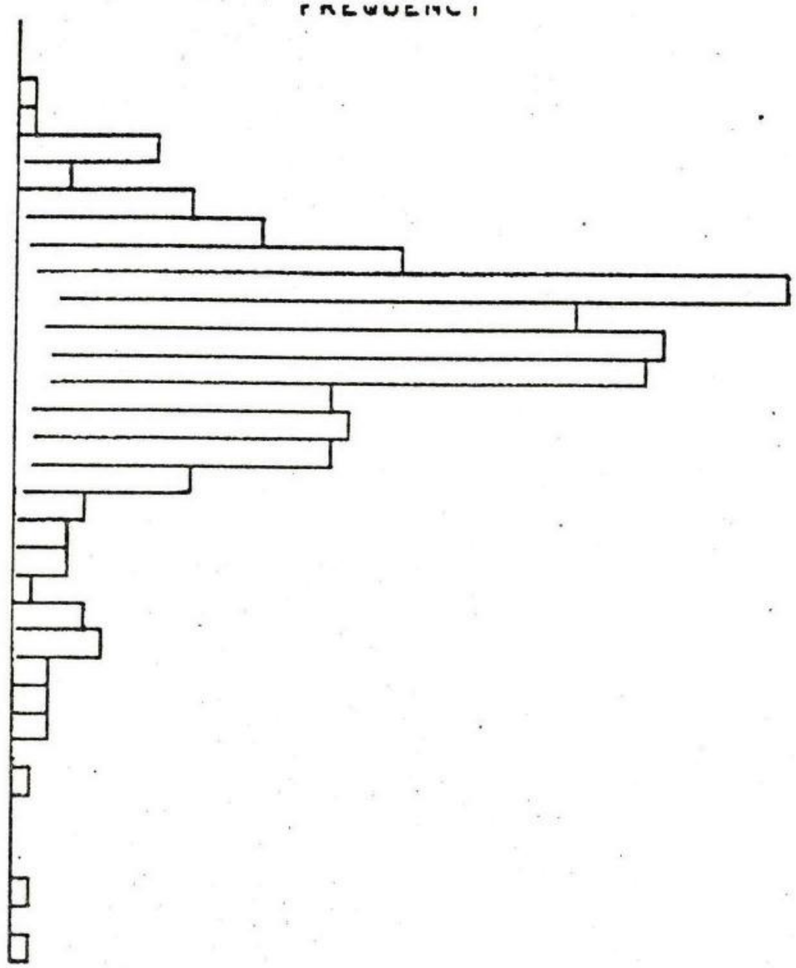
Both Roads
Excavation
Men & Women
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.2550	.2550
MAXIMUM	2.170	1.870
AVERAGE	.8570	.8531
STANDARD DEVIATION	.3084	.3004
NUMBER OF POINTS	340	339

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
1	.06250	.1250
1	.1250	.1875
8	,1875	.2500
3	.2500	.3125
10	.3125	.3750
14	.3750	.4375
22	.4375	.5000
44	.5000	.5625
32	.5625	.6250
37	.6250	.6875
36	.6875	.7500
18	.7500	.8125
19	.8125	.8750
18	.8750	.9375
10	.9375	1.000
4	1.000	1.062
3	1.062	1.125
3	1.125	1.187
1	1.187	1.250
4	1.250	1.312
5	1.312	1.375
2	1.375	1.437
2	1.437	1.500
2	1.500	1.562
0	1.562	1.625
1	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
1	1.875	1.937
0	1.937	2.000
1	2.000	∞



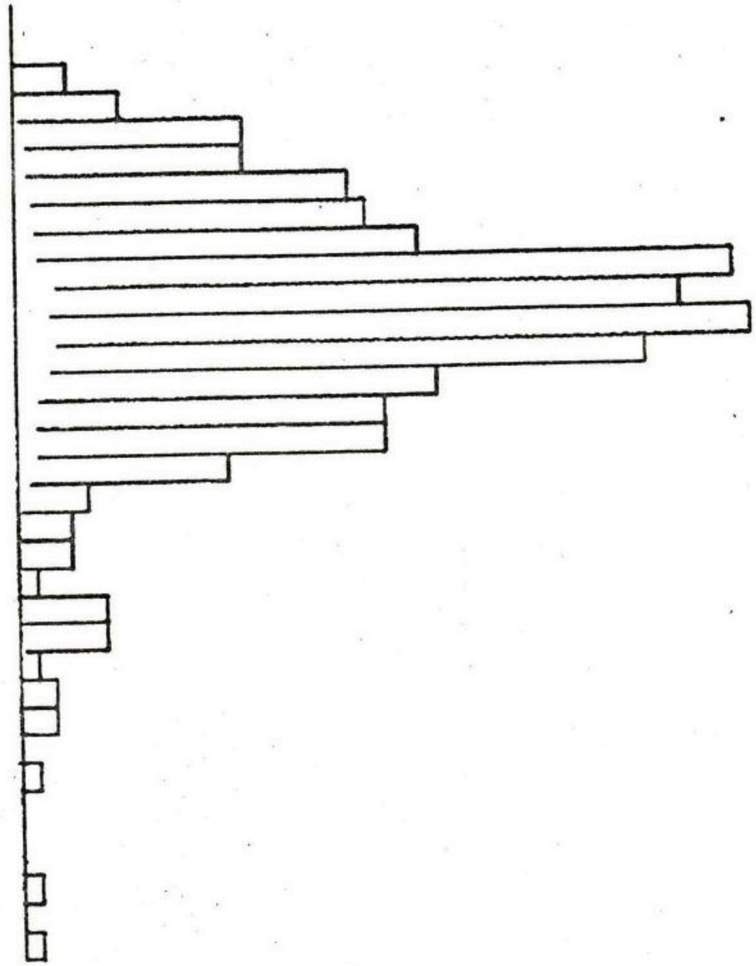
Both Roads
Men & Women
Ditching & Slopi

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1210	.1210
MAXIMUM	2.140	1.900
AVERAGE	.6940	.6892
STANDARD DEVIATION	.2783	.2660
NUMBER OF POINTS	302	301

SFINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
3	.06250	.1250
6	.1250	.1875
13	.1875	.2500
13	.2500	.3125
19	.3125	.3750
20	.3750	.4375
23	.4375	.5000
41	.5000	.5625
38	.5625	.6250
42	.6250	.6875
36	.6875	.7500
24	.7500	.8125
21	.8125	.8750
21	.8750	.9375
12	.9375	1.000
4	1.000	1.062
3	1.062	1.125
3	1.125	1.187
1	1.187	1.250
5	1.250	1.312
5	1.312	1.375
1	1.375	1.437
2	1.437	1.500
2	1.500	1.562
0	1.562	1.625
1	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
1	1.875	1.937
0	1.937	2.000
1	2.000	∞



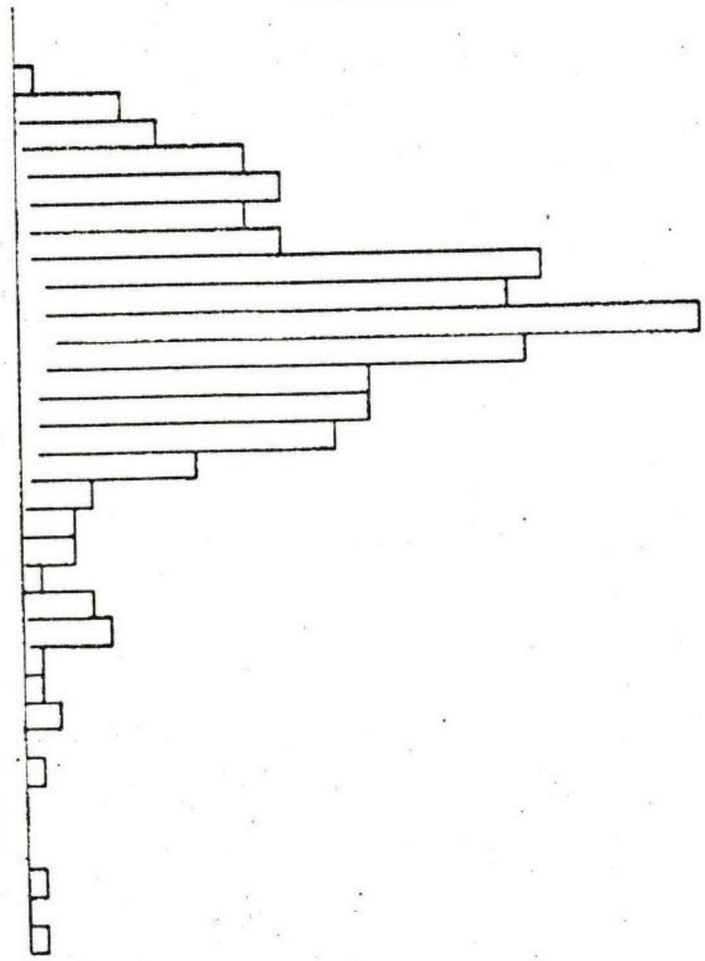
Road 12
3① All productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1100	.1100
MAXIMUM	2.140	1.900
AVERAGE	.6557	.6515
STANDARD DEVIATION	.2865	.2759
NUMBER OF POINTS	361	360

$FINISHED?

0	- ∞	0.0
0	0.0	.06250
1	.06250	.1250
6	.1250	.1875
8	.1875	.2500
13	.2500	.3125
15	.3125	.3750
13	.3750	.4375
15	.4375	.5000
30	.5000	.5625
28	.5625	.6250
39	.6250	.6875
29	.6875	.7500
20	.7500	.8125
20	.8125	.8750
18	.8750	.9375
10	.9375	1.000
4	1.000	1.062
3	1.062	1.125
3	1.125	1.187
1	1.187	1.250
4	1.250	1.312
5	1.312	1.375
1	1.375	1.437
1	1.437	1.500
2	1.500	1.562
0	1.562	1.625
1	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
1	1.875	1.937
0	1.937	2.000
1	2.000	∞

FREQUENCY



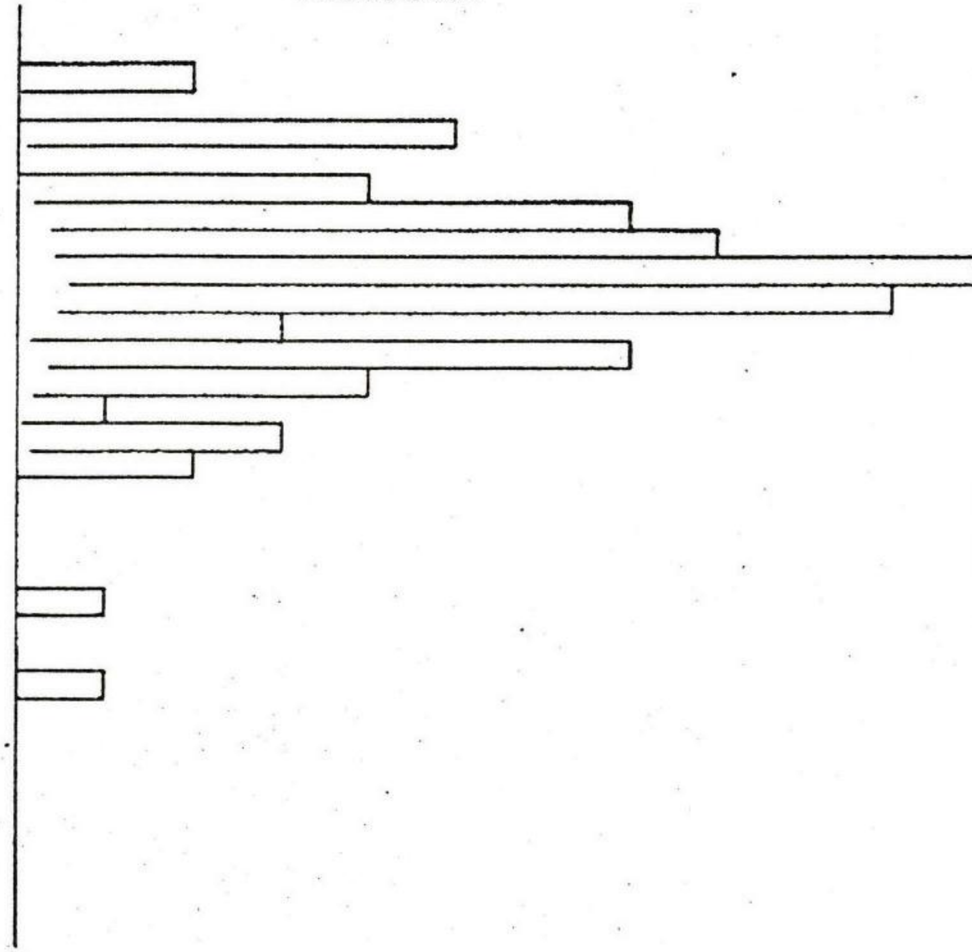
Road 12
Men
Instrumentation
All tasks

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1210	.1210
MAXIMUM	2.140	1.900
AVERAGE	.6749	.6699
STANDARD DEVIATION	.2931	.2807
NUMBER OF POINTS	292	291

$FINISHED^

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
2	.06250	.1250
0	.1250	.1875
5	.1875	.2500
0	.2500	.3125
4	.3125	.3750
7	.3750	.4375
8	.4375	.5000
11	.5000	.5625
10	.5625	.6250
3	.6250	.6875
7	.6875	.7500
4	.7500	.8125
1	.8125	.8750
3	.8750	.9375
2	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
1	1.250	1.312
0	1.312	1.375
0	1.375	1.437
1	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



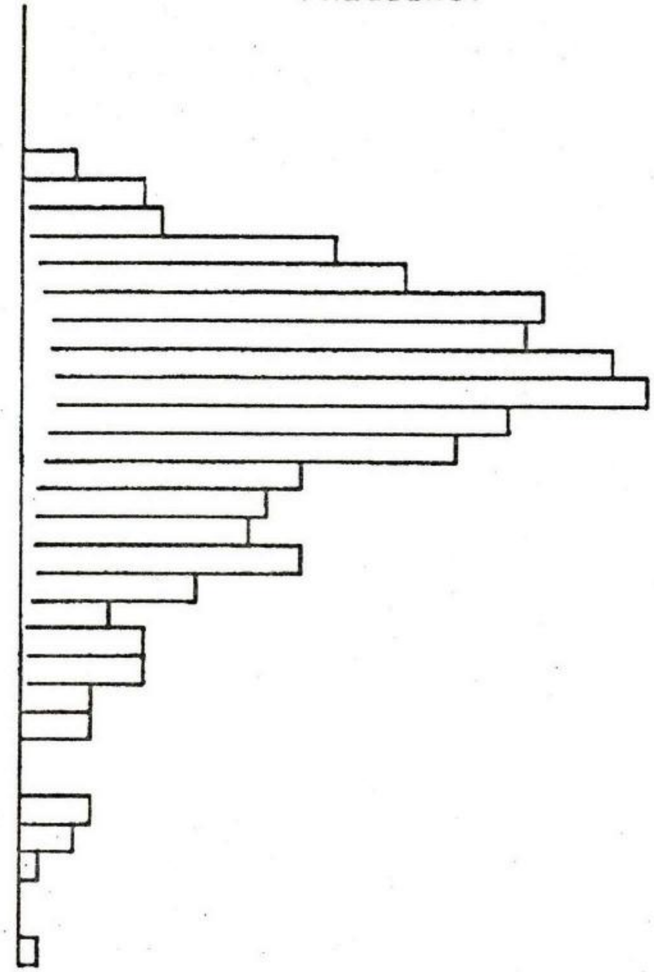
Road 12
Women
Productivities
All tasks

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1100	.1100
MAXIMUM	1.490	1.490
AVERAGE	.5741	.5741
STANDARD DEVIATION	.2419	.2419
NUMBER OF POINTS	69	69

$FINISHED>

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
3	.2500	.3125
7	.3125	.3750
8	.3750	.4375
18	.4375	.5000
22	.5000	.5625
30	.5625	.6250
29	.6250	.6875
34	.6875	.7500
36	.7500	.8125
28	.8125	.8750
25	.8750	.9375
16	.9375	1.000
14	1.000	1.062
13	1.062	1.125
16	1.125	1.187
10	1.187	1.250
5	1.250	1.312
7	1.312	1.375
7	1.375	1.437
4	1.437	1.500
4	1.500	1.562
0	1.562	1.625
0	1.625	1.687
4	1.687	1.750
3	1.750	1.812
1	1.812	1.875
0	1.875	1.937
0	1.937	2.000
1	2.000	∞



Road 7

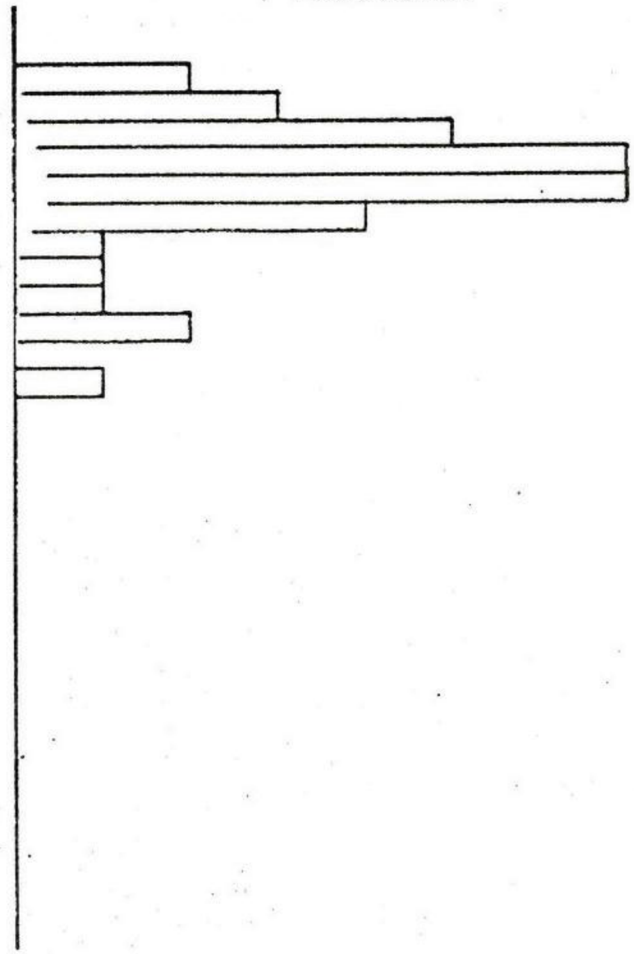
3.1 Productivities, All task

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.2550	.2550
MAXIMUM	2.170	1.870
AVERAGE	.8436	.8397
STANDARD DEVIATION	.3159	.3081
NUMBER OF POINTS	345	344

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
2	.06250	.1250
3	.1250	.1875
5	.1875	.2500
7	.2500	.3125
7	.3125	.3750
4	.3750	.4375
1	.4375	.5000
1	.5000	.5625
1	.5625	.6250
2	.6250	.6875
0	.6875	.7500
1	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



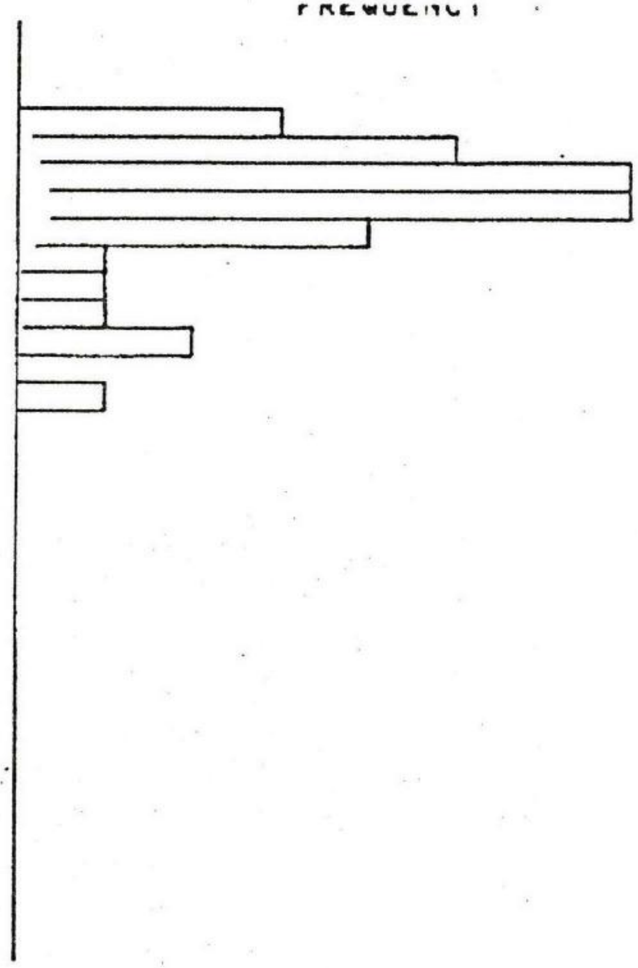
Road 12
Ditching
Men & Woman

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1100	.1100
MAXIMUM	.7850	.7850
AVERAGE	.3390	.3390
STANDARD DEVIATION	.1597	.1597
NUMBER OF POINTS	34	34

$FINISHED?

FREQUENCY

Ø	- ∞	Ø.Ø
Ø	Ø.Ø	.Ø625Ø
Ø	.Ø625Ø	.125Ø
3	.125Ø	.1875
5	.1875	.25ØØ
7	.25ØØ	.3125
7	.3125	.375Ø
4	.375Ø	.4375
1	.4375	.5ØØØ
1	.5ØØØ	.5625
1	.5625	.625Ø
2	.625Ø	.6875
Ø	.6875	.75ØØ
1	.75ØØ	.8125
Ø	.8125	.875Ø
Ø	.875Ø	.9375
Ø	.9375	1.ØØØ
Ø	1.ØØØ	1.Ø62
Ø	1.Ø62	1.125
Ø	1.125	1.187
Ø	1.187	1.25Ø
Ø	1.25Ø	1.312
Ø	1.312	1.375
Ø	1.375	1.437
Ø	1.437	1.5ØØ
Ø	1.5ØØ	1.562
Ø	1.562	1.625
Ø	1.625	1.687
Ø	1.687	1.75Ø
Ø	1.75Ø	1.812
Ø	1.812	1.875
Ø	1.875	1.937
Ø	1.937	2.ØØØ
Ø	2.ØØØ	∞



Road 12
Ditching
Men
Productivity

STATISTICS OF	ALL DATA	Ø.Ø TO 2.ØØØ
MINIMUM	.162Ø	.162Ø
MAXIMUM	.785Ø	.785Ø
AVERAGE	.3533	.3533
STANDARD DEVIATION	.1535	.1535
NUMBER OF POINTS	32	32

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
2	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
0	.3125	.3750
0	.3750	.4375
0	.4375	.5000
0	.5000	.5625
0	.5625	.6250
0	.6250	.6875
0	.6875	.7500
0	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞

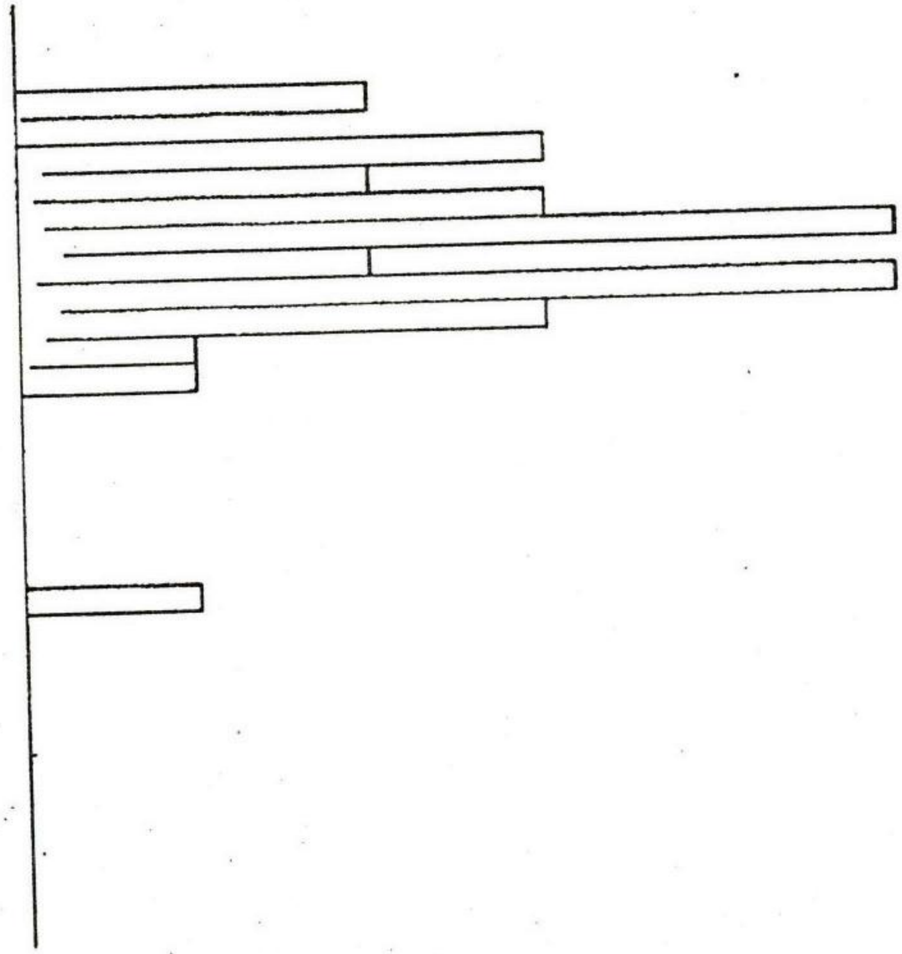
Road 12
Ditching
Women
Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1100	.1100
MAXIMUM	.1100	.1100
AVERAGE	.1100	.1100
STANDARD DEVIATION	0.0	0.0
NUMBER OF POINTS	2	2

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
2	.1250	.1875
0	.1875	.2500
3	.2500	.3125
2	.3125	.3750
3	.3750	.4375
5	.4375	.5000
2	.5000	.5625
5	.5625	.6250
3	.6250	.6875
1	.6875	.7500
1	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
1	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



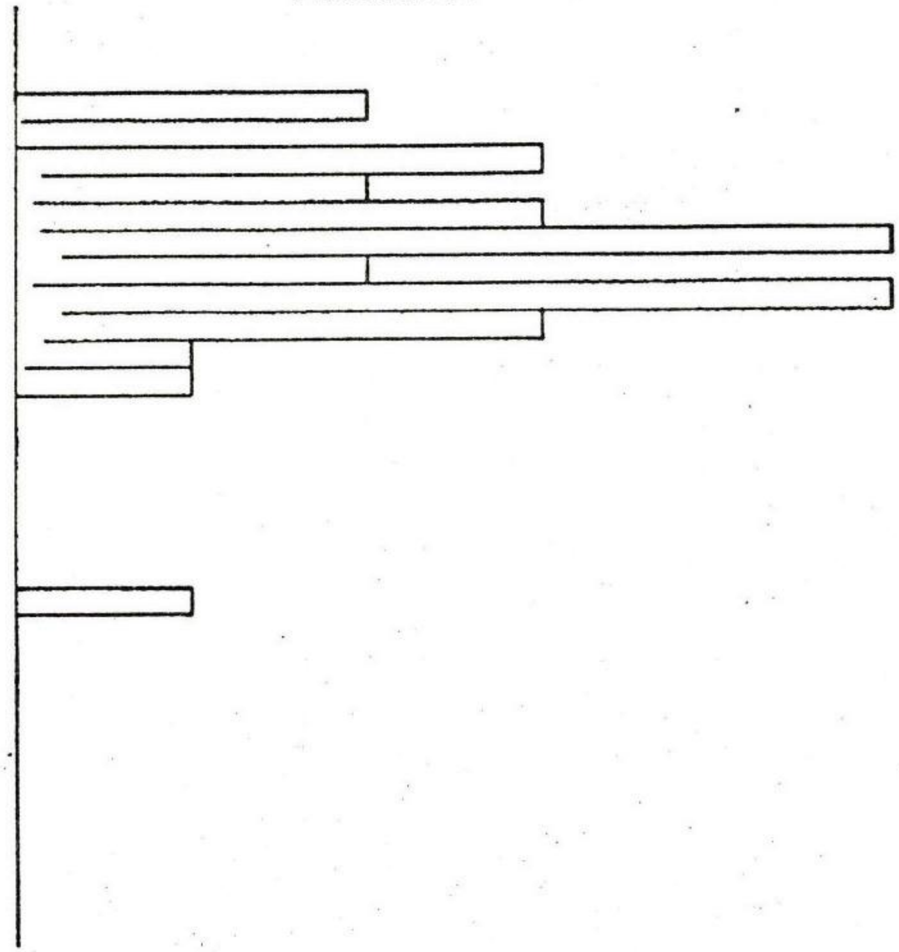
Road 12
Sloping
Men
Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1540	.1540
MAXIMUM	1.290	1.290
AVERAGE	.5108	.5108
STANDARD DEVIATION	.2242	.2242
NUMBER OF POINTS	28	28

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
2	.1250	.1875
0	.1875	.2500
3	.2500	.3125
2	.3125	.3750
3	.3750	.4375
5	.4375	.5000
2	.5000	.5625
5	.5625	.6250
3	.6250	.6875
1	.6875	.7500
1	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
1	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞

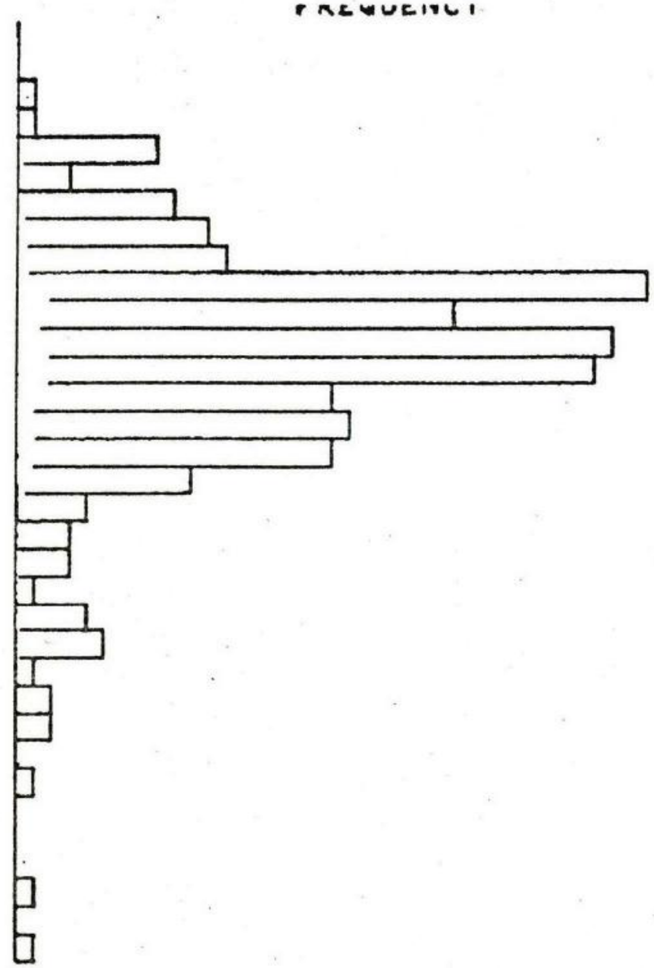


Road 12
Sloping
Men & Women
Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1540	.1540
MAXIMUM	1.290	1.290
AVERAGE	.5108	.5108
STANDARD DEVIATION	.2242	.2242
NUMBER OF POINTS	28	28

$FINISHED?

FREQUENCY

0	- ∞	0.0	
0	0.0	.06250	
1	.06250	.1250	
1	.1250	.1875	
8	.1875	.2500	
3	.2500	.3125	
9	.3125	.3750	
11	.3750	.4375	
12	.4375	.5000	
36	.5000	.5625	
25	.5625	.6250	
34	.6250	.6875	
33	.6875	.7500	
18	.7500	.8125	
19	.8125	.8750	
18	.8750	.9375	
10	.9375	1.000	
4	1.000	1.062	
3	1.062	1.125	
3	1.125	1.187	
1	1.187	1.250	
4	1.250	1.312	
5	1.312	1.375	
1	1.375	1.437	
2	1.437	1.500	
2	1.500	1.562	
0	1.562	1.625	
1	1.625	1.687	
0	1.687	1.750	
0	1.750	1.812	
0	1.812	1.875	
1	1.875	1.937	
0	1.937	2.000	
1	2.000	∞	

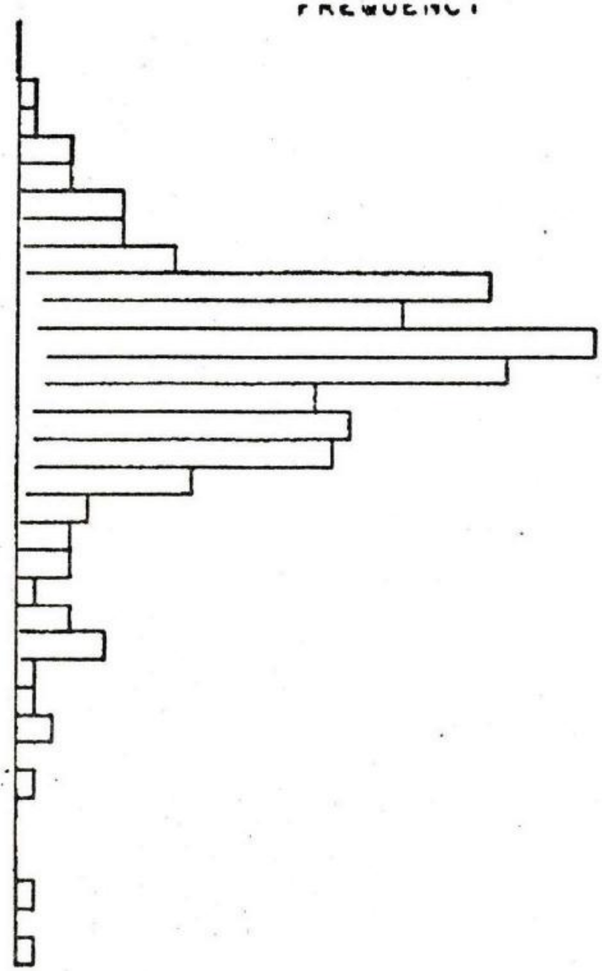
Road 2
Men & Women
Ditching & Sloping
Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1210	.1210
MAXIMUM	2.140	1.900
AVERAGE	.7117	.7063
STANDARD DEVIATION	.2851	.2718
NUMBER OF POINTS	266	265

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
1	.06250	.1250
1	.1250	.1875
3	.1875	.2500
3	.2500	.3125
6	.3125	.3750
6	.3750	.4375
9	.4375	.5000
27	.5000	.5625
22	.5625	.6250
33	.6250	.6875
28	.6875	.7500
17	.7500	.8125
19	.8125	.8750
18	.8750	.9375
10	.9375	1.000
4	1.000	1.062
3	1.062	1.125
3	1.125	1.187
1	1.187	1.250
3	1.250	1.312
5	1.312	1.375
1	1.375	1.437
1	1.437	1.500
2	1.500	1.562
0	1.562	1.625
1	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
1	1.875	1.937
0	1.937	2.000
1	2.000	∞



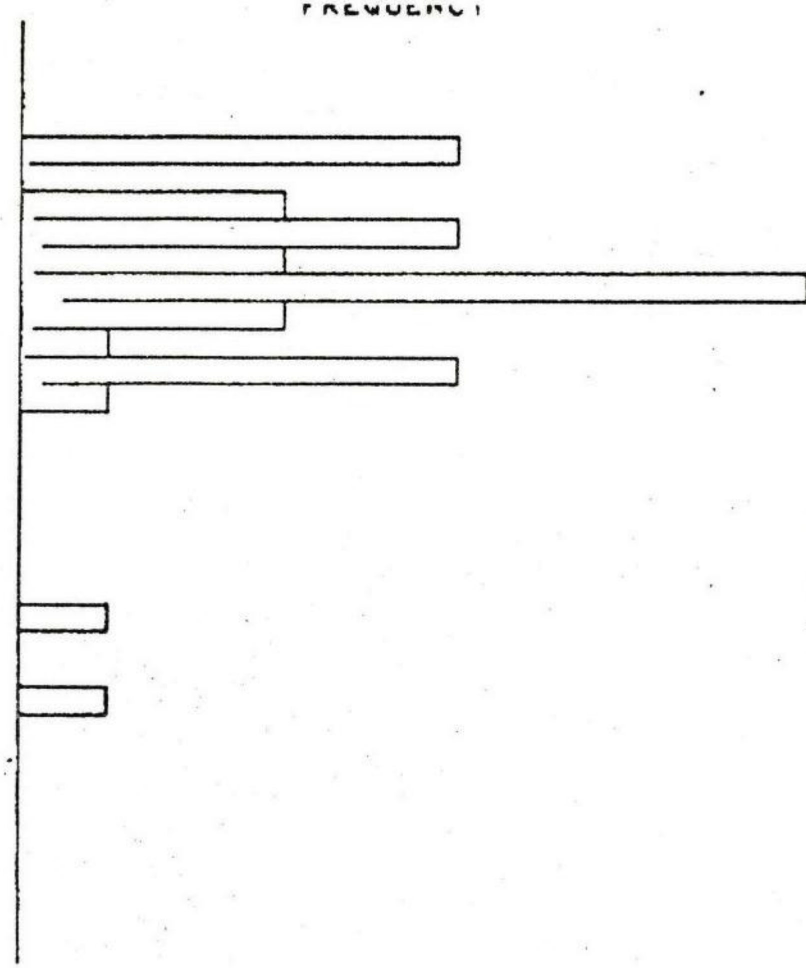
Road 12
Men
Ditching & Slop
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.1210	.1210
MAXIMUM	2.140	1.900
AVERAGE	.7391	.7329
STANDARD DEVIATION	.2800	.2647
NUMBER OF POINTS	229	228

$FINISHED?

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
5	.1875	.2500
0	.2500	.3125
3	.3125	.3750
5	.3750	.4375
3	.4375	.5000
9	.5000	.5625
3	.5625	.6250
1	.6250	.6875
5	.6875	.7500
1	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
1	1.250	1.312
0	1.312	1.375
0	1.375	1.437
1	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞

FREQUENCY

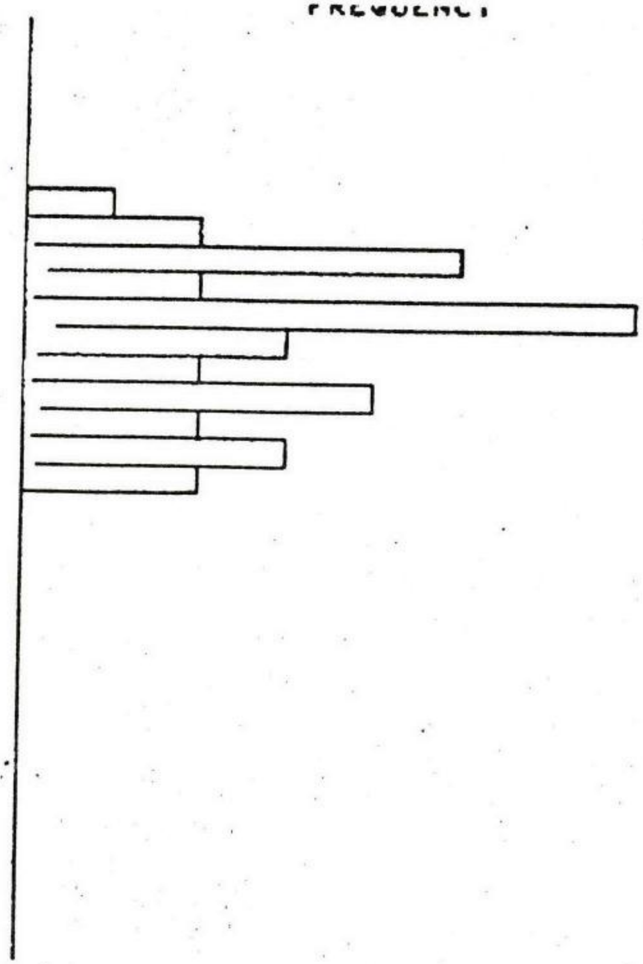


Road 12
Women
Ditching & Sloping
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.2140	.2140
MAXIMUM	1.490	1.490
AVERAGE	.5422	.5422
STANDARD DEVIATION	.2599	.2599
NUMBER OF POINTS	37	.37

$FINISHED?

0	-∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
1	.3125	.3750
2	.3750	.4375
5	.4375	.5000
2	.5000	.5625
7	.5625	.6250
3	.6250	.6875
2	.6875	.7500
4	.7500	.8125
2	.8125	.8750
3	.8750	.9375
2	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



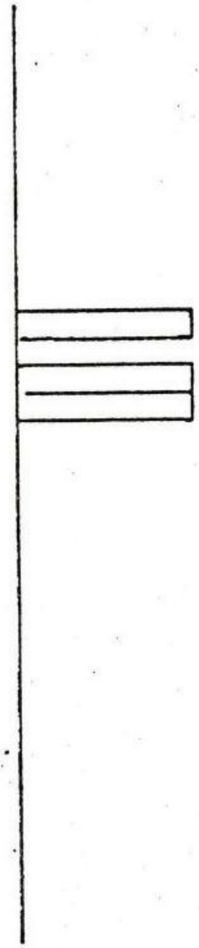
Road 12
Excavation
Men & Women
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.3290	.3290
MAXIMUM	.9700	.9700
AVERAGE	.6532	.6532
STANDARD DEVIATION	.1740	.1740
NUMBER OF POINTS	33	33

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
0	.3125	.3750
0	.3750	.4375
0	.4375	.5000
0	.5000	.5625
0	.5625	.6250
1	.6250	.6875
0	.6875	.7500
1	.7500	.8125
1	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞

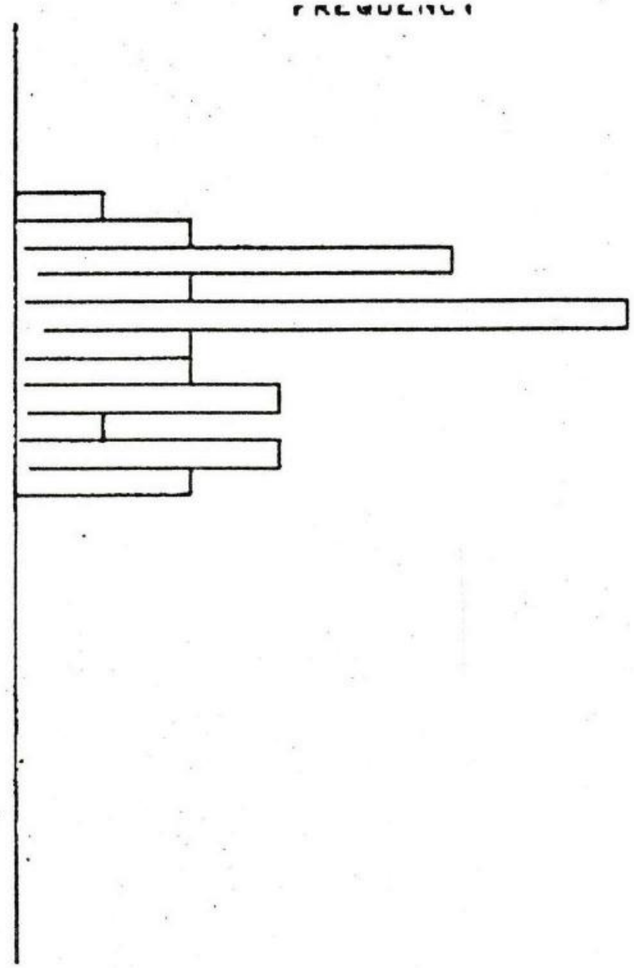


Road 12
Excavation
Men
Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.6550	.6550
MAXIMUM	.8180	.8180
AVERAGE	.7423	.7423
STANDARD DEVIATION	.08212	.08212
NUMBER OF POINTS	3	3

$FINISHED?

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
1	.3125	.3750
2	.3750	.4375
5	.4375	.5000
2	.5000	.5625
7	.5625	.6250
2	.6250	.6875
2	.6875	.7500
3	.7500	.8125
1	.8125	.8750
3	.8750	.9375
2	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



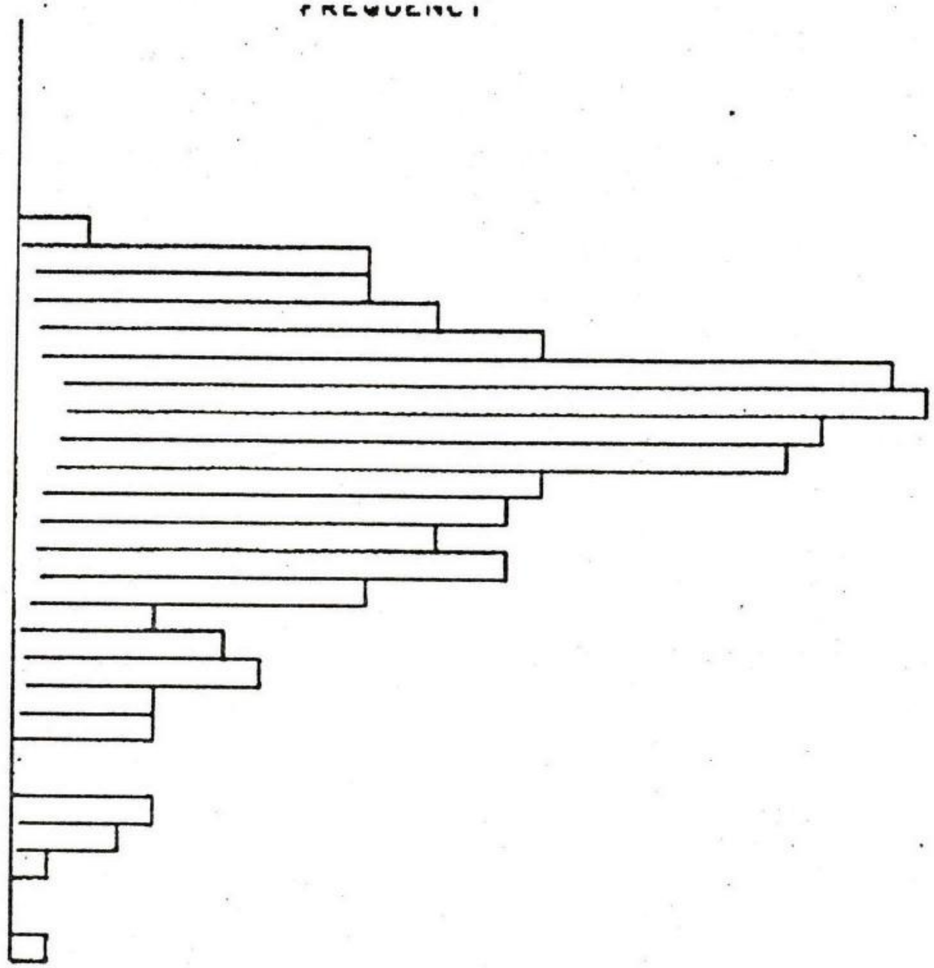
Road 12
Excavation
Women
Productivity

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.3290	.3290
MAXIMUM	.9700	.9700
AVERAGE	.6443	.6443
STANDARD DEVIATION	.1790	.1790
NUMBER OF POINTS	30	30

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
0	.3125	.3750
2	.3750	.4375
10	.4375	.5000
10	.5000	.5625
12	.5625	.6250
15	.6250	.6875
25	.6875	.7500
26	.7500	.8125
23	.8125	.8750
22	.8750	.9375
15	.9375	1.000
14	1.000	1.062
12	1.062	1.125
14	1.125	1.187
10	1.187	1.250
4	1.250	1.312
6	1.312	1.375
7	1.375	1.437
4	1.437	1.500
4	1.500	1.562
0	1.562	1.625
0	1.625	1.687
4	1.687	1.750
3	1.750	1.812
1	1.812	1.875
0	1.875	1.937
0	1.937	2.000
1	2.000	∞

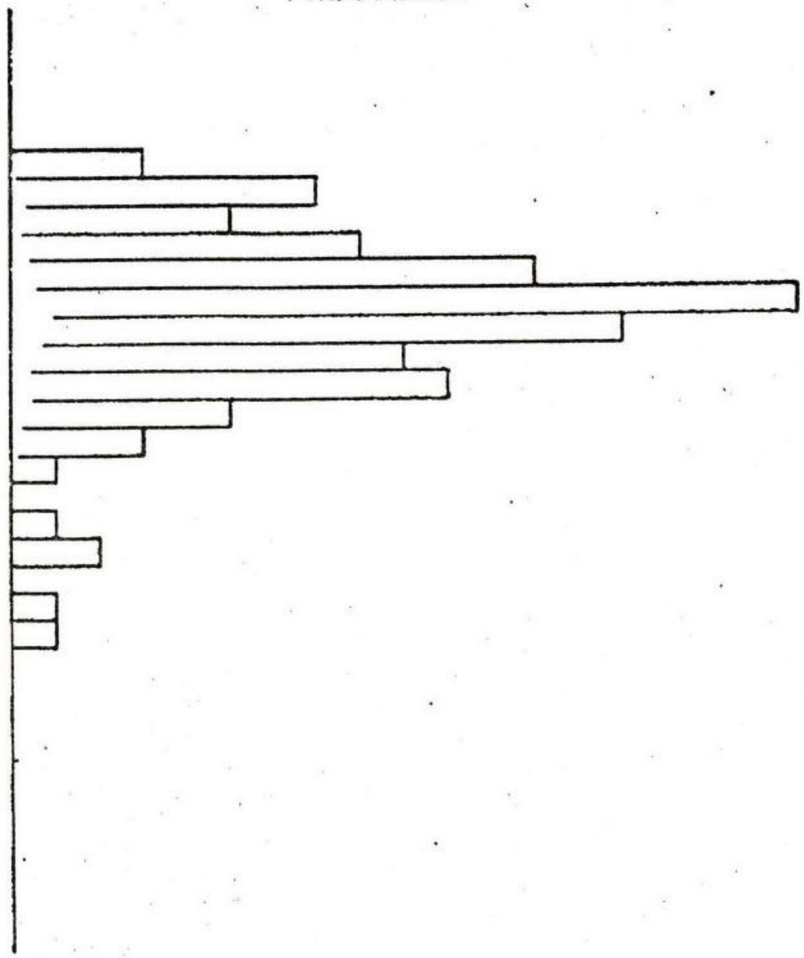


Road 7
Men
Productivities
All tasks

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.4280	.4280
MAXIMUM	2.170	1.870
AVERAGE	.9310	.9259
STANDARD DEVIATION	.3130	.3033
NUMBER OF POINTS	244	243

$FINISHED?

FREQUENCY

0	- ∞	0.0	
0	0.0	.06250	
0	.06250	.1250	
0	.1250	.1875	
0	.1875	.2500	
3	.2500	.3125	
7	.3125	.3750	
5	.3750	.4375	
8	.4375	.5000	
12	.5000	.5625	
18	.5625	.6250	
14	.6250	.6875	
9	.6875	.7500	
10	.7500	.8125	
5	.8125	.8750	
3	.8750	.9375	
1	.9375	1.000	
0	1.000	1.062	
1	1.062	1.125	
2	1.125	1.187	
0	1.187	1.250	
1	1.250	1.312	
1	1.312	1.375	
0	1.375	1.437	
0	1.437	1.500	
0	1.500	1.562	
0	1.562	1.625	
0	1.625	1.687	
0	1.687	1.750	
0	1.750	1.812	
0	1.812	1.875	
0	1.875	1.937	
0	1.937	2.000	
0	2.000	∞	

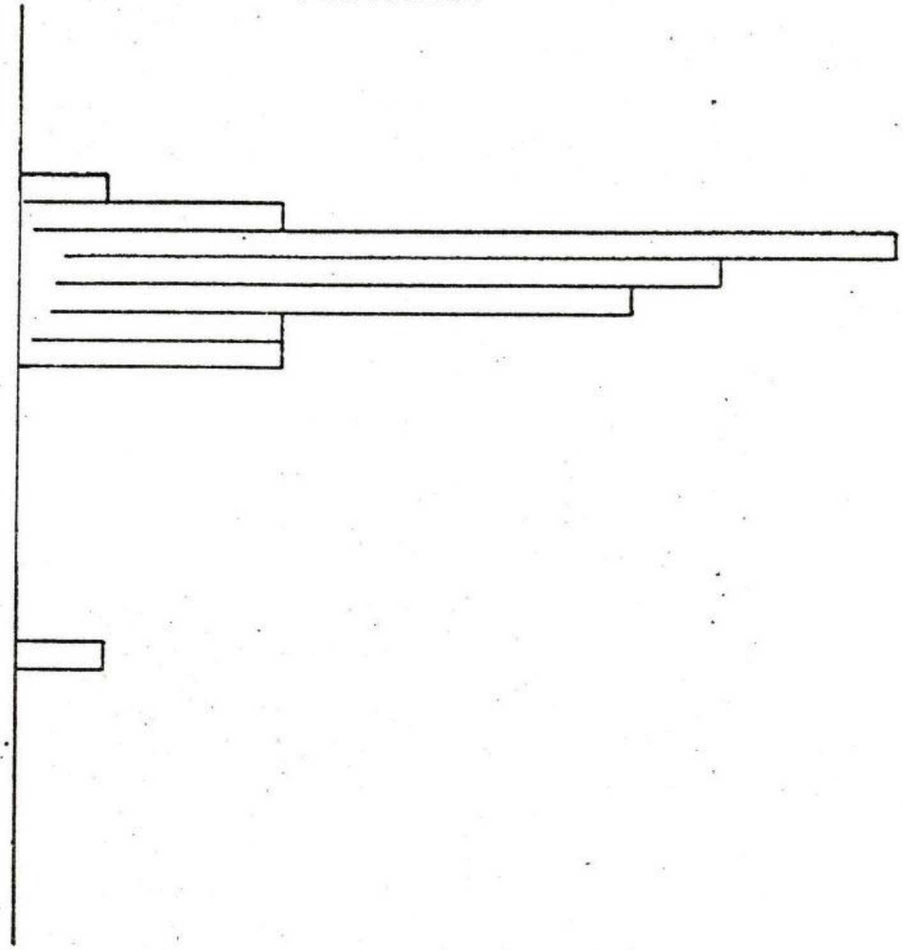
Road 7
Women
Productivities
All tasks.

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.2550	.2550
MAXIMUM	1.330	1.330
AVERAGE	.6344	.6344
STANDARD DEVIATION	.2035	.2035
NUMBER OF POINTS	100	100

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
1	.3125	.3750
3	.3750	.4375
10	.4375	.5000
8	.5000	.5625
7	.5625	.6250
3	.6250	.6875
3	.6875	.7500
0	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
1	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



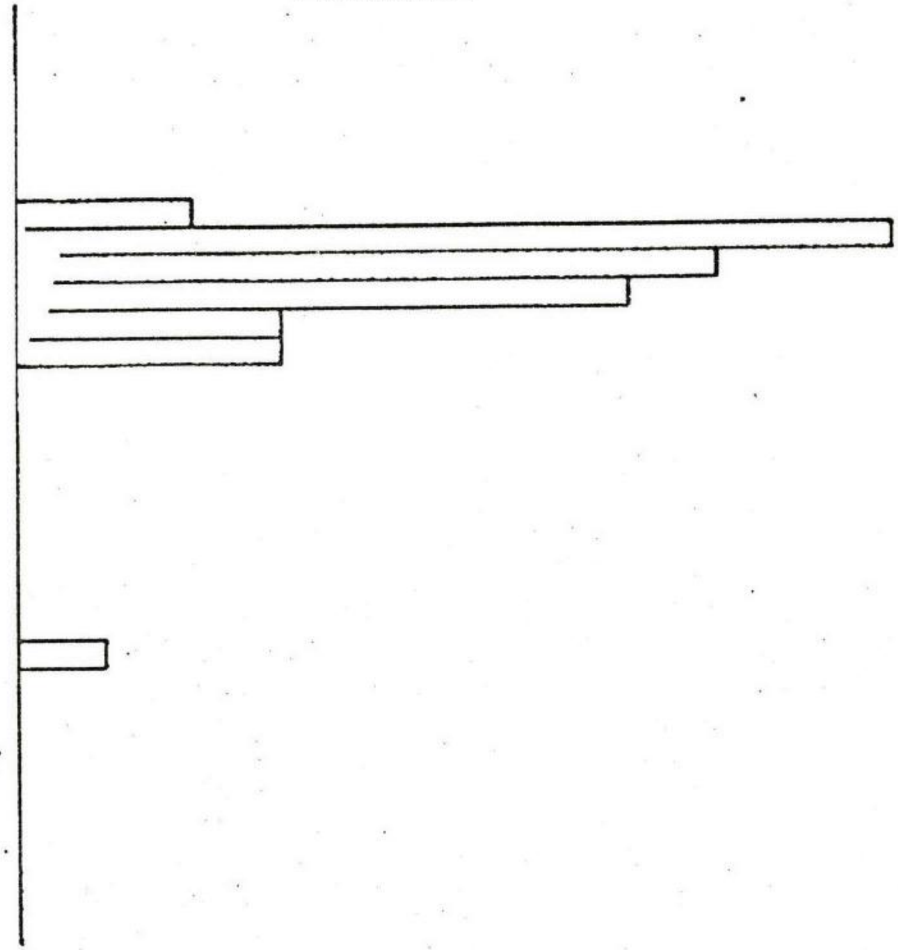
Road 7
Men & Women
Ditching & Sloping
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.3530	.3530
MAXIMUM	1.430	1.430
AVERAGE	.5635	.5635
STANDARD DEVIATION	.1751	.1751
NUMBER OF POINTS	36	36

$FINISHED?

FREQUENCY

Ø	- ∞	Ø.Ø
Ø	Ø.Ø	.Ø625Ø
Ø	.Ø625Ø	.125Ø
Ø	.125Ø	.1875
Ø	.1875	.25ØØ
Ø	.25ØØ	.3125
Ø	.3125	.375Ø
2	.375Ø	.4375
1Ø	.4375	.5ØØØ
8	.5ØØØ	.5625
7	.5625	.625Ø
3	.625Ø	.6875
3	.6875	.75ØØ
Ø	.75ØØ	.8125
Ø	.8125	.875Ø
Ø	.875Ø	.9375
Ø	.9375	1.ØØØ
Ø	1.ØØØ	1.Ø62
Ø	1.Ø62	1.125
Ø	1.125	1.187
Ø	1.187	1.25Ø
Ø	1.25Ø	1.312
Ø	1.312	1.375
1	1.375	1.437
Ø	1.437	1.5ØØ
Ø	1.5ØØ	1.562
Ø	1.562	1.625
Ø	1.625	1.687
Ø	1.687	1.75Ø
Ø	1.75Ø	1.812
Ø	1.812	1.875
Ø	1.875	1.937
Ø	1.937	2.ØØØ
Ø	2.ØØØ	∞



Load 7
Ditching & Slopi
Men
Productivities

STATISTICS OF	ALL DATA	Ø.Ø TO 2.ØØØ
MINIMUM	.428Ø	.428Ø
MAXIMUM	1.43Ø	1.43Ø
AVERAGE	.5747	.5747
STANDARD DEVIATION	.1737	.1737
NUMBER OF POINTS	34	34

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
0	.2500	.3125
1	.3125	.3750
1	.3750	.4375
0	.4375	.5000
0	.5000	.5625
0	.5625	.6250
0	.6250	.6875
0	.6875	.7500
0	.7500	.8125
0	.8125	.8750
0	.8750	.9375
0	.9375	1.000
0	1.000	1.062
0	1.062	1.125
0	1.125	1.187
0	1.187	1.250
0	1.250	1.312
0	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞

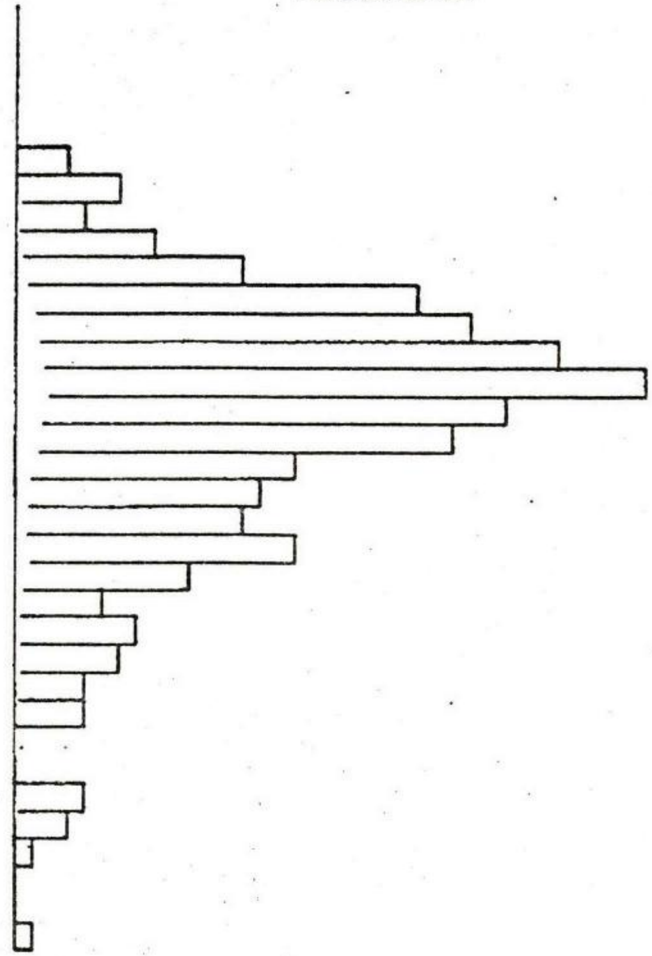
Road 7
Women
Ditching & Sloping
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.3530	.3530
MAXIMUM	.3920	.3920
AVERAGE	.3725	.3725
STANDARD DEVIATION	.02757	.02757
NUMBER OF POINTS	2	2

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
3	.2500	.3125
6	.3125	.3750
4	.3750	.4375
8	.4375	.5000
13	.5000	.5625
23	.5625	.6250
26	.6250	.6875
31	.6875	.7500
36	.7500	.8125
28	.8125	.8750
25	.8750	.9375
16	.9375	1.000
14	1.000	1.062
13	1.062	1.125
16	1.125	1.187
10	1.187	1.250
5	1.250	1.312
7	1.312	1.375
6	1.375	1.437
4	1.437	1.500
4	1.500	1.562
0	1.562	1.625
0	1.625	1.687
4	1.687	1.750
3	1.750	1.812
1	1.812	1.875
0	1.875	1.937
0	1.937	2.000
1	2.000	∞



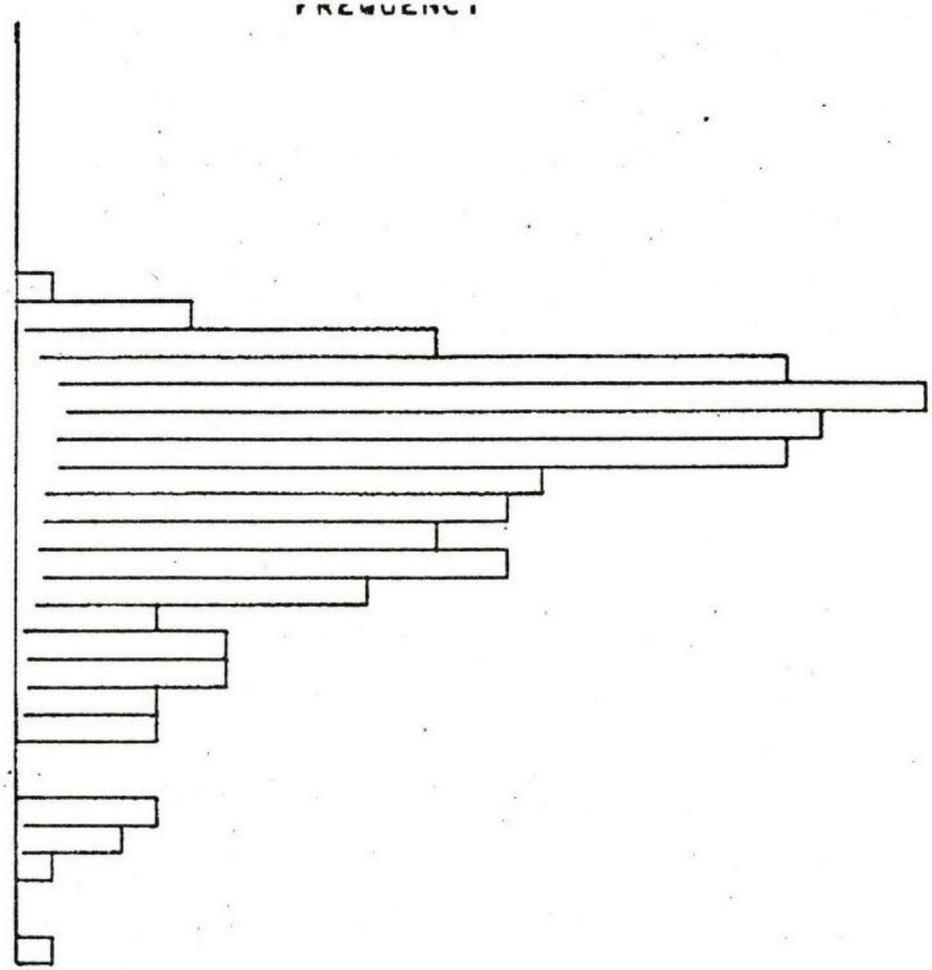
Road 7
Excavation
Men & Women
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.2550	.2550
MAXIMUM	2.170	1.870
AVERAGE	.8789	.8746
STANDARD DEVIATION	.3118	.3034
NUMBER OF POINTS	307	306

$FINISHED?

FREQUENCY

Ø	- ∞	Ø.Ø
Ø	Ø.Ø	.Ø625Ø
Ø	.Ø625Ø	.125Ø
Ø	.125Ø	.1875
Ø	.1875	.25ØØ
Ø	.25ØØ	.3125
Ø	.3125	.375Ø
Ø	.375Ø	.4375
Ø	.4375	.5ØØØ
1	.5ØØØ	.5625
5	.5625	.625Ø
12	.625Ø	.6875
22	.6875	.75ØØ
26	.75ØØ	.8125
23	.8125	.875Ø
22	.875Ø	.9375
15	.9375	1.ØØØ
14	1.ØØØ	1.Ø62
12	1.Ø62	1.125
14	1.125	1.187
1Ø	1.187	1.25Ø
4	1.25Ø	1.312
6	1.312	1.375
6	1.375	1.437
4	1.437	1.5ØØ
4	1.5ØØ	1.562
Ø	1.562	1.625
Ø	1.625	1.687
4	1.687	1.75Ø
3	1.75Ø	1.812
1	1.812	1.875
Ø	1.875	1.937
Ø	1.937	2.ØØØ
1	2.ØØØ	∞



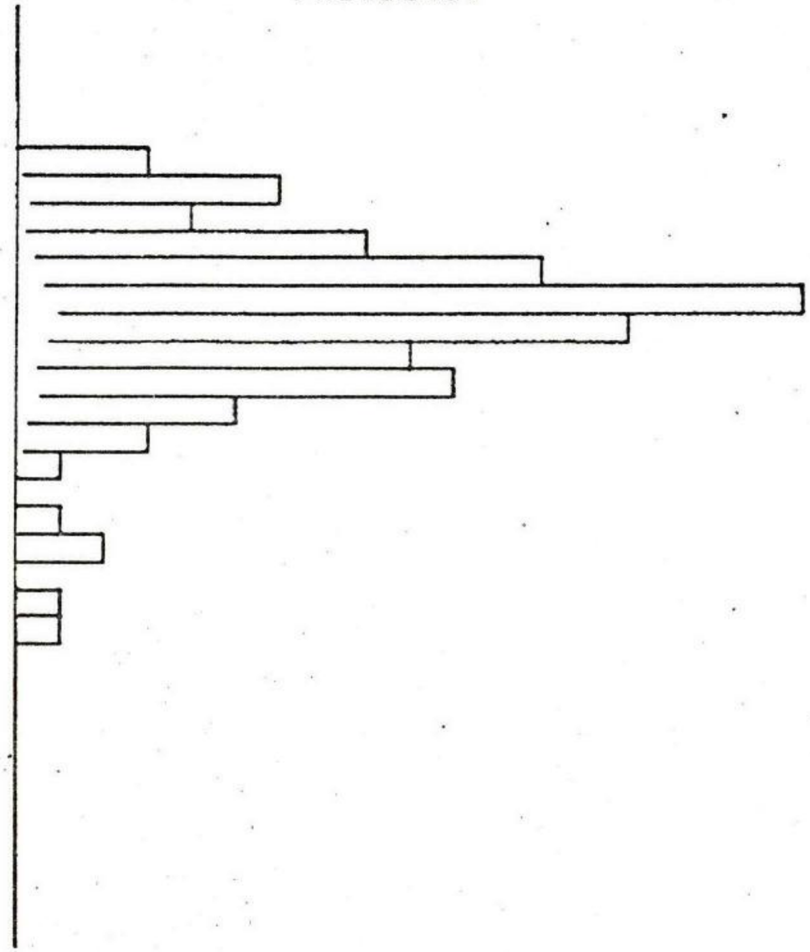
Road 7
Excavation
Men
Productivities

STATISTICS OF	ALL DATA	Ø.Ø TO 2.ØØØ
MINIMUM	.535Ø	.535Ø
MAXIMUM	2.17Ø	1.87Ø
AVERAGE	.991Ø	.9853
STANDARD DEVIATION	.29Ø6	.2795
NUMBER OF POINTS	2Ø9	2Ø8

$FINISHED?

FREQUENCY

0	- ∞	0.0
0	0.0	.06250
0	.06250	.1250
0	.1250	.1875
0	.1875	.2500
3	.2500	.3125
6	.3125	.3750
4	.3750	.4375
8	.4375	.5000
12	.5000	.5625
18	.5625	.6250
14	.6250	.6875
9	.6875	.7500
10	.7500	.8125
5	.8125	.8750
3	.8750	.9375
1	.9375	1.000
0	1.000	1.062
1	1.062	1.125
2	1.125	1.187
0	1.187	1.250
1	1.250	1.312
1	1.312	1.375
0	1.375	1.437
0	1.437	1.500
0	1.500	1.562
0	1.562	1.625
0	1.625	1.687
0	1.687	1.750
0	1.750	1.812
0	1.812	1.875
0	1.875	1.937
0	1.937	2.000
0	2.000	∞



Road 7
Excavation
Women
Productivities

STATISTICS OF	ALL DATA	0.0 TO 2.000
MINIMUM	.2550	.2550
MAXIMUM	1.330	1.330
AVERAGE	.6398	.6398
STANDARD DEVIATION	.2020	.2020
NUMBER OF POINTS	98	98

$FINISHED?

PRODUCTIVITY, M^3/MHR, ALL ACTIVITIES

ROAD NO 12 ID	NOBS	MEAN	STD.DEV.
2	9	.601	.2477
3	3	.649	.2111
4	5	.767	.5747
5A	8	.449	.1945
6	1	.667	.0000
9	3	.683	.2328
11	6	.560	.0869
13	11	.615	.1398
15	10	.811	.4598
16	1	.329	.0000
19	3	.559	.3074
20	2	.475	.3649
21	3	.473	.0907
23	1	.471	.0000
25A	11	.730	.1672
26	2	.556	.2107
27A	1	.743	.0000
29	1	.400	.0000
30	5	.444	.2411
33	1	.547	.0000
36	12	.712	.2642
39	4	.510	.2849
41	3	.586	.1330
46	13	.744	.2155
47	2	.646	.1697
49	13	.643	.2081
50A	13	.760	.2089
51	8	.580	.2725
52	11	.558	.1947
53	10	.811	.3377
54A	13	.648	.4188
58	5	.550	.2723
63	1	.844	.0000
64A	12	.840	.3672
69	4	.323	.1862
70	1	.588	.0000
71	2	.326	.3062
73A	1	.523	.0000
75	2	.411	.2786
76	14	.781	.3568
77	1	.566	.0000
78	2	.361	.2079
78A	2	.568	.2150
79A	3	.267	.1530
80	9	.817	.1756
81	1	.557	.0000
83	2	.564	.1450
84	3	.597	.0230
86	4	.663	.0918
87A	8	.652	.1847
88	3	.742	.0821
90A	8	.578	.1834
92	3	.548	.1532
94	11	.677	.2407
95	9	.895	.6257
96A	8	.811	.3905
97	14	.767	.2029
98	3	.527	.0414
99	3	.499	.2896
105	5	.549	.0648
106A	9	.443	.2523
107	10	.652	.1566
109	3	.550	.1444
110	6	.768	.2064

TASK TIME, HRS, ALL ACTIVITIES

ROAD NO 12 ID	NOBS	MEAN	STD.DEV.
2	9	4.861	1.8862
3	3	3.278	.6736
4	5	3.917	1.9194
5A	8	5.221	1.9138
6	1	7.500	.0000
9	3	3.083	.3333
11	6	3.822	.3361
13	11	4.661	1.9852
15	10	3.587	1.8817
16	1	6.083	.0000
19	3	4.444	1.2057
20	2	5.242	1.0489
21	3	4.500	1.0000
23	1	4.250	.0000
25A	11	3.462	1.6543
26	2	3.625	.6482
27A	1	2.250	.0000
29	1	5.000	.0000
30	5	6.403	1.4166
33	1	3.800	.0000
36	12	4.115	1.7797
39	4	4.508	1.2492
41	3	3.850	.3884
46	13	4.135	1.5130
47	2	4.167	.3536
49	13	4.438	1.6456
50A	13	3.710	1.7683
51	8	4.554	1.8465
52	11	4.853	1.6741
53	10	3.298	1.6478
54A	13	4.999	1.8843
58	5	5.250	2.1779
63	1	5.333	.0000
64A	12	3.935	2.0164
69	4	6.229	1.7137
70	1	4.250	.0000
71	2	6.083	.0000
73A	1	4.333	.0000
75	2	6.333	.3536
76	14	4.121	1.7059
77	1	4.417	.0000
78	2	6.292	.2946
78A	2	4.292	.4125
79A	3	7.039	.6834
80	9	3.230	.9809
81	1	2.667	.0000
83	2	4.417	.1179
84	3	4.806	.6787
86	4	4.171	1.1688
87A	8	4.069	1.1689
88	3	3.111	.4883
90A	8	3.579	.8767
92	3	3.694	1.0844
94	11	4.505	1.6348
95	9	4.693	2.1824
96A	8	3.910	2.0561
97	14	4.075	1.8791
98	3	4.639	1.1191
99	3	5.833	1.0639
105	5	4.017	.5725
106A	9	4.770	1.9962
107	10	3.770	.7617
109	3	3.900	1.1084
110	6	4.236	1.3202

RODUCTIVITY, ALL ACTIVITIES, M^3/M-HR

ROAD NO 7 ID	NOBS	MEAN	STD.DEV.
4	3	.648	.1102
7	2	.643	.0933
19	3	1.084	.4696
21	8	1.154	.1947
23	9	1.208	.2974
26	7	.862	.2686
31	10	1.144	.3074
34	4	.653	.1812
38	5	.904	.2410
48	6	.836	.2155
54	7	.786	.1885
76	3	.735	.2149
79	6	.722	.1427
85	7	.596	.1717
88	4	.612	.2060
90	3	1.459	.7270
95	3	.485	.3133
96	1	.947	.0000
106	1	1.060	.0000
109	2	.803	.0651
113	8	.944	.2964
114	6	.749	.3118
119	9	.605	.2610
121A	1	.444	.0000
122	7	.659	.1187
126	10	1.140	.2907
133	8	.796	.3375
135	7	.870	.2932
137	7	.731	.1438
143	5	.946	.2784
148	3	.814	.1355
149	7	.797	.2407
150	5	.681	.1710
151	5	.702	.1503
154	6	.501	.0929
155	9	.952	.3134
158	5	.523	.1135
160	7	.560	.1174
164	1	.909	.0000
165	3	.682	.0492
167	9	1.022	.2605
168	7	.902	.2401
171	8	.604	.1112
173	3	.938	.1518
174	8	.743	.1418
177	10	.906	.3423
178	1	.763	.0000
183	7	1.213	.2297
185	7	.873	.2873
186	6	1.018	.4599
189A	7	.902	.4227
190	6	.855	.5404
191	10	1.107	.2899
192	2	1.020	.2963
193	8	.624	.1725
194	10	.779	.2254
198	7	.750	.2796
199	6	.537	.1891
202	8	.923	.2467
205	2	.824	.1895

TASK TIME HRS, ALL ACTIVITIES,

ROAD NO 7 ID	NOBS	MEAN	STD.DEV.
4	3	4.294	1.0417
7	2	4.292	1.4731
19	3	3.306	.7087
21	8	3.473	.6695
23	9	3.217	.5659
26	7	4.381	.9560
31	10	3.625	.9845
34	4	5.342	.3643
38	5	4.000	.5980
48	6	4.375	.5838
54	7	4.769	.8137
76	3	4.333	1.0442
79	6	4.986	.7196
85	7	5.838	.9788
88	4	5.942	.9348
90	3	2.861	.9586
95	3	6.389	1.2285
96	1	4.083	.0000
106	1	3.217	.0000
109	2	5.042	.6482
113	8	3.715	.4290
114	6	5.042	1.5080
119	9	5.917	1.2775
121A	1	5.067	.0000
122	7	5.633	.8673
126	10	3.520	.7764
133	8	4.946	1.5064
135	7	4.019	.7860
137	7	5.105	.7737
143	5	3.807	.6434
148	3	4.889	1.1970
149	7	4.383	.8661
150	5	5.310	.9632
151	5	5.363	1.3093
154	6	6.139	.5366
155	9	4.472	1.1922
158	5	6.050	.7514
160	7	6.152	.5390
164	1	3.783	.0000
165	3	5.556	.6028
167	9	3.950	.8641
168	7	4.379	.9695
171	8	5.915	.5696
173	3	4.161	.7897
174	8	5.142	.9206
177	10	4.462	1.1521
178	1	5.250	.0000
183	7	3.140	.9271
185	7	4.250	.9936
186	6	4.103	1.1277
189A	7	4.464	1.2521
190	6	4.547	1.5817
191	10	3.712	.8268
192	2	3.875	1.3553
193	8	5.812	.7230
194	10	5.168	1.5717
198	7	5.669	1.2571
199	6	6.078	.9895
202	8	4.387	.8436
205	2	5.000	1.1785

ROAD NO 12

DITCHING

ID	NOBS	MEAN	STD.DEV.
2	1	0.676	0.0000
5A	2	0.268	0.0269
6	1	0.667	0.0000
13	1	0.465	0.0000
15	1	0.276	0.0000
25A	1	0.364	0.0000
30	2	0.285	0.0269
39	1	0.110	0.0000
49	2	0.322	0.1188
50A	1	0.313	0.0000
51	1	0.177	0.0000
52	2	0.520	0.3748
54A	2	0.356	0.0212
58	1	0.319	0.0000
64A	1	0.358	0.0000
69	3	0.244	0.1205
71	1	0.110	0.0000
76	1	0.511	0.0000
79A	2	0.340	0.1223
94	1	0.593	0.0000
95	2	0.305	0.1344
97	1	0.366	0.0000
106A	3	0.234	0.0679

DITCHING & SLOPING

ID	NOBS	MEAN	STD.DEV.
2	7	0.654	0.2103
3	3	0.649	0.2111
4	5	0.767	0.5747
5A	5	0.558	0.1631
9	1	0.489	0.0000
11	6	0.560	0.0869
13	8	0.659	0.1386
15	9	0.871	0.4450
19	1	0.356	0.0000
20	2	0.475	0.3649
21	1	0.376	0.0000
25A	9	0.785	0.1127
26	2	0.556	0.2107
27A	1	0.743	0.0000
30	2	0.700	0.1195
33	1	0.547	0.0000
36	10	0.765	0.2570
39	2	0.590	0.1138
46	10	0.777	0.2320
49	10	0.732	0.1337
50A	11	0.809	0.1699
51	6	0.684	0.2213
52	8	0.601	0.1442
53	10	0.811	0.3377
54A	9	0.733	0.4775
58	4	0.600	0.2769
64A	10	0.926	0.3391
69	1	0.560	0.0000
71	1	0.543	0.0000
73A	1	0.523	0.0000
75	2	0.411	0.2786
76	11	0.815	0.3053
78	2	0.361	0.2079
78A	1	0.416	0.0000
79A	1	0.121	0.0000
80	8	0.834	0.1796
81	1	0.557	0.0000
84	1	0.591	0.0000
86	4	0.664	0.0918
87A	8	0.652	0.1847
90A	8	0.578	0.1834
92	1	0.373	0.0000
94	9	0.721	0.2402
95	6	1.120	0.6459
96A	5	0.999	0.3765
97	11	0.834	0.1637
98	2	0.551	0.0106
99	2	0.352	0.1945
105	5	0.549	0.0648
106A	6	0.548	0.2461
107	10	0.652	0.1566
109	3	0.550	0.1444
110	3	0.597	0.1335

SLOPING

ID	NOBS	MEAN	STD.DEV.
2	1	0.154	0.0000
5A	1	0.267	0.0000
13	2	0.513	0.0509
25A	1	0.600	0.0000
30	1	0.253	0.0000
36	2	0.448	0.0728
46	3	0.634	0.1124
49	1	0.397	0.0000
50A	1	0.667	0.0000
51	1	0.361	0.0000
52	1	0.284	0.0000
54A	2	0.557	0.1655
64A	1	0.462	0.0000
76	2	0.728	0.7948
80	1	0.681	0.0000
94	1	0.371	0.0000
95	1	0.727	0.0000
96A	3	0.497	0.1155
97	2	0.599	0.0212

EXCAVATE SMALL Q[illegible]S.

ID	NOBS	MEAN	STD.DEV.
9	2	0.780	0.2284
16	1	0.329	0.0000
19	2	0.661	0.3564
21	2	0.521	0.0495
23	1	0.471	0.0000
29	1	0.400	0.0000
39	1	0.750	0.0000
41	3	0.586	0.1330
47	2	0.646	0.1697
63	1	0.844	0.0000
70	1	0.588	0.0000
77	1	0.566	0.0000
78A	1	0.720	0.0000
83	2	0.565	0.1450
84	2	0.600	0.0318
88	3	0.742	0.2821
92	2	0.636	0.0318
98	1	0.488	0.0000
99	1	0.793	0.0000
110	3	0.939	0.0285

ROAD NO 7

DITCHING

ID	NOBS	MEAN	STD.DEV.

-NIL-

DITCHING & SLOPING

ID	NOBS	MEAN	STD.DEV.
4	2	0.608	0.1195
7	1	0.577	0.0000
19	1	0.621	0.0000
23	1	0.620	0.0000
26	1	0.458	0.0000
34	1	0.392	0.0000
38	1	0.528	0.0000
48	1	0.467	0.0000
54	1	0.467	0.0000
76	1	0.538	0.0000
79	1	0.475	0.0000
85	1	0.353	0.0000
90	1	0.717	0.0000
113	2	0.555	0.0057
121A	1	0.444	0.0000
133	2	0.572	0.1457
135	3	0.661	0.0685
137	1	0.480	0.0000
143	1	0.528	0.0000
149	2	0.502	0.0417
150	1	0.428	0.0000
174	1	0.569	0.0000
177	2	0.600	0.0085
183	1	1.430	0.0000
185	2	0.589	0.1011
186	1	0.475	0.0000
189A	1	0.447	0.0000
190	2	0.479	0.0665

SLOPING

ID	NOBS	MEAN	STD.DEV.

-NIL-

BULK EXCAVATE

ID	NOBS	MEAN	STD.DEV.
4	1	0.730	0.0000
7	1	0.709	0.0000
19	2	1.315	0.3465
21	8	1.154	0.1947
23	8	1.281	0.2134
26	6	0.929	0.2204
31	10	1.144	0.3074
34	3	0.740	0.0610
38	4	0.998	0.1360
48	5	0.909	0.1314
54	6	0.839	0.1375
76	2	0.633	0.1853
79	5	0.771	0.0845
85	6	0.636	0.1471
88	4	0.613	0.2060
90	2	1.830	0.4808
95	3	0.485	0.3133
96	1	0.947	0.0000
106	1	1.060	0.0000
109	2	0.803	0.0651
113	6	1.074	0.2051
114	6	0.749	0.3118
119	9	0.685	0.2610
122	7	0.659	0.1187
126	10	1.140	0.2907
133	6	0.871	0.3594
135	4	1.027	0.3035
137	6	0.773	0.1004
143	4	1.051	0.1748
148	3	0.814	0.1355
149	5	0.915	0.1595
150	4	0.744	0.1114
151	5	0.702	0.1503
154	6	0.501	0.0929
155	9	0.952	0.3134
158	5	0.523	0.1135
160	7	0.560	0.1174
164	1	0.909	0.0000
165	3	0.682	0.0492
167	9	1.022	0.2605
168	7	0.902	0.2401
171	8	0.604	0.1112
173	3	0.938	0.1518
174	7	0.768	0.1330
177	8	0.983	0.3422
178	1	0.763	0.0000
183	6	1.177	0.2289
185	5	0.987	0.2539
186	5	1.126	0.4195
189A	6	0.978	0.4076
190	4	1.043	0.5864
191	10	1.107	0.2899
192	2	1.021	0.2963
193	8	0.624	0.1725
194	10	0.779	0.2254
198	7	0.750	0.2796
199	6	0.537	0.1891
202	8	0.923	0.2467
205	2	0.024	0.1895

The University of Birmingham

DEPARTMENT OF ECONOMICS
Faculty of Commerce and Social Science
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Kenya

ADC/LML

2nd November, 1978

Dr. M.C. Latham,
Cornell University,
Division of Nutritional Sciences,
Savage Hall,
Ithaca,
New York 14853,
U. S. A.

Dear Michael,

Thank you for the copy of your letter to Clell Harral of October 25th. I am a little worried that you may feel that I have been over-critical of the conduct of the current Kenya study. My role as I see it is to make a realistic assessment of the quality of the data and this is what I have tried to do. I accept that the conditions under which the study has been carried out have not been ideal and I am sure that the best has been done given the problems which have arisen.

I commented on the importance of accurate measurement of productivity in my letter of October 9th and you raised this in your letter of October 25th. These comments were meant to suggest that if we had a limited budget in some future study and could take say, 3 people to take measurements we might consider substituting one "productivity measurer" for one "anthropometric attribute measurer" but I do not know if this would be feasible.

I agree that the attainment of all the desirable qualities of my "perfect" project is unlikely to be possible but my intention was really only to give a ranking to the qualities that we would like a site to have.

I too expect that the data that has been collected will provide some useful information and if I am involved in its analysis I shall do all I can to obtain this.

Best wishes,
Yours sincerely,

Andrew Chesher

c.c. Dr. C. Harral
Mr. M. Sharrock

Pl. File Kenya File

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF
HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

October 27, 1978

Dr. Samir Basta
Nutrition Division
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Samir:

Many thanks for your letter of October 19 in which you comment on the Inception Report. We found the comments to be most useful. I will keep them in mind when we produce the next report which will I hope fill in some of the gaps that you mention.

I do hope that you and others at the Bank will remember that this is an "Inception Report", on a project that has only recently begun. It is meant to tell you what we are doing and not to provide results of research. We would appreciate it if the findings were neither quoted nor disseminated. The tables we provided are tentative and quite rough. No data have yet been put on punch cards, no use has yet been made of the computer, and no proper interpretation of findings has been attempted yet.

Now to some specific comments.

(1) Ages. Yes, we will analyze the data by age and also using several other social, economic and demographic parameters. We agree wholeheartedly that this is important.

(2) Food intake etc. We are obtaining detailed dietary information. This is mentioned in the first paragraph of P. 12 of the Inception Report where I also state "No analyses of the dietary findings or clinical examinations data have been completed." You must appreciate the huge amount of work involved in translating several hundred dietary recalls into nutrients consumed per person. It will therefore be quite a long time before these have all been analyzed. June Wolgemuth will run the highland data through the computer when she returns to Cornell. The findings and interpretation are things for the final report, not the inception report.

(3) Cost of experimental diet. We realize the discrepancy between the cost of the supplement and the amount that workers might be willing to pay. On page 17 of the Inception Report some reasons are given of why the full cost of meals or snacks should not be paid. The objective has been to find if workers were willing to pay a proportion of the cost.

(4) Hemoglobin levels.

(a) Your point is well taken. We will bring out this point in some future report.

(b) I agree that the WHO recommendation of 13 g% should be used for the cut off point. We will of course report all levels, but anemia in men should be

(as you suggest) a hemoglobin below 13 g/%. I reported these hematological findings in the Inception Report in the manner they were sent to me by Andrew Hall and Terry Elliott.

(5) Deworming Kwale workers. You raise an interesting point which we have considered. I agree in general with your comments. We have had discussions about this issue. At some future sites we probably will not deworm the men before providing the intervention. In the present Kwale studies we are seeing if we can demonstrate a different effect on hemoglobin of two dietary supplements (one of which is moderately high in iron and ascorbic acid, and one of which is not). In order to have the best possible chance of showing an effect we decided to deworm first. You will appreciate that it is extremely difficult (and has seldom been done) to show that an improved diet has a significant positive effect on hemoglobin levels over the short run. We know that the real life situation in Kwale is for people to have parasites and poor diets. If we do get a positive result we may try to see if we can get a similar result without deworming first. We are of course quite interested in the different responses to the two different supplements.

(6) Ascaris study in Kenya. We, like you, are somewhat disappointed that more children are not now worm free. We assume that many re-infections are taking place, and we hope that next year the percentage of children with Ascaris will be considerably further reduced. It will take time, of course, to interrupt transmission to a major degree. If you wanted a more detailed explanation, Lani could provide this.

We do appreciate your comments and thoughts on all aspects of the study. I hope that you will understand that this was a very preliminary, cautious and incomplete report. No scientists like to send off data and findings when a study has barely begun let alone been completed, and before the results so far collected have been properly tabulated, analyzed or interpreted. But IBRD requires us to furnish regular reports, and we want these to be as informative as possible. We do not want these reports to be regarded as results, or to be circulated widely except within the Bank. I hope that you will appreciate this.

With all good wishes.

Sincerely,

Michael

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

cc: Mr. Clell Harral
Mr. Emmerich Schebeck
Dr. D. Crompton
Dr. Lani Stephenson
Ms. J. Wolgemuth (please share with A. Hall)
Mr. T. Elliott

WORLD BANK / INTERNATIONAL FINANCE CORPORATION

OFFICE MEMORANDUM

TO: Mr. Samir S. Basta, Nutrition Expert, AGRNU   DATE: October 27, 1978

FROM: Emmerich M. Schebeck, Chief, AGRNU

SUBJECT: Nutrition and Productivity Research (RPO 671-73, RPO 671-71) - University of California Workshop

1. You will proceed to San Diego on or about October 29, 1978, following Prof. Doris Calloway's invitation and request for your attendance at the University of California international workshop (October 30-November 3) on nutrient intake, work performance and physical activity.

2. At the workshop, you will explore with the other members of the select panel, methods to standardize nutrition/productivity research worldwide, given your past and present work in this field. Results from the ongoing Kenya research project (RPO 671-73) will be discussed, and you should also attempt to integrate more fully in this and other research our recent concerns regarding timely and adequate baseline information on the sociological, behavioral and economic parameters needed to complement biochemical and clinical data. The influence of disease such as anemia in both uncompensated versus compensated labor situations should be explored per your earlier work in Indonesia. The possible need to separate or define limits to Western "perceptions" of productivity, time allocation, and motivation from current and future projects should also be tackled.

4. During these discussions, you will also take the opportunity to obtain and discuss with Dr. Michael Latham (Cornell University) his plans for an extension/reallocation of the Phase I component of the Bank-funded Kenya Nutrition and Productivity Research, and discuss with him his plan of action for the January/February 1979 field visits. In this regard, you should also ascertain the views of other researchers who will be present at the meeting, such as Drs. Viteri (Guatemala), Bliss (Oxford) and Churchman (California).

5. On your return on or around November 4, 1978, you should prepare a brief memo outlining the workshop results.

Cleared with and cc: Mr. J. Merriam, IPA

cc: Messrs. van der Tak, PAS
Yudelman, AGR
Christoffersen, AGR
Davis, AGR
Donaldson, AGR
Berg, AGR
Hamann, AGRNU
Greene, AGRNU
Cernea, AGR
Churchill, URB
Weiss, PAS
Lee, PAS
Golladay, PAS
King, DED

SSB:EMS:jm

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

A DIVISION OF THE NEW YORK STATE COLLEGES OF HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

File
Kenya

October 25, 1978

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

I was most interested to receive a copy of Andrew Chesher's letter of 9th October 1978 written to you. I very much appreciate the time and thought that he is giving to the project, and for many of his constructive suggestions. There might be some advantage in both Andrew and Mark writing directly to me instead of through you.

Andrew's last paragraph concerning the needs for any future study is a fine summation of most of the attributes necessary for the definitive study on nutrition and work output. He states "For any future study we require a site with a large static workforce who do arduous work under good incentives producing an easily measured output insensitive to in-site variations in conditions and to short-term climatic changes." These I am sure are the characteristics sought by Durnin in his studies around the world, the ones Viteri has been looking for in Guatemala, the sorts of conditions that Basta, Karyadi and his colleagues would like to have found in Indonesia, and certainly the ones we sought in Jamaica and in Kenya both in 1974 and this year. The unfortunate thing is that none of us have found these ideal conditions nor anything near it. That is why the questions trying to be answered by us and others have not been easily answered. I know of many of the leading nutritionists, physiologists, work study engineers and others who would follow Andrew Chesher around the world to help him with a project which satisfied these conditions. I doubt however that they exist in a real life situation in a work force where malnutrition is common. Therefore we have to do the best we can in any area where we are working.

We did try to use most of these criteria within the limitations imposed on us, one of which was to work within the Rural Access Roads Program.

I, too, regret that only a few days data are available on a sizeable number of workers and that Mark Sharrock, presumably out of necessity, used tasks that were of varying degrees of difficulty. In our earlier study we did (a) get a similar number of days of work on each worker, (b) use almost identical tasks for each worker doing ditching, or wheelbarrow work. I would have liked the same procedures to have been followed in 1978 but apparently this was not feasible.

The question concerning the representativeness of the workers is true. But it may be almost impossible to get a truly representative group. And anyway the testing whether a caloric supplement increases productivity may not require a truly representative sample. What really do we mean by representative (of the population of Kenya; of the work force in Kenya; or what?)? The inclusion of women, old persons and teenagers creates problems but in fact may be more representative than in our earlier study. I agree however that diversity is not a desirable attribute for our research purposes.

I am intrigued by the idea of the inclusion of extra workers at the post-intervention measurement stage in order to concentrate on the relationship between productivity and anthropometric attributes. Clearly Mark Sharrock should give priority to (1) getting adequate days of measurement on workers on whom good measurements exist from the base-line, (2) get an even number of days measurements on these workers--say 6 days per person (not 1 day for some and 15 for others), (3) should try to get tasks that are of similar difficulty, with similar soil type etc. (These were all attributes suggested for the base-line.) Having obtained these data it would in my view be excellent if Mark could get productivity data on extra workers as well, so that we can relate their productivity to anthropometric findings. I think this is an excellent suggestion. If this is done June Wolgemuth could easily obtain the anthropometric measurements.

Andrew's stress that in future studies sample size can be lessened if "investment is made in accurate measurement of productivity" is I believe absolutely true. I do hope that work study engineers can achieve this goal for us. However I do not quite understand the statement "It may be worthwhile spending proportionately less on anthropometric measurement and more on productivitiy measurement." Surely we need both to be accurately done. Does this refer to less effort and time? I do not believe that the two are competitive. Well trained nutritionists etc. can get reliable anthropometric measurements without a great deal of time invested and at little cost.

I really had put unrealistic hopes on the ability of Mark to get reliable productivity measurements for a good number of days on all of the subjects on whom we were able to do clinical, anthropometric and parasitological examinations. We were wrong, and despite all his efforts he could not do this. I am therefore a little concerned now that Andrew's letter, and remarks from other quarters are suggesting that the main problem is one of study design. All of us discussed the study (you, Samir, Andrew, Mark, June, other people at IBRD, presumably the ODM reviewers including Waterlow and others). None of us could predict the changed labor conditions nor the difficulties that Mark would encounter in getting the types of measurements called for in the protocol.

I still think that something useful may emerge from these data. I also believe that some advantage may accrue from learning from these mistakes and difficulties, and repeating a study in Kenya early next year. I see no value in wishing that things were different in June-July 1978 from what they actually were. Let us all do the very best we can, and let us all cooperate on what has to be done in November with the follow-up measurements and with any future study. If we do undertake a new worker productivity study and if your budget allows it then I think that Andrew should be asked to come out to Kenya at the beginning (say in February) with the work study engineer (who I understand from Mark may be someone different) and while I am still there. I would really welcome this.

I really do believe that this is the way we should operate.

With all good wishes,

Sincerely,

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd
cc: Andrew Chesher
Mark Sharrock (1 to U.K. and 1 to Kenya)
✓Samir Basta
June Wolgemuth

Cornell University
DIVISION OF NUTRITIONAL SCIENCES
Savage Hall
Ithaca, New York 14853

CC EMS
& file in my Kenya File.

A DIVISION OF THE NEW YORK STATE COLLEGES OF
HUMAN ECOLOGY AND AGRICULTURE AND LIFE SCIENCES
Statutory Colleges of the State University of New York

October 23, 1978

Mr. Clell Harral
Transportation Department
The World Bank
1818 H Street N.W.
Washington, D. C. 20433

Dear Clell:

I have now had news from Mark Sharrock that for personal reasons he can only afford to spend 4-5 weeks in Kenya beginning at the end of October. This means that he will do the final productivity measurements on the two roads near Karatina, but would not be able to do the base line on any new site. This then helps me to make a decision that I was about to make anyway. That is that we will not launch a new productivity study at least before February 1979 when I will be in Kenya. This will give me an opportunity first to assess with the help of Chesher, Sharrock and Wolgemuth the results of the first study and secondly to consider with my team and Peter Hopcraft possible other types of work besides RAR projects. But the feasibility of a different kind of study in terms of manpower, finances and authority from the Kenya government and ODM will need careful investigation.

Phil Green's suggestion of a study in Chad although an interesting idea is not really on the cards in the next year, nor will it be feasible under the present funding arrangement. You will remember that when I first approached the Bank concerning a continuation of our work in Kenya I was opposed to doing any further work which involved worker productivity measurements. I really felt, and still believe, that our other studies are of greater importance, of more relevance to Bank objectives and of more interest to the Kenya government. I think it terribly important if at the end of the project we can provide the World Bank and the Kenya Government with tested guidelines for (1) improving the health and nutritional status and reducing protein energy malnutrition in young children through routine low-cost deworming, (2) the feeding of workers engaged in hard physical activities, (3) the control of anemia either through supplementation with iron or through feeding programs, (4) for reducing the effects of prevalent and sometimes devastating diseases like hookworm, schistosomiasis and malaria, and (5) for what actions are appropriate in each particular ecological zone through a mapping of health, nutritional and related parasitic diseases in each of the four ecological zones to be studied.

We were not of course completely opposed to being pushed into a productivity study by ODM because we regard this also as an important project. But we realized that this would be difficult, and that it had a risk of not producing a positive result. We were able to forecast some of the problems that have now arisen, although others such as labor problems were not foreseen. We do intend to do our very best to try to demonstrate the effects on work output of worker feeding. We now have a little time to think about the problems and to decide on our next course of action. But I would stress that it is only a little time. If we are to do another study either on the Rural Access Roads or on an estate, then it

will have to be begun between January 15 and March 1 when I'll be in Kenya, and the final productivity measurements will have to be done 4-6 months later. Accordingly I have cabled Mark Sharrock asking him if he would be available for a few weeks beginning in February and again beginning in June 1979. If he was available, do you have funds to cover his travel and costs. If not, would an alternative be for one of our people (perhaps Terry Elliott) to do these measurements after getting instruction from Mark. This is not an alternative I favor, but it may be a necessary compromise. Yes

We do have an agreement with ODM to do these studies and so I feel obliged to do the best job we can.

I assume that you will have no objection to having Mark Sharrock while in Kenya in November consult with Peter Hopcraft about alternative sites for productivity studies and then perhaps visit one or two sites (perhaps agricultural or other) in order to say whether he thinks that measurable tasks exist. Perhaps one of the difficulties that we now have would not have arisen if Mark had been able to make a reconnaissance of the RAR sites a few months before he arrived to do the measurements. SB see this

I would appreciate your views and those of Samir's on my thoughts expressed here. will discuss in College

I have read with interest Andrew Chesher's comments. I appreciate these. I know that he is right about many things. But we all have to appreciate some of the limitations imposed by field studies. The ideal scientific and statistical design is not possible and the N cannot be decided by us but is dependent on factors beyond our control.

I appreciate the amount of time that you are spending on this project and the support that you have always given to us.

With all good wishes.

Sincerely,

Michael

Dr. Michael C. Latham
Professor of International Nutrition

MCL:dd

cc: Samir Basta ✓
Mark Sharrock
June Wolgemuth
Andrew Chesher
Peter Hopcraft