Preliminary draft
Please do not cite without permission

Adult health in the time of drought

September 1998

John Hoddinott, International Food Policy Research Institute

Bill Kinsey, Free University Amsterdam and University of Zimbabwe

Paper prepared for the IFPRI Workshop on Gender and Intrahousehold Supplemental Country Studies, Washington DC, September 17-18, 1998.

Address for correspondence:
John Hoddinott
International Food Policy Research Institute
2033 K Street NW
Washington DC 20006
United States of America
email: J.Hoddinott-IFPRI@cgnet.com

1. Introduction[1]

It is well known that households in developing countries experience fluctuations in incomes both inter- and intra-annually. A growing literature is exploring the extent to which households can smooth consumption in the face of these shocks. The principal result that emerges, as summarized in the recent reviews by Besley (1995), Morduch (1995) and Townsend (1995), is that some, but not all households can smooth consumption. In particular, households facing liquidity constraints have limited smoothing ability. For these households, therefore, income fluctuations will generate a welfare loss.

This paper contributes to this literature, but does so by examining a different measure of well being, namely the body mass of adults. We do so for four reasons. First, body mass index is a good proxy for underlying adult health which is a valid welfare outcome in its own right. Second, there is an increasing body of evidence linking adult BMI to agricultural productivity (Dercon and Krishnan, 1997; Strauss and Thomas, 1995; Pitt, Rosenzweig and Hassan, 1990) Third, it is correlated with a large number of health-related indicators, including mortality risk (Waaler, 1984 cited in Higgins and Alderman,

[1] Funding for data collection has been provided by the British Development Division in Central Africa, UNICEF and the former Ministry of Lands, Resettlement and Rural Development. Additional support was provided by grants in the United Kingdom from the Nuffield Foundation, the Overseas Development Institute, and the Department for International Development (formerly ODA). Assistance has also been received from the International Food Policy Research Institute, the Centre for the Study of African Economies at the University of Oxford, the Free University, Amsterdam, and the Research Board of the University of Zimbabwe. Supervision of data collection and initial cleaning were undertaken by Kinsey. Further cleaning, model specification and estimation and initial drafting were undertaken by Hoddinott, with the final drafting undertaken by Hoddinott and Kinsey. Research support from Trudy Owens and Alison Slack is gratefully acknowledged

1997). Fourth, it permits examination of the intra-household consequences of income shocks, something often not possible with household level data.

The paper examines this issue by drawing on a unique panel data set of households residing in rural Zimbabwe. Adult anthropometric data, together with other relevant individual, household and community data, were collected annually between 1994 and 1997. Over this period, there were two years of reasonably good rainfall, one poorish year and one drought. Our core finding is that, controlling for community, household and individual level fixed, unobservable effects, women, but not men, are adversely affected by the drought. However, these effects are not borne equally by all women. Daughters and heavier wives of the head appear to bear the brunt of this shock. Public interventions to mitigate the effects of drought appear to have had little effect on adult health.

The paper begins with a short conceptual framework, followed by a detailed description of the data. Basic results are presented, followed by extensions that consider distributional issues, the role of unobservables and the impact of public interventions.

2. Conceptual framework

Higgins and Alderman (1997) and Thomas, Lavy and Strauss (1996) outline the relationship between adult health and individual, household and community characteristics. The derivation, and notation, presented here draws heavily on their work.

Households are assumed to maximize utility over some time horizon subject to a budget constraint and those imposed by the technology through which inputs such as food and care generate health. This inter-temporal utility function can be written as:

$U = v(U_1, U_2, \ldots, U_T)$ for time periods 1 to T. (1)

Utility in each period is a function of consumption of goods (x), leisure (ℓ) and health status (h). This utility may also be affected by household characteristics (A_{ht}) such as its life cycle position, preferences for health and the education of household members. The utility function for time period t is:

$$U_t = u_t(x_t, \ell_t, h_t; A_{ht}) \qquad (2)$$

At this point, two further assumptions are made. First, as Deaton (1992) notes, the preferences implied by (1) are extremely general, allowing unlimited complementarities and substitutions across periods. Following Foster (1995) and Alderman et al. (1994), preferences are assumed to be inter-temporally additive or separable and that individual sub-utility functions are increasing and quasi-concave in their arguments. It is also assumed that there exists a household utility function. Although this is questionable on both theoretical and empirical grounds (Alderman, Chiappori, Haddad, Hoddinott and Kanbur 1995), the data available here will not permit implementation of a collective model of the household. Following the principal of Occam's razor, therefore, the simpler - though unrealistic - assumption of a unitary household is used instead.

The next step is to specify a health production function. Adult anthropometry in the current period depends on past health history (h_{t-1}), recent disease incidence (d_t), nutrient intake (N_t) and energy expenditure (E_t). Individual characteristics (z_t) such as age and sex will affect health outcomes through their impact on intrahousehold allocation, as in Pitt, Rosenzweig and Hassan (1990) as well as a direct effect. (For example, basal metabolic rates slow with age.) Household characteristics (z_{ht}) such as location and community characteristics (z_{ct}) such as availability of health care are also inputs in the health production function. Finally, ϵ_i captures characteristics of the adult such as inherent healthiness that are unobserved by the social scientist but which may, or may not, be known to the household.

$$h_{it} = h(h_{it-1}, d_t, N_t, E_t, z_{it}, z_{ht}, A_{ht}, z_{ct}, \epsilon_i) \qquad (3)$$

In the context of rural households, farm production (Y^h) will depend on characteristics of individual members, individual health status (whereby better health leads to improved labor productivity), capital stock and land endowments (K_t), other intermediate inputs (OI_{ht}) and locality characteristics (z_{ct}).

$$Y^h = y(z_{it}, h_{it}, K_{ht}, OI_{ht}, z_{ct}) \quad i = 1, \ldots, I \qquad (4)$$

Finally, note that individuals may contribute to household income via providing labor time, remittances or other transfers. These contributions are a function of wages, which will vary by sex (given labor market discrimination), education and age, health (via the links between health/child quality and productivity reviewed in Strauss and Thomas (1995) and community or cultural factors (θ)). For example, when daughters of the household head are married, the groom and his family are required to transfer resources in the form of cattle and money to provide compensation for the woman. These contributions can be expressed as:

$$R_{it} = r(z_{it}, h_{it}, \theta) \quad i = 1, \ldots, I \qquad (5)$$

Maximizing (1) subject to (3), (4) and (5) generates a set of first order conditions that can be solved out to yield a set of reduced form commodity and health demand functions. Under the assumption of inter-temporal separability, a standard result is that the discounted expected value of additional income is constant, implying as Alderman et al. (1994) and Foster (1995) point out, that analogous to a consumer durable, households will seek to smooth fluctuations in health. Accordingly, the reduced form health demand function takes the form (suppressing the individual subscripts):

$$h_t = f_t(z_{it} , A_{ht} , K_{ht} , z_{ht} \quad z_{ct} , \epsilon_i , \theta_t , \epsilon_i) \tag{6}$$

3. Data and model specification

(i) Background

Before specifying the model in detail, it is helpful to have some understanding of the history of households in this sample.

It is well known that access to land has long been an issue of major economic and political importance in Zimbabwe. Anger at the gross disparities in land ownership between blacks and whites was a major factor motivating armed rebellion against White minority rule. Upon gaining Independence, the Government of Zimbabwe announced a wide ranging programme of land reform, designed to redress these severe inequalities. A component of the land reform programme was the resettlement of households on farms previously occupied by white commercial farmers. The supply of land for resettlement was determined by the availability of areas which had been abandoned during the liberation war and also the general insecurity of European farmers in peripheral areas who were willing to sell. In most cases, these were the commercial farms contiguous or generally bordering the communal areas. The majority of land tended to be in the worst agro-ecological zones, 78 percent of resettlement occurred in zones III, IV and V, and only 22 percent in the more climatically favoured zones I and II.

These data are drawn from a random sample of approximately 400 such households located in three different resettlement schemes. These schemes were chosen so as to ensure representation in each of the major agro-ecological zones in Zimbabwe suited to cropping: Mupfurudzi in Mashonaland Central (which lies to the north of Harare in Zone II), Sengezi in Mashonaland East (which lies south east of Harare in Zone III) and Mutanda in Manicaland (which lies south east of Harare, but farther away than Sengezi and in Zone IV). Mupfurudzi, situated in the most favourable agro-climatic zone, receives the highest mean levels of rainfall and has the best quality soil. On average, it has higher levels of income and crop production than the other two schemes. Conversely, Mutanda which is situated in the worst agro-climatic region, with the lowest mean rainfall and poorer quality soils, consistently reports the worst income from crop production.

The criteria for selection into these schemes were, in descending order of priority: (i) refugees or other persons displaced by war, including extra-territorial refugees, urban refugees and former inhabitants of protected villages; (ii) those who were residing in Communal areas but were landless; and (iii) those who had insufficient land to maintain themselves and their families (Kinsey, 1982). At the time of settlement, the household heads were also supposed to be married or widowed, aged 25 to 50 and not in formal employment. Families selected for resettlement were assigned to these schemes, and the nucleated villages within them, largely on a random basis. Generally, these criteria seem to have been followed. In our sample, some 90% of households settled in the early 1980s had been adversely affected by the war for Independence in some form or another. Before being resettled, most (66%) had been peasant farmers with the remainder being landless laborers on commercial farms, workers in the rural informal sector or wage earners in the urban sector.

Individuals settled on these schemes were required to renounce any claim to land elsewhere in Zimbabwe. They were not given ownership of the land on which they were settled but instead were given permits covering occupancy of homes and for cultivation. Each household was allocated 5 hectares of arable land for cultivation, with the remaining area in each resettlement site being devoted to communal grazing land. Households were also allocated a residential plot within a planned village. In return for this allocation of land, the Zimbabwean government expected male heads of households to be farmers. Until 1992, male household heads were not permitted to work on other farms, nor could they migrate to cities, leaving their wives to work these plots.

These households were first interviewed over the period July-September 1983 to January- March 1984. They are located in 20 different villages (Two additional villages were added to the sample in 1993). Just over half (57%) are found in Mupfurudzi with 18% located in Mutanda and 25% found in Sengezi.   They were re-interviewed in the first quarter of 1987 and annually, in February and March, from 1992 to 1998. There is remarkably little sample attrition. Approximately 85% of households interviewed in 1983/84 are still in the sample. There is no systematic pattern to the few households that drop out. Some were inadvertently dropped during the re-surveys, a few disintegrated (such as those where all adults died) and a small number were evicted by government officials responsible for overseeing these schemes.

These particular characteristics of the sample provide it with properties that are desirable from the point of view of examining the determinants of adult health. First, there is no requirement to address biases brought about by *household* sample attrition. Second, as Rosenzweig and Wolpin (1988) have argued, examination of the impact of any public intervention is hampered by considerations of selective migration. There are strong *a priori* grounds for believing that this will not affect these results. Relocation of these households preceded, by a significant period of time, the droughts that occurred in the 1990s and which, as discussed below, is the principal focus of the study. Third, the availability of repeated observations makes it possible to control for any correlation between explanatory variables and fixed, unobserved characteristics. Fourth, as the survey is conducted at the same time each year, the impact of seasonality considerations is minimized. Fifth, the random allocation of households to plots of land, together with prohibitions on transfers, means that certain land characteristics such as distance to plots, number of plots, soil types and land slope, can be treated as exogenous. Sixth, the prohibitions on non-agricultural activities, together with the fact that each household received an identical quantity of land, implies that data on agricultural capital stock and livestock will provide a good proxy for household wealth and permanent income.[2] Seventh, each survey round records deaths that have occurred in the previous 12 months

---

[2] For example, Owens and Hoddinott (1998) find that every additional dollar of agricultural capital stock raises annual household income by about 30 cents.

and enumerators are instructed to probe carefully for all deaths. There are relatively few deaths in any one year, suggesting that these results are unlikely to be affected by selective mortality. Finally, it was not until after the 1991-92 drought that adult male heads were permitted to out-migrate. Rural-urban migration by males, together with temporary visits to rural areas, are an important mechanism by which HIV is passed from urban areas - where the disease is widespread - to rural areas. The presence of this prohibition, which appears to have been strictly enforced, provides an *a priori* reason for believing that HIV infection will play a much smaller part in explaining trends in adult health than might be the case in other parts of Zimbabwe or sub-Saharan Africa. Although we do not have direct evidence on HIV rates, we also note that there have been relatively few adult deaths from diseases such as tuberculosis, which are often HIV related, which is also suggestive of relatively low HIV prevalence in these areas.[3]

(ii) Trends in personal and household characteristics, 1994-97

Adult body mass measures were first collected in 1994 and so we have four rounds of data from this ongoing panel, 1994 to 1997 inclusive. It is important to note that not every adult in the household is measured. Heights and weights were only collected on those adults who had children aged 6 months to 6 years (1994, 1995 and 1996 rounds) and 6 months to 7 years (1997 round). We will return to the obvious selectivity issues

[3] Further indirect evidence underlying this claim comes from the 1997 survey round. Households were asked if they knew of anyone whom they believed had died from AIDS and if they knew of anyone who was living with HIV/AIDS. Affirmative answers to these questions were followed with the questions, "How many people altogether?" and "How many from this area". Mean values to these questions were: 3.22 deaths altogether; 0.92 deaths locally; 0.58 people living with HIV/AIDS; and 0.21 living locally.

that arise from this feature of the data later in the paper. At this point, we note that the first two agricultural seasons in this panel are recovery years following a major drought. The third year is a major drought and the final agricultural year a good one in terms of rainfall and crop production. This is shown in Table 1 which records mean rainfall levels by agricultural year and resettlement scheme. In examining these data, it is important to place them within the context of the seasonal cycles of these households. The Zimbabwean agricultural year runs from July to June. Planting typically occurs in October/November with harvesting occurring in May and June. The household survey takes place in February and March. The timing was deliberately chosen so as to interview households at the height of the hungry season. It does, however, mean that dating events can be somewhat confusing. Drought in the 1994-95 agricultural year implies that households potentially face severe food shortages in the year that *follows* as it will be a full 12 months before the next harvest is ready. Consequently, when examining the impact of this drought on adult health, the 'drought observation' will be 1996.

Trends in adult body mass indices (weight divided by the square of height) for men and women are reported in Figure 1 and Table 2. Figure 1 shows mean BMI adult body mass indices by year and sex. There is virtually no variation in male BMI's over this four year period. By contrast, women's mean BMI falls in 1996 by about three per cent. Table 2, based on the classification developed by James, Ferro-Luzzi and Waterlow (1988) indicates that this reduction did not lead to any perceptible increase in moderate or severe chronic energy deficiency. Table 3 describes other individual and household characteristics. A feature of these data is the decline in the proportion of women who are spouses of the household head, and the presence of women who are daughters and daughters-in-law of the household head. Recall that at the time of settlement male heads were aged between 25 and 50. As the sample literally ages, so too do the spouses of these heads. As they do so, they become less and less likely to have children aged six months to six years. Concurrently, there are an increasing number of women in these households who are daughters-in-law of the head. They, and their spouses find themselves in these households - rather than splitting off and forming a separate household unit - for two reasons. First, deteriorating economic prospects in urban areas are reducing the incentive to migrate. Second, the absence of a clear policy regarding land succession rights in these resettlement areas means that there is no land for these sons to operate that is separate from the land operated by their fathers. Daughters of the household are either young women who have had children out of wedlock, or increasingly women who have either separated or divorced their husbands and have returned to their natal homes.

Finally, note that these households appear to be accumulating assets, both livestock and agricultural capital stock.[4] Although the mean values presented here are based on a sample of children, not households (implying that trends are also affected by households dropping out or in of the sample), a similar trend is observed when the sample is household based (Kinsey, Burger and Gunning, 1998; Owens and Hoddinott, 1998).

---

[4] Agricultural capital stock is defined as those tools and equipment used in crop production. It includes the real value of the number of functioning ox-ploughs, scotch carts, cultivators/harrows, ox-planters, water carts, cotton sprayers, wheelbarrows, tractors and tractor equipment, hoes, axes, spades, machetes, slashers and trained oxen. Owens and Hoddinott (1998) provide further details on the construction of this variable. ** There is an error in the deflator used in the calculation of capital stock for years 1995, 1996 and 1997 which will be corrected in the next version of the paper. Preliminary work suggests that this will not alter the results presented here. **

(iii) Model specification

Recall that we seek to estimate the following relationship:

$$h_t = f_t(z_{it}, K_{ht}, A_{ht}, z_{ht}, z_{ct}, \theta_t, \epsilon_i) \quad (6)$$

We now describe the variables used to estimate (6). The dependent variable is the log of adult body mass index (BMI). Personal characteristics include log of height, log age, and years of completed schooling. These partly capture unobserved genetic endowments, as well as individual labor productivity and knowledge regarding how to combine inputs and activities so as to produce health (Higgins and Alderman, 1997). Individuals relationship to the household head are also specified, permitting examination of the extent to which BMI varies within the household, conditional on other factors.

Household productive assets (K_t) are the log of the real value of livestock and agricultural capital stock, acres of land that are sloped or steeply sloped and soil type. It is assumed that the stock of household assets at time t can be treated as pre-determined. Replacing these variables with their lagged (t-1) values, or using these t-1 values as instruments for the values at time t, does not alter the results presented here. Other household characteristics (z_{ht}) are time to fuel source if the individual is a woman, time to main plot and number of plots. These are included under the hypothesis that increased time costs will adversely affect health. Note that the random allocation of households to localities and plots of land implies that it is plausible to treat plot characteristics and time costs as exogenous.

Most household data sets do not collect data on household attitudes towards health and health care (A_{ht}). Although this is also the case for these data, there is available an interesting proxy for attitudes towards use of medical facilities. Approximately, 15 per cent of households in the sample are headed by individuals belonging to the "Apostolic" religious faith and another six per cent belong to the related "Johane Masowe" faith. Adherents to these faiths are prohibited from using western medical facilities. Direct inclusion of religion of head as a regressor proved to be uninformative. One reason for this is that these tenents may simply be ignored - there are cases where these women in these households give birth in clinics and their children are immunized. However, an alternative measure of these attitudes is available. The household questionnaire contains a module on illness and treatments in the previous four weeks. Households not seeking treatment for illnesses were asked why no treatment had been sought. One response was "religion forbids it." This variable - household has not sought medical treatment for serious illnesses on religious grounds - is included to capture attitudes towards health and health care.

Household location, by village, is captured via the inclusion of dummy variables for 21 of the 22 villages in the sample. This controls for time invariant village characteristics such as distances to roads, markets, health clinics, water and fuel supplies. This captures some, but not all, of the components of z_{ct} . In addition to the household data used here, as part of the survey work a short questionnaire is administered annually to local clinic staff. Results from these questionnaires were cross-checked against comparable information available held at the Ministry of Health. They were used to determine, *inter alia*, whether these clinics have experienced drug or staff shortages.

Finally, year dummies are included to capture other factors that vary by year. Recall that the 1994-95 drought implies that households potentially faced severe food shortages in the year that *followed.* For this reason, we refer to 1996 as the 'drought year'. The 1996 year dummy is interacted with gender in light of the preliminary finding reported in Figure 1 that women's BMI appears to fall in that year.

4. Results

(i) Basic findings

The next step is to specify an estimable version of (6): This is written as:

$$\text{BMI}_{it} = \;_{\mathbf{i}}\mathbf{'} \cdot \mathbf{X}_{\mathbf{it}} + \;_{\mathbf{H}}\mathbf{'} \cdot \mathbf{X}_{\mathbf{Ht}} + \;_{\mathbf{C}}\mathbf{'} \cdot \mathbf{X}_{\mathbf{Ct}} + \epsilon_i + \epsilon_H + \epsilon_C + \epsilon_t \qquad (7)$$

where:

BMI_{it} is log of adult body mass index; $\mathbf{X}_{\mathbf{it}}$ is a vector of individual characteristics at period t; $\mathbf{X}_{\mathbf{Ht}}$ is a vector of household characteristics at period t; $\mathbf{X}_{\mathbf{Ct}}$ is a vector of time varying community characteristics; $\;_{\mathbf{C}}\mathbf{'}$, $\;_{\mathbf{H}}\mathbf{'}$, **&** $\;_{\mathbf{C}}\mathbf{'}$ are parameters to be estimated (column vectors are indicated in bold); ϵ_i, ϵ_H, & ϵ_C are unobserved characteristics of the adult, household and locality that are assumed to not vary over time; and ϵ_t is a white noise disturbance term. The key change to note in moving from (6) to (7) is the explicit acknowledgment that certain relevant individual, household and community characteristics, are not observed in these data but will affect adult health outcomes.

Least squares estimates of (7) are reported in Table 4. The inclusion of a full set of village dummies together with the inclusion of year dummy variables implies that these results are robust to village and year invariant effects. A Lagrange multiplier test easily rejects the null that the disturbance terms are homoscedastic. Standard errors are corrected for heteroscedasticity using the Huber (1967) - White (1980) correction.[5] The F statistic rejects the null that the estimated coefficients are jointly zero.

As expected, both age and schooling are positively associated with body mass and height has a positive association with weight. A 1 per cent increase in height leads to a 1.3 per cent increase in weight. Evaluated at the mean, an additional centimetre of height causes weight to rise by just under 0.5 kilograms.[6] All these effects are well measured.

Household physical assets have a positive effect on adult BMI, but one that is not especially well measured. A number of the soil type dummies are positive and significant, most notably that for households with sandy loam soils. Adults in these

---

[5] It has been argued that these estimates can be adversely affected by a small number of outliers in the weighting matrix. Thomas (1994) argues that this can lead, on occasion, to dramatically understating standard errors and therefore overstating levels of significance. Deaton (1997) point to a second area of concern. This sample is derived from a two-stage process. First, within each resettlement scheme, villages were randomly selected. Within each village, households were then randomly selected. Clearly households in the same village will share some common characteristics. In a statistical sense, therefore, the disturbance terms are not independent. In results available on request, two additional estimates of coefficents' standard errors were calculated. The first of these, based on Mackinnon and White (1985), is robust in the presence of leverage points. The second, based on Rogers (1993) calculates robust standard errors in the presence of intra-cluster correlation. These alternative corrections have no substantive effects on the principal results presented here.

[6] As the coefficient on log height is negative, some additional explanation is helpful. Denote weight as w and height as h, for simplicity, ignore all other regressors and recall that BMI is defined as w/h^2. We have the following relationship: $\ln(w/h^2) = -0.698 \cdot \ln(h)$. We can re-write this as $\ln(w) = \ln(h^2) - 0.695 \cdot \ln(h)$ or $\ln(w) = 1.302 \cdot \ln(h)$. In this log-log specification, the elasticity is the coefficient on ln(h). Further, $\partial\ln(w)/\partial h = 1.302/h = 1/w \cdot \partial w/\partial h$ and so $\partial w/\partial h = w \cdot 1.302/h$. Mean weight is 57 kg and mean height 163 cm yielding an increase in weight of 0.46 kg for every additional 1 cm of height.

households have BMI's about 10 per cent higher than the reference group (households where soil quality is unknown). There may be a direct relationship running from soil quality to output to improved body mass. Alternatively, knowledge of soil type may reflect better knowledge about farming. Of the three time variables in the regression, only number of plots has a significant, negative relationship to BMI. Also consistent with prior expectations, living in a household that does not make use of western medical treatment is associated with lower body mass. Drug shortages in local clinics have an adverse effect, but staff shortage do not appear to significantly affect this health outcome.

Table 4 also finds that, controlling for all other characteristics, women in the drought year have significantly lower body masses. The coefficient indicates that these are about 1.8 per cent smaller than those of individuals in the reference group, male household heads in 1997.[7] In Table 5, the model is re-estimated replacing the drought year-gender interaction terms with drought year - relationship to the household interaction terms. This follows a suggestion found in Behrman (1988) that allocative decisions may be affected by short-run variations in household resources. A comparison Tables 4 and 5 suggests that although there is a drought effect on women, it does not appear to vary amongst women in the household.

---

[7] Halvorsen and Palmquist (1981) note that the percentage impact of a dummy variable on a logged dependent variable is $100 \cdot \{ \exp(c) - 1\}$ where c is the estimated coefficient. As c approaches zero, however, this expression and the actual coefficient converge.

(ii) Extensions: Quantile regressions[8]

There is a feature of these results that requires further attention. Return to the descriptive statistics reported in Table 2. These note the distribution of BMI's by sex and drought/non-drought year. They are consistent with Figure 1, namely that women's BMI's fall in drought years, but not men's. But they are also suggestive that the drop in BMI is concentrated amongst heavier women. The proportion of women considered overweight falls by about 14 per cent in the drought year. (Also recall that the data are heteroscedastic.) Although we may be generally concerned about the adverse effect of drought on health status, it is clearly relevant whether this effect is common across all women, concentrated amongst less healthy women (which would increase our concerns) or amongst overweight individuals (which perhaps would lessen our concern). The quantile regression techniques proposed by Koenker and Bassett (1978, 1982) and described in Deaton (1997) provide a natural mechanism for doing so.

Table 6 reports the results of five quantile regressions corresponding to the 10th, 33rd, 50th (median), 67th and 90th centiles as well as, for the purposes of comparison, the least squares results reported in Table 4. These are obtained by simultaneously estimating quantile regressions for each specified centile and then obtaining the variance-covariance matrix by bootstrapping (Gould, 1997). Note the close correspondence between the least squares and median quintile results, suggesting that any outliers in the data are not unduly influencing the least squares results. But of much greater interest are the parameters on schooling, clinic drug shortages and the interaction term between gender and the dummy

[8] Our thanks to Emmanuel Skoufias for assistance in developing the material presented here.

for the drought year, 1996. Moving from the 10th to the 90th centiles is associated with an increased positive effect of education, and increased negative effects of drug shortages and drought if a woman. Higher levels of educational attainment appears to increase both the levels and dispersion of BMI, whereas drug shortages reduce both.[9] Most importantly, the drought-gender interaction term is not constant across centiles. The largest effect is found at the 90th centile, suggesting that the drought has its strongest effect amongst (given their height) heavier women. The difference between these estimates is statistically significant at the 10 per cent confidence level.

The finding that the adverse effects of drought are felt most strongly by those women with greatest body mass might temper our concerns regarding the impact of the drought. However, in Table 7, this gender dummy is broken down by different relationships to the household head. This tells a somewhat different story. At the lower end of the BMI distribution, daughters of the head appear to be especially adversely affected by the drought. By contrast, at the upper end of the distribution, it is wives, other female relations and female heads who are adversely affected.

(iii) Extensions: Accounting for unobservables

We now turn to an additional concern. Recall that our empirical specification (7) contained unobserved characteristics of the adult, household and locality that are assumed to be time invariant as well as a white noise disturbance term. Although locality effects

[9] It should be noted, however, that these effects are significantly different at only the 20 per cent confidence level.

are controlled for via the inclusion of village dummy variables, unobserved household and individual characteristics are assumed in Tables 4 through 7 to be randomly distributed and hence are incorporated into the disturbance term. However, there are good reasons for testing this assumption. First, there are likely to be unobserved individual characteristics - such as innate healthiness - that will affect body mass. Second, recall that although household selection is random, individual selection is not. Adults are only measured if they have a preschooler (aged over 6 months) living with them in the household. This selectivity is another factor that may bias our results.

Table 8 presents individual fixed effects estimates of the determinants of log body mass. An F test easily rejects the null hypothesis that these individual unobservables have no effect, as does a Lagrange multiplier test in the case of a (not reported) random effects estimation. A Hausman (1978) test rejects the null that these unobservables are randomly distributed across the sample. There are two key findings. First, the drought gender interaction term has a coefficient of -0.022 (absolute value of t statistic 3.248), a result very similar to the OLS results reported in Table 4. Second, controlling for unobservables, daughters of the household head fare especially poorly, losing about four per cent of BMI.

(iv) Extensions: Assessing the impact of the grain loans scheme

The 1994-95 drought did not go unremarked in Zimbabwe. Its aftermath saw the implementation of two anti-hunger interventions. A supplementary feeding - consisting of a daily meal of maize porridge mixed with ground nuts and some cooking oil - was provided to children under the age of five years. The second component was a notionally targeted grain loan program. Rather than provide households with outright transfers of maize, the intention was that these would be loans, repayable after the next (1995-96) harvest. Households were required to apply for these loans, with these applications vetted at the local, district level In practice, the scheme appears to have been largely untargeted. In these survey areas, 87 per cent of all household received loans. There was virtually no variation in the amount of grain allocated across households regardless of income or wealth levels. In practice, households received about one-quarter of their request.[10]

Table 9 reports several estimates of the impact of the grain loan on body mass. The first row is taken from a least squares specification comparable to that reported in Table 4, but with the amount of the grain loan received interacted with both drought year and gender dummies. Note that the amount of the grain loan received is treated as exogenous - instrumental variables estimation of its impact does not alter the results presented here. Three quantile regressions are also reported, based on the 10^{th}, 50^{th} and 90^{th} centiles. There is one significant effect picked up. Centering on the 10^{th} centile, it is observed that the grain loan improves the BMI of adult males, but not females. However, the effect is rather small. An increase in the grain loan of 100kg increases the body mass index by 0.5 per cent.

5. Conclusions

[10] In practice, few households actually repaid these loans, largely because no government agency appears to have bothered to collect these payments.

This paper has examined the impact of the 1994-95 drought on the health of adults in rural Zimbabwe. It is argued that women, but not men, were adversely affected by this event, with women's BMI's falling by about two percent in a regression controlling for unobserved time invariant individual, household and community effects. This effect is not uniform across all women. Daughters of the household head appear to be especially vulnerable.

In a companion paper to this one, we investigate the impact of the 1994-95 drought on the growth (in stature) velocities of children aged 12-24 months (Hoddinott and Kinsey, 1998). We come to a remarkably similar conclusion to the findings reported here. Specifically, the drought lowers annual growth rates for these children by somewhere between 1.5 and 2 cm. This adverse effect is most pronounced amongst children whose mothers are themselves daughters of the head. The vulnerability of this group - daughters of the head and children of these daughters - deserves further comment.

Changes in body mass reflect changes in the balance between energy intake and energy needs. We hypothesize that during drought, there is relatively little change in the energy needs of these women. In particular, we suspect that they may have continued responsibilities for household reproductive activities such as the carriage of water and fuel. To the extent to which these resources become more scarce during drought, or if these women are forced to seek employment outside the household, energy needs might actually increase. At the same time, the position of these women in the household is somewhat ambiguous. Women who have returned to the household following failed marriages are sometimes stigmatized (Armstrong, 1997) and there may be an expectation that the woman will return to her husband. In such circumstances, the household head may decide to limit the amount of resources made available to such daughters (and the daughters children) and these women will have little bargaining power within the household. Unmarried daughters who have had children out of wedlock may face similar constraints within their households.

Finally, we note that these results are preliminary and that there are a number of areas where further work is warranted. In particular, we are aware that our model specification and estimation requires further attention. Specifically:

- there are good arguments for including recent illness and expressing certain regressors (such as asset holdings) in per capita terms. Doing so, however, requires us to address plausibly address the endogeneity of these variables;
- as noted in footnote 4, there is an error in the deflator used to calculate certain components of capital stock. Experimentation suggests that this is unlikely to affect these results;
- we should probably exclude pregnant women from the sample. However, we suspect that there are relatively few such observations
- finally, we do not yet have a good explanation for the failure of the grain loans scheme to protect BMI's (and we note that it does affect child growth either). Given that this was the main vehicle for drought relief, this warrants further examination.

References

Alderman, H., P. Gertler, J. Strauss and D. Thomas. 1994. The dynamics of child growth and household resources. Santa Monica CA: RAND Corporation, work in progress.

Alderman, H. P.A. Chiappori, L. Haddad, J. Hoddinott and R. Kanbur. 1995. Unitary versus collective models of the household: Is it time to shift the burden of proof? *World Bank Research Observer* 10: 1-19.

Armstrong, A. 1997. *Struggling over scares resources: Women and maintenance in Southern Africa* (Harare: University of Zimbabwe Press).

Behrman, J. 1988. Intrahousehold allocation of nutrients in rural India: Are boys favored? Do parents exhibit inequality aversion. *Oxford Economic Papers* 40: 32-54.

Behrman, J. and A. Deolalikar. 1988. Health and nutrition in *Handbook of development economics* vol 1 ed by H. Chenery and T.N. Srinivasan (Amsterdam: North Holland).

Besley, T. 1995. Nonmarket institutions for credit and risk sharing in low-income countries. *Journal of Economic Perspectives* 9: 115-124.

Deaton, A. 1992 *Understanding consumption* (Oxford: Clarendon Press).

Deaton, D. 1997 *The analysis of household surveys* (Baltimore: Johns Hopkins University Press).

Dercon, S. and P. Krishnan. 1997. In sickness and in health: Risk-sharing within households in rural Ethiopia. mimeo, CSAE Oxford.

Foster, A. 1995. Prices, credit markets and child growth in low-income rural areas *Economic Journal* 105: 551-570.

Gould, W. 1997. Interquantile and simultaneous quantile regression. *STATA Technical Bulletin* 38: 14-22.

Halvorsen, R. and R. Palmquist. 1981. The interpretation of dummy variables in semilogarithmic equations. *American Economic Review* 71: 474-475.

Hausman, J. 1978. Specification tests in econometrics. *Econometrica* 46: 1251-1271.

Higgins, P. and H. Alderman. 1997. Labor and women's nutrition: The impact of work effort and fertility on nutritional status in Ghana. *Journal of Human Resources* 32: 577-595.

Hoddinott, J. and B. Kinsey. 1998. Child growth in the time of drought. mimeo, International Food Policy Research Institute, Washington D.C.

Huber, P. 1967. The behavior of maximum likelihood estimates under non-standard conditions in *Proceedings of the Fifth Berkeley Symposium in Mathematical Statistics and Probability*. Berkeley CA: University of California Press.

James, W., A. Ferro-Luzzi and J. Waterlow. 1988. Definition of chronic energy deficiency in adults. *European Journal of Clinical Nutrition* 43: 969-981.

Kinsey, B. 1982. Forever gained: Resettlement and land policy in the context of national development in Zimbabwe. *Africa* 52: 92-113.

Kinsey, B., K. Burger and J. Gunning. 1998. Coping with drought in Zimbabwe: Survey evidence on responses of rural households to risk *World Development* 26: 89-110.

Koenker, R. and G. Bassett. 1978. Regression quantiles *Econometrica* 46: 33-50.

Koenker, R. and G. Bassett. 1982. Robust tests for heteroscedasticity based on regression quantiles *Econometrica* 50: 43-61.

MacKinnon, J. and H. White. 1985. Some heteroscedasticity consistent covariance matrix estimators with improved finite sample properties. *Journal of Econometrics* 29: 305-325.

Murdoch, J. 1995. Income smoothing and consumption smoothing. *Journal of Economic Perspectives* 9: 103-14.

Owens, T. and J. Hoddinott. 1998. Investing in development of investing in relief? Quantifying the poverty tradeoffs using Zimbabwe household panel data, mimeo, International Food Policy Research Institute, Washington D.C.

Pitt, M., M. Rosenzweig and MD Hassan. 1990. Productivity, health and inequality in the intrahousehold distribution of food in low income countries *American Economic Review* 80: 1139-1156.

Rogers, W. 1993. Regression standard errors in clustered samples. *STATA Technical Bulletin* 13: 19-23.

Rosenzweig, M. and K. Wolpin. 1988. Migration selectivity and the effects of public programs *Journal of Public Economics* 37: 265-289.

Strauss, J. and D. Thomas. 1995. Human resources: Empirical modeling of household and family decisions in *Handbook of development economics* vol 3 ed by J. Behrman and T.N. Srinivasan (Amsterdam: North Holland).

Thomas, D. 1994. Like father, like son: Like mother, like daughter: Parental resources and child height *Journal of Human Resources* 29: 950-988.

Thomas, D., V. Lavy and J. Strauss. 1996. Public policy and anthropometric outcomes in the Cote d'Ivoire. *Journal of Public Economics* 61: 155-192.

Townsend, R. Consumption insurance: An evaluation of risk-bearing systems in low-income countries. *Journal of Economic Perspectives* 9: 83-102.

White, H. 1980. A heteroscedasticity-consistent covariance matrix and a direct test for heteroscedasticity *Econometrica* 48: 817-838.

World Bank. 1993. *World Development Report: Investing in health* (New York: Oxford University Press).

Table 1: Rainfall by agricultural year and resettlement scheme

Agricultural Year	Resettlement scheme		
	Mupfurudzi	Sengezi	Mutanda
1992-93	736	723	571
1993-94	794	531	562
1994-95	510	410	369
1995-96	900	565	846

Notes:
1. Rainfall stations used are: Mupfurudzi resettlement (Mupfurudzi); Bita (Sengezi) ; and Stonedale farm (Mutanda)

Table 2: Distribution of nutritional status (Chronic energy deficiency) by sex and drought/non-drought years

		Women		Men	
BMI Range	Classification	Non-drought years	Drought year	Non-drought years	Drought year
> 23.0	Overweight	28.5	24.7	22.5	22.0
18.5 - 23.0	Normal	58.6	60.8	64.9	64.7
17.0-18.5	Normal to mild CED	9.5	11.7	9.3	10.3
16.0-17.0	Mild to moderate CED	2.7	2.2	2.3	3.0
< 16.0	Severe CED	0.7	0.6	1.0	0

Notes:
1. Classification of Chronic energy deficiency (CED) based on James, Ferro-Luzzi and Waterlow (1988).

Table 3: Trends in adult and household characteristics, 1993-97

Variable means at time of observation	Year of observation					
	1994	1995	1996	1997		All Observations
Personal characteristics						
Body mass index: Men *Women*	21.7 *22.2*	21.3 *22.1*	21.3 *21.5*	21.6 *22.0*		21.5 *21.9*
Age	35.1	35.6	35.6	35.7		35.5
Years schooling	6.2	5.8	6.3	6.7		6.3
Height	162.6	163.3	163.9	163.4		163.4
Relationship to head (per cent)						
Male head	19.4	25.4	22.9	21.7		22.5
Female head	1.6	0.6	0.4	0.6		0.7
Wife	36.6	33.4	31.0	28.2		31.7
Son	7.7	7.8	13.3	14.7		11.3
Daughter	11.5	8.0	6.1	6.8		7.8
Daughter-in-law	17.8	17.6	19.2	21.8		19.4
Other	5.4	7.2	7.1	6.2		6.6
Household characteristics						
Real (1993 Zimbabwe dollars) value of agricultural capital stock	12263	21690	22831	29356		22626
Real (1993 Zimbabwe dollars) value of livestock	3787	7324	10837	14329		9770
Sample size	366	476	520	614		1976

Table 4: Least squares (village effects) determinants of log adult body mass index

Variable	Estimated coefficient	Absolute value of t statistics based on Huber-White standard errors
Personal characteristics		
Log height	-0.698	6.778**
Log age	0.093	5.584**
Years of completed schooling	0.005	4.039**
Female household head	0.071	3.287*
Wife	0.027	1.919*
Daughter	0.014	0.766
Daughter-in-law	0.004	0.253
Other female relation	-0.009	0.402
Son	0.012	1.023
Other male relation	0.021	1.325
Household characteristics		
Log of real value of livestock and agricultural capital stock	0.0015	1.501
Acres of land holdings that are steeply sloped	-0.001	0.241
Soil type: Sandy	0.050	1.862*
Sandy loam	0.026	1.356
Loam	0.107	3.204**
Clay loam	0.052	2.547**
Red clay	0.034	1.694*
Black clay	0.018	0.729
Time to fuel source if woman	0.0008	0.487
Time to main plot	-0.0007	0.469
Number of plots	-0.009	2.958**
Attitudinal characteristics		
Has not sought medical treatment on religious grounds	-0.025	1.880*
Year of observation		
1994	-0.017	1.248
1995	0.018	1.185
1996 and male	0.003	0.255
1996 and female	-0.018	1.825*

Settlement characteristics		
Local clinic experiences drug shortages	-0.052	2.486**
Local clinic experiences staff shortages	0.023	1.239
Constant	6.235	11.604**
F Statistic		8.59**
Adjusted R2		0.166

Notes:
1. Dependent variable is log of body mass index.
2. Sample are adults with a child aged 6 to 72 months currently residing in the household.
3. Omitted category is a male household head, measured in 1997, residing in Tongogara village (Mupfurudzi resettlement scheme), where household soil type is known and where the household is not prevented, on religious grounds, from seeking (western) medical treatment.
4. Breusch-Pagan Lagrange Multiplier test for heteroscedasticity = 263.1 (prob value = 0.000).
5. Calculating asymptotic t statistics based on Mackinnon-White (jacknife) standard errors or based on robust (cluster) effects does not significantly alter the pattern of statistical significance reported here.
6. * significant at the 10% level; ** significant at the 5% level.
7. Also included, but not reported are a complete set of village dummy variables. Expressing the dependent variable in levels yields comparable results.
8. Sample size is 1831.

Table 5: Disaggregating drought effects by relationship to household head

Variable	Estimated coefficient	Absolute value of t statistics based on Huber-White standard errors
Interacting drought year with relationship to household head		
Female household head	-0.027	1.193
Wife	-0.023	1.582
Daughter	-0.010	0.391
Daughter-in-law	-0.015	1.077
Other female relation	-0.005	0.149
Male household head	0.003	0.170
Son	0.001	0.068
Other male relation	0.013	0.485

Notes:
1. Dependent variable is log of body mass index.
2. Sample and specification as per table 4.
3. * significant at the 10% level; ** significant at the 5% level.

Table 6: Comparing least squares and quantile regression results for selected regressors

Centile	log height	schooling	log assets	clinic experiences drug shortages	1996 and female
10	-0.598 (4.369)**	0.003 (1.737)*	0.0025 (1.456)	-0.019 (0.638)	-0.005 (0.280)
33	-0.656 (9.780)**	0.003 (1.724)*	0.0024 (1.975)**	-0.038 (1.332)	-0.005 (0.554)
50	-0.706 (7.985)**	0.005 (2.666)**	0.001 (1.498)	-0.059 (1.993)**	-0.013 (1.581)
67	-0.752 (5.419)**	0.004 (3.016)**	0.0025 (2.401)**	-0.088 (2.399)**	-0.022 (1.710)*
90	-1.001 (4.922)**	0.007 (3.368)**	0.0018 (0.909)	-0.071 (2.544)**	-0.043 (2.747)**
OLS	*-0.698* *(6.778)***	*0.005* *(4.039)***	*0.0015* *(1.501)*	*-0.052* *(2.486)***	*-0.018* *(1.825)**

Notes:
1. Dependent variable is log of body mass index.
2. Sample and model specification as per table 4.
3. Centiles refer to estimation of quantile regressions at the 10th, 33rd, 50th, 67th and 90th centiles.
4. Twenty bootstrap replications are used to obtain the estimated variance-covariance matrix.
5. * significant at the 10% level; ** significant at the 5% level.
6. Sample size is 1831.

Table 7: Quantile regression estimates of drought effects by relationship to household head

Centile	Female head	Wife	Daughter	Daughter-in-law	Other female relation
10	0.033 (1.016)	-0.028 (1.428)	-0.064 (2.027)**	0.020 (1.230)	0.032 (0.625)
33	-0.003 (0.088)	-0.014 (0.987)	0.030 (0.741)	0.0002 (0.015)	0.061 (1.994)**
50	-0.027 (0.525)	-0.014 (0.967)	-0.005 (0.196)	-0.018 (0.991)	0.011 (0.356)
67	-0.024 (0.654)	-0.021 (1.271)	-0.032 (0.816)	-0.015 (0.799)	-0.033 (0.742)
90	-0.073 (1.293)	-0.043 (1.756)*	-0.031 (0.591)	-0.014 (0.570)	-0.076 (1.918)*

Notes:
1. Dependent variable is log of body mass index.
2. Sample and model specification as per table 5.
3. Centiles refer to estimation of quantile regressions at the 10^{th}, 33^{rd}, 50^{th}, 67^{th} and 90^{th} centiles.
4. Twenty bootstrap replications are used to obtain the estimated variance-covariance matrix.
5. * significant at the 10% level; ** significant at the 5% level.
6. Sample size is 1831.

Table 8: Determinants of adult body mass index controlling for unobservable individual effects

Variable	Estimated coefficient	Absolute value of t statistics
Drought interaction terms		
Female household head	-0.032	0.487
Wife	-0.024	2.856**
Daughter	-0.044	2.085**
Daughter-in-law	-0.016	1.412
Other female relation	0.028	0.719
Male household head	-0.011	1.180
Son	-0.007	0.477
Other male relation	-0.007	0.205
Household characteristics		
Log of real value of livestock and agricultural capital stock	0.001	1.113
Settlement characteristics		
Local clinic experiences drug shortages	-0.033	2.274**
Local clinic experiences staff shortages	0.018	1.531
F statistic on joint significance of regressors		1.74**
F statistic on joint significance of individual dummies		6.916**
Lagrange multiplier test comparing OLS and (not reported) random effects		741.89**
Hausman test comparing (not reported) random and fixed effects estimates		35.59**

Notes:
1. Dependent variable is log of body mass index.
2. Sample are adults with a child aged 6 to 72 months currently residing in the household observed twice, three or four times.
3. * significant at the 10% level; ** significant at the 5% level.
4. Also included, but not reported are dummy variables for year of observation 1994 and 1995.
5. Estimating the model using drought year interacted with gender yields a coefficient for women of -0.022 (t statistic 3.248**)
6. Sample size is 1610. There are 579 individuals in the sample with an average of 2.78 observations per person.

Table 9: Impact of grain loans on adult body mass

Centile	Amount of grain loan received (x 100) x drought year x male	Amount of grain loan received (x 100) x drought year x female
OLS	*0.00008* *(0.053)*	*-0.002* *(1.270)*
10	0.005 (2.379)**	-0.0009 (0.487)
50	-0.027 (0.525)	-0.004 (1.738)*
90	0.003 (1.128)	0.0002 (0.050)

Notes:
1. Dependent variable is log of body mass index.
2. Sample and model specification as per table 4.
3. Centiles refer to estimation of quantile regressions at the 10th, 50th, and 90th centiles.
4. Twenty bootstrap replications are used to obtain the estimated variance-covariance matrix for the quantile regressions.
5. * significant at the 10% level; ** significant at the 5% level.
6. Sample size is 1831.