The impact of the AIDS epidemic on the health of the elderly in Tanzania

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"Bena Nakayima has buried four of her children, dead from AIDS, beneath the bananas next to her packed, mud homestead. … Two more of her children are buried elsewhere… In her 70s and a widow, [she] has come to be the caretaker for 35 grandchildren orphaned by her children's deaths. At an age when she expected to be "laughing with my children", she is instead searching for ways to feed her grandchildren."[1]

I. Introduction

High HIV infection rates in Sub-Saharan Africa are producing dramatic increases in the mortality of prime-aged adults. As of the end of 1999, an estimated 24.5 million Africans were living with HIV/AIDS, accounting for more than 70% of all global infections (UNAIDS 2000). In Tanzania an estimated 1.3 million people out of a total population of nearly 33 million were believed to be infected with HIV and 140,000 had already died of AIDS. The estimated infection rate among prime-aged adults (aged 15-49) was 8.1%, or about one in every 12 adults. In neighboring Uganda, a study of Masaka District found that when HIV prevalence reached this level, two-thirds of all adult mortality was due to AIDS (Nunn et al 1997). The probability of death for a 15 year old in Masaka before reaching 60 had already reached 61%, while in the absence of HIV/AIDS it would have been only 24% (Boerma et al 1998).

The high mortality of prime-aged adults due to AIDS has left in its wake orphaned children and elderly in households with fewer breadwinners to support them (Barnett and Blaikie 1992; Hunter and Williamson 1998; National Research Council 1996; World Bank 2000). African couples have large families in part because of the role of adult children in supporting their parents in old age. However, as a result of the AIDS epidemic, the elderly are often the caregivers for their adult children stricken with HIV/AIDS, the guardians of orphaned grandchildren, and substitute workers for ill or deceased adults in the home and on the farm. In Uganda, nearly a third of AIDS patients were cared for by their parents in 1995 (Ntozi and Nakayiwa 1995). In Northwestern Tanzania, more than a quarter of sick household members are cared for by those 50-65 (Beegle 1998). In Thailand, elderly parents were the main source

[1] Drusilla Menaker, "Elderly are left to raise orphans: Disease's toll stretches their limited means", *Dallas Morning News*, December 28, 1999.

of finance for medical care for 60% of the AIDS patients who lived with their parents while ill, for 40% of the AIDS patients who lived adjacent to their parents and for about 25% of the AIDS patients whose parents lived elsewhere (Knodel et al 2000).[2] Up to now, however, most of what is known about the impact of AIDS on the elderly is anecdotal, based on case studies of those who are highly affected and without comparison to a control group. Are these impacts typical? Which elderly are most seriously affected? What policies can be most cost-effective in helping them?

This paper uses longitudinal household data from the Kagera Region of Tanzania collected in 1991-94 to measure the impact of mortality of prime-aged adult household members on the level and changes in physical well-being of the elderly. Our measure of physical well-being is the body mass index (BMI), defined as the respondent's weight in kilograms divided by height in meters squared. BMI is considered a strong measure of overall health status for adults as it is predictive of morbidity and mortality and responds to shorter-term changes in energy inputs and outputs. In industrialized countries, extreme low and high values of BMI have been associated with higher risk of morbidity and adult mortality (Duerksen et al 2000, Engelman et al 1999, Expert Subcommittee 1998, Kushner 1993, Stefanovic et al 2000, Waaler 1984). Adults with a BMI greater than 35 double their mortality risk and run even higher risks of morbidity from cardiovascular disease, diabetes and certain cancers (Kushner 1993). The mortality risk of low BMI in industrialized countries is confounded by smoking behavior, as there tends to be a positive correlation between leanness and smoking and those who smoke also suffer from smoking-related causes of morbidity and mortality. Mortality associated with low BMI is due to tuberculosis, lung disease, and lung and stomach cancer (Expert Subcommittee 1998). There are very few studies of health risks for the BMI of adults or the elderly in developing countries, where the highest risks of morbidity and mortality in adults are associated with extremely *low* values of BMI, indicative of acute under-nutrition (WHO Expert Committee 1995). In a longitudinal study of Chinese 70 and older, those

[2] This is not the pattern observed in the US, however, where only 6% of the caregivers for AIDS patients in the US were 60 or older, according to one study (Turner et al 1994).

with lower BMI had higher mortality, after controlling for age, sex and physical activity (Woo et al 1998). In a study of poor men in Calcutta, those with BMI less than 16 were more likely to have respiratory tract infections and tuberculosis (Campbell and Ulijaszek 1994). The relation between BMI and infection runs in both directions: morbidity contributes to changes in BMI and low or high BMI raises the susceptibility to ill health (Expert Subcommittee 1998).

Aging affects both stature and weight, which can confound the interpretation of BMI levels and health risk at older ages (Expert Subcommittee 1998). Height declines by 1-2 cm/decade due to compression and other changes in the vertebra, reduced muscle tone and worse posture. In western countries, weight plateaus after age 65 in men and 75 in women due to reduced cell mass and loss of body water. However, in the short run, changes in weight and BMI are predictive of greater health risk. Thus, the recommended "healthy" range for BMI among adults varies according to the source and sometimes by age and gender, but in general the range for the elderly is higher than for middle-aged adults (Kushner 1993). For example, the U.S. Department of Health and Human Services recommends a BMI range of 19-25 for those aged 19-34 but a range of 21-27 for those 35 and older. The U.S. National Academy of Sciences suggests a range of 23-28 for those 55-64 and 24-29 for those 65 and older, compared to a range of 20-25 for those aged 25-34 (Kushner 1993).

In this paper we analyze the impact of prime-aged adult mortality and other determinants of nutritional status on the level and changes in BMI of the elderly in Northwestern Tanzania. The elderly are defined as everyone over 50, to distinguish between those in the prime-aged group (15-50) subject to mortality (and potentially low BMI) due to AIDS and those who are older and presumably suffer the adverse impacts of prime-age adult mortality. The next section describes the analytical framework that justifies the choice of explanatory variables in the model of the determinants of BMI, the channels through which an adult death in the household can affect the physical well-being of the elderly, and the evidence from the literature on key determinants. The third section presents the setting, the dataset, econometric models and descriptive statistics. The fourth section reports the results of multivariate analysis of the determinants of the level and changes in physical well-being of the elderly following adult deaths. The final section summarizes the results and conclusions for policy.

We find that the elderly in non-poor households suffer a decline in BMI *prior* to the death of a prime-aged adult, while this is not true for the elderly in the poorest households. The impact on BMI *following* an adult death in the household is confounded by the fact that many households receive private transfers, in some cases to mitigate the impact of the loss. When we control for public transfers to the household and private transfers received by other household members, we find that a recent death (within the past 3 months) is associated with a sizeable drop in BMI among the elderly in households with no public or private transfers. However, BMI recovers over time. For comparison, we also examine the impact on BMI of losing a spouse within the past 6 months. The elderly in both poor and non-poor households suffer a decline in BMI following the death of a spouse, and the impact is greater for those in non-poor households. Again, however, BMI recovers and does not show long-term impacts. The elderly in wealthier households have higher BMI and those in communities with poor road infrastructure have substantially lower BMI. An increase in the number of teenagers in the household and an epidemic of communicable disease in the community in the past 6 months are associated with a short-run decrease in the physical well-being of the elderly. Availability of health infrastructure and the quality of health care have no relation with the physical well-being of the elderly in this dataset.

II. Analytic Framework

We analyze the determinants of the level of BMI and the short-run change in BMI as a function of exogenous individual characteristics, household characteristics, community characteristics, and recent adult deaths. The choice of explanatory variables is based on an underlying economic model in which the household maximizes the utility of its members in terms of health, leisure, and the consumption of other goods, subject to a budget constraint and a 'health production function' that expresses the relation between various household and individual inputs and health outcomes (e.g., Behrman and Deolalikar

1988). Consider a one-period model of the production of health of adult i in household j and community k :

$$(1) \qquad H_i = H (Z_i ; E_i , \eta_i \; C_i, C_j, C_k) , \qquad Z_i = \{ N_i , M_i , T^H_i \}, \qquad i = 1, \ldots n$$

where Z_i represents a vector of endogenous health inputs (food intake, N_i, medical care, M_i, time of the individual in producing health, T^H_i), E_i denotes the individual's education as an adult, which can enhance the availability of information and affect the efficiency of use of health inputs, η_i denotes the individual's genetic endowment, C_i denotes a vector of other exogenous endowments for the individual, C_j is a vector of the household's endowments, and C_k is a vector of the community or environmental endowments. The individual endowment includes the person's age, gender, and 'tastes' for health. Household endowments include productive assets and other indicators of wealth and the human capital, number, and demographic composition of the household. Exogenous community characteristics or endowments include the availability, price and quality of medical care, food prices, the presence of disease vectors, community wage and price levels, rainfall, and other infrastructure. The budget constraint equates the total value of the time of household members plus any net transfers or other non-wage income sources, I_j, with the value of consumption expenditure (including health) and the value of the leisure of household members. Maximizing utility subject to the health production function and budget constraint results in reduced-form demand equations in which the endogenous health (and health-input) demands are expressed as a function of all exogenous variables:

$$(2) \qquad H_i = H (E_i, \eta_{i,} \; C_i, C_j, C_k, p_k, w_k, I_j)$$

where p_k is a vector of food and non-food prices and w_k is a vector of market wages at the community level.

We will be estimating two variants of equation (2), to explain the current BMI *level* of the elderly and short-run (6-month) *changes* in BMI. The level of BMI observed at any point in time, H_{it}, will be a function not only of characteristics and inputs during the current period, but all of those in the past. In this instance, the vectors of individual, household, and community characteristics, and wages, prices, and household income include the values for time t, t-1, t-2, etc. A few time-invariant variables remain (η_i, and the gender component of C_i). This can be expressed as:

(2)' $H_{it} = H (E_i, \eta_i, \mathit{C_i}, \mathit{C_j}, \mathit{C_k}, \mathit{p_k}, \mathit{w_k}, \mathit{I_j})$

where italicized vectors $\mathit{Cj} = \{C_{jt}, C_{jt-1}, C_{jt-2}, \ldots\}$, and so forth. This is the model estimated for the level of BMI, although not all information on past variables is available. We estimate the determinants of changes in BMI by simply subtracting equation (2)' for time t-1 from time t, such that the change in BMI is a function of the change in other right-hand side determinants in the same time increment:

(2)" $H_{it} - H_{it-1} = H (C_{it} - C_{it-1} , C_{jt} - C_{jt-1}, C_{kt} - C_{kt-1}, p_{kt} - p_{kt-1}, w_{kt} - w_{kt-1}, I_{jt} - I_{jt-1})$

Note that when we do this, all time-invariant variables (like E_i, η_i and time-invariant variables in the vectors of household and community characteristics) disappear from the model. This model expresses changes in BMI as a function of *all other variables that have changed* between time $t-1$ and time t.[3]

Our main interest is in the impact of the death of a prime-aged adult in the household. An adult death can shock the health of the elderly person through two channels – the budget constraint and the health production function. In this reduced form context, it appears as a component of C_j , and the sign of the coefficient on adult deaths cannot be predicted a priori. If the deceased adult produced more than he/she consumed, then holding other things constant the death could result in lower household income and human capital, reducing nutrients and health care of surviving household members. However, these reductions could be compensated for by increased transfers from other households, inheritance, and increased labor force participation/productive activities by the remaining household members. The fatal illness and death of an adult will also divert time and household resources away from the elderly to care for the terminally ill adult and to compensate for the patient's tasks in the household. To the extent that the adult death is due to an extended illness like AIDS, the major impact for other household members

[3] For example, since variables like the distance to a health center did not change in the course of the survey, we will not be able to analyze the impact of a reduction in the distance on a change in BMI.

may occur *prior* to the death; following the death a reallocation of household resources to the health and nutrient intake of other household members may be possible, improving outcomes. Thus, while we cannot predict the direction of the impact of an adult death on the elderly, we expect that adverse impacts are more likely to be observed in the short run, because of lower disposable income, greater demand for medical expenditure for the ill adult at the expense of health inputs for other household members, possible diversion of the elderly person's time away from production of their own health, and the shorter time frame for mitigation measures.[4] We do not dismiss the possibility, however, that the AIDS epidemic has hit some communities so hard and repeatedly that their coping mechanisms are permanently depleted and they are unable to recover. Thus, in addition to an indicator of recent and future adult deaths in the household, we will include in our model a measure of the community-level adult mortality rate and the number of living children of each elderly person.

The literature on the economic determinants of BMI of adults and especially the elderly is scarce in both industrialized and developing countries. From our priors based on economic theory and the literature we can glean some expectations for the likely influence of the other exogenous variables.

Education and individual characteristics. We expect the BMI of the elderly with more education to be higher because of their better access to information, possibly better health behaviors, and better ability to translate health inputs into better outcomes. Controlling for wealth, additional education was associated with higher BMI of women over 20 in Ghana (Alderman 1990), while in Côte d'Ivoire it was not among men and women 20-60 (Thomas, Lavy and Strauss 1996). Based on the literature, we also anticipate BMI to decline with age and for women to have higher BMI than men. BMI declined with age in Indonesia over the age range 20-69 (Frankenberg, Thomas and Beegle 1999), while in Sarawak, Malaysia, it peaked at age 50 for men and age 40 for woman and then declined linearly with age

[4] There are also epidemiological and emotional reasons why the BMI of the elderly could decline with an adult AIDS patient in the household. Tuberculosis is the major AIDS opportunistic infection in Africa and it can be passed on to caregivers who are HIV-negative. Grief and depression could also produce a negative impact on BMI.

(Strickland and Ulijaszek 1993, 1994). Adult women 20-60 in Côte d'Ivoire had higher BMI than men, controlling for other factors (Thomas, Lavy and Strauss 1996).

Household assets. We expect that household wealth and income will be associated with better health, as those with more resources can afford more and better-quality health inputs. The literature supports this. In Côte d'Ivoire and Ghana, higher per capita household expenditures were associated with higher BMI in adults 20-60 and adult women 20 and older, respectively (Thomas, Lavy and Strauss 1996; Alderman 1990). In Indonesia, an increase in per capita income between 1997 and 1998 was associated with an increase in BMI for women, but not for men (Frankenberg, Thomas and Beegle 1999). In Bangladesh, higher household assets (number of rooms in the dwelling and ownership of a cow) were associated with a reduced mortality risk among elderly women (Rahman, Foster and Menken 1992). A second study in Bangladesh found that ownership of at least one household asset (cow, boat, watch, or quilt) at the beginning of the survey was associated with lower mortality both of elderly men and women, as compared with those having none of these assets (Rahman 1999).

Household composition. We expect that the elderly who head their households will have better health outcomes because of their greater access to household resources and their likely role as the key decision-maker in resource allocation within the household. Using longitudinal data from Matlab, Bangladesh, Rahman (1999) found that the head of household or spouse of the head had lower mortality, even after controlling for disability status, the presence of spouses and sons and joint household resources. However, the effect of being the household head declined with age and became insignificant after age 75. Elderly Bangladeshi widows in rural households they do not head are at increased risk of mortality, compared with married women and widows who are heads of household (Rahman, Foster and Menken 1992).

We also expect that the elderly in households with a larger number of prime-aged adults will benefit from higher income and a lower demand on their time for labor input on the farm or in home production. Holding other things constant, we expect that elderly in households with relatively more young children will have greater demands on their time and energy in caring for children, and thus have lower health status. The presence of children in the household may also divert household resources from the consumption of the elderly (including their health inputs) to investments in children's health and education. In Bangladesh, the presence of one or more adult sons in the household was associated with reduced mortality for elderly women but not for elderly men (Rahman 1999). However, the (log of) household size had no relation with BMI for Indonesian men or women aged 20-69 (Frankenberg, Thomas and Beegle 1999).

Community and policy variables. We expect higher food prices to reduce food intake or the quality of food purchased and a higher price of medical care or lower quality medical care to reduce its use, reducing BMI. Among adults aged 20-60 years in Côte d'Ivoire, higher food prices were associated with lower BMI, and these effects were greatest for those living in rural areas (Thomas, Lavy and Strauss 1996). The availability and quality of health services in the community had no effect (individually or jointly). In the sample of men and women in Côte d'Ivoire and of women in Ghana, those living in urban areas had significantly higher BMI than those living in rural areas (Alderman 1990).

III. Setting, dataset, descriptive statistics and econometric model

Our data come from the Kagera region of Tanzania, located to the west of Lake Victoria, adjacent to Uganda, Rwanda, and Burundi, in an area of high HIV prevalence and high adult mortality. The 1988 census reported more than 1.3 million people living in the region, with more than 80 percent residing in rural areas. Most of the population is engaged in agriculture – tree crops in the north and annual crops and livestock in the south. Household consumption expenditure in 1991 was US $217 per capita based on data used from this study, ranging US$118 to US$357 across Kagera's six districts.

Kagera is at the epicenter of the African AIDS epidemic. The first case of AIDS in the region was diagnosed in 1983, although HIV was most likely present at least a decade earlier. A population-based seroprevalence survey conducted in 1987 found that about one in four adults in the regional capital (Bukoba) were infected with HIV, and one in 10 adults in rural areas surrounding Bukoba (Killewo et al 1990). In the rural south and southwest of Kagera, in contrast, fewer than 1% of adults were infected; to the west the adult infection rate was 5%. These levels of infection are not unlike those projected nationally at present—about 8% of prime-aged adults. A follow-up study in 1993 found that HIV infection had declined from 24% to 18% in Bukoba town among those 15-54 years of age, and in the rural area surrounding Bukoba, from 10% to 6.8% (Kwesigabo et al 1998). However, in the latter case, the only population group that registered a significant decline was rural women aged 15-24.[5]

Dataset

The Kagera Health and Development Survey (KHDS) is a longitudinal living standards survey of over 800 households, with 4 waves of data collected at 6 to 7 month intervals from 1991 to 1994 (Ainsworth et al 1992; Over and Ainsworth 1989). The objective of the data collection and research effort was to measure the impact of prime-aged adult deaths on the welfare of surviving household members. Even with the high HIV infection and mortality rates in Kagera, the sample of households had to be heavily stratified in order to observe a sufficient number of households likely to suffer an adult death during the short time frame of the panel (2.5 years). A total of 51 primary sampling units (PSU) were chosen from both high- and low-mortality communities in each of four geographical zones of the region.[6] In each PSU, a sample of 16 households was randomly selected from one of two groups: 14 households were selected from among households reporting either an adult death from illness, an adult too sick to work, or both; and 2 households were selected from among those reporting neither event.[7] A total of 816 households were selected for the original sample and 757 completed all four interviews.[8] We will analyze the height and weight of a total of 695 persons over 50, observed at least once and as many as four times.[9]

[5] Since HIV infection is life-long, the only way that prevalence can decline over time in a cohort is for the mortality rate to exceed the new infection rate (incidence) or for HIV-positive people to migrate out of the study population.

[6] An exhaustive listing was made of all households in these 51 PSUs, more than 29,000 households in total, each of which was asked about the recent mortality of prime-aged adults (in the 12 preceding months), the cause of death (illness, accident, childbirth, etc.) and whether there were any adults too sick to work.

[7] The questionnaire and sampling are described in greater detail in Ainsworth et al (1992).

[8] Since households that left the sample were replaced, a total of 915 households were interviewed at least once.

[9] 413 persons in our sample (59%) were interviewed 4 times, 107 (15%) 3 times, 87 (13%) twice, and 88 (13%) once. The most important reasons why some people were not interviewed four times were: they turned 51 during the survey; their household moved out of the sample during the survey; their household moved into the sample (replacing a household that dropped out) during the survey. Among the households interviewed four times, there was remarkable stability in the population of household members over 50 (see Ainsworth and Dayton 2000).

The average BMI of the elderly in the KHDS was about 20% lower than that in the U.S. and the lowest among the four developing countries for which information is available (Table 1). In the developing countries, including in Kagera, the BMI of elderly women is generally greater than that for men, and BMI declines with age. In contrast, in the US, average male and female BMI are roughly the same. More than a third (36%) of the elderly 60 and older observed for the first time in the KHDS sample had a BMI less than 18.5 (not shown). This is a much larger share of low BMI than measured in Indonesia (14%) and Cote d'Ivoire (4%), although in these two countries the population included prime-aged adults (18 and older and 20-60, respectively), so the results are not strictly comparable (Frankenberg et al 1999, Thomas et al 1996).

Table 1: Mean and standard deviation of Body Mass Index (BMI) by age group, KHDS and selected developing and industrialized countries (Standard deviations in parentheses)

	Age group		
Location	**60-69**	**70-79**	**>=80**
Men			
Kagera, Tanzania (1991-94)	***20.3 (3.0)***	***19.3 (2.6)***	***18.1 (2.0)***
Brazil (1989)	23.7 (5.4)	22.9 (5.0)	22.4 (4.1)
China	20.8 (3.0)	21.7 (3.9)	20.9 (2.6)
Guatemala (rural)	21.3 (2.6)	20.2 (2.2)	19.6 (2.3)
United States	26.4 (4.0)	25.6 (3.7)	24.6 (3.8)
Women			
Kagera, Tanzania (1991-94)	***21.3 (4.3)***	***19.7 (3.3)***	***19.7 (3.9)***
Brazil (1989)	25.8 (6.7)	25.0 (7.4)	23.9 (4.9)
China	21.7 (3.9)	20.7 (3.6)	19.6 (3.1)
Guatemala (rural)	22.4 (3.3)	21.4 (4.4)	20.7 (4.1)
United States	26.5 (5.3)	25.7 (4.9)	24.5 (5.0)

Source: Kagera: authors' calculations on observations of the elderly from wave 1 of the KHDS; Other countries: WHO Expert Committee (1995). The KHDS results describe the sample and are not weighted to be representative of Kagera region.

Independent variables

The independent variables represent measures of adult deaths and arguments of the reduced form demand for health. The descriptive statistics in Table 2 are for two samples – the sample of 586 adults over 50 the second time they were observed and the 1512 "differenced" observations in adjacent periods, leaving from 1-3 observations on 695 adults over 50.[10]

[10] We use the second observation on each individual for the single-wave estimates because we believe that the accuracy of the reporting of the timing of the adult death and classification of the individual as a household member is better during the follow-up interviews than at the baseline, when there was no concrete reference point like the previous visit of an interviewer. The differenced means are the mean of the difference between the value of each variable in time t and in time t-1. With a maximum of four observations per individual, the maximum number of 'first differences' is three. The total number of observations on the 695 elderly before differencing was 2235. Since a difference requires two adjacent observations in time, those individuals seen only once drop out.

Table 2: Definition of variables and descriptive statistics

		OLS (n=586)		*First differenced (n=1512)*	
Variable Name	***Description***	***Mean***	***SD***	***Mean***	***SD***
Dependent variable					
bmi	Body mass index	20.346	3.443	0.032	1.018
Adult mortality and interactions					
past3mo	=1 if any adult 15-50 died past 0-3 months, else 0	0.017	0.130	-0.001	0.139
past6mo	=1 if any adult died past 4-6 months, else 0	0.015	0.123	-0.015	0.202
past9mo	=1 if any adult died past 7-9 months, else 0	0.012	0.109	-0.016	0.195
futr3mo	=1 if any adult died in next 0-3 months, else 0	0.017	0.130	-0.005	0.156
futr6mo	=1 if any adult died in next 4-6 months, else 0	0.005	0.071	-0.003	0.121
futr9mo	=1 if any adult died in next 7-9 months, else 0	0.012	0.109	-0.005	0.121
pst3_dur	Interaction: past3mo*durbadlt	0.091	1.600	0.011	1.524
pst6_dur	Interaction: past6mo*durbadlt	0.016	0.229	-0.046	0.808
pst9_dur	Interaction: past9mo*durbadlt	2.489	42.517	-0.038	1.262
futr3_dur	Interaction: fut3_dur*durbadlt	0.032	0.468	-0.004	0.426
futr6_dur	Interaction: fut6_dur*durbadlt	0.018	0.403	-0.006	0.615
futr9_dur	Interaction: fut9_dur*durbadlt	0.011	0.201	0.007	0.286
spsdth	=1 if spouse died since previous wave/past 6 months	0.007	0.082	-0.007	0.141
spsd_durb	Interaction: spsdth*durbadlt	0.014	0.344	-0.010	0.721
Household assets					
goodfloor	=1 if house has non-dirt floor	0.135	0.343		
landown	Acres of land owned by household	5.221	5.719		
durbadlt	Value of durable goods/adult/1000	10.228	59.840	0.224	9.158
homeown	=1 if respondent owns dwelling	0.640	0.480		
headage	Age of household head	61.250	13.823	0.593	3.868
headeduc	Years of schooling of head	3.381	2.932	-0.017	0.723
Demographic characteristics of the respondent					
age55_59	=1 if age 55-59, else 0	0.224	0.417	-0.007	0.212
age60_64	=1 if age 60-64, else 0	0.200	0.400	0.007	0.210
age65_69	=1 if age 65-69, else 0	0.143	0.351	0.000	0.193
age70_74	=1 if age 70-74, else 0	0.094	0.292	0.010	0.164
age75pl	=1 if age 75 or greater, else 0	0.174	0.379	0.009	0.092
female	=1 if female, else 0	0.534	0.499		
educ	=1 if any formal education, else 0	0.493	0.500		
ownkids	Number of own living children here and away	6.420	4.832	-0.030	0.335
kids_fem	Interaction: allkids* female	2.399	3.102	-0.026	0.172
widow	=1 if widow/er, else 0	0.350	0.477		
Household composition					
head	=1 if head of household, else 0	0.637	0.481	0.007	0.106
parent	=1 if parent of head of household, else 0	0.114	0.318	0.001	0.103
nadults	Number of household members 15-50	3.684	2.066	-0.017	1.017
nteens	Number of household members 7-14	1.551	1.448	-0.029	0.639
nkids	Number of household members 0-6	1.043	1.412	-0.046	0.723
Household sanitation					
good h20	=1 if household has piped water or covered well	0.193	0.395		
no toilet	=1 if dwelling has no toilet or latrine	0.043	0.202		
Community health and infrastructure					
hlthfac	=1 if health facility within 5km , else 0	0.737	0.441		
admrt	1991 mortality rate/1000 of those 15 and older	16.442	7.713		
rdimpass	=1 if road is impassable part of year, else 0	0.459	0.499		
Epidemic	=1 if community had epidemic in past 6 months, else 0	0.224	0.417	0.005	0.552
Urban	=1 if urban residence, else 0	0.258	0.438		
Household transfer income					
pvt transfers	log of remittances received by all household members except respondent since last wave/6 months	7.150	2.710	0.806	3.038
trans_dth	Interaction: pvt transfers*dummy variable for adult death since last wave/6 months	0.051	0.620	-0.071	2.092
assistance	log of assistance from govt and NGOs to household since last wave/6 months	5.305	3.221	1.340	4.164
asst_dth	Interaction: assistance*dummy variable for adult death since last wave/6 months	0.044	0.531	0.013	1.508

Adult deaths. We investigate the impact of prime-aged (15-50) adult deaths in the household in the past – within 0-3 months, 4-6 months and 7-9 months before the interview –and in the future – 0-3 , 4-6 and 7-9 months following the interview. The collection of dummy variables representing deaths in the past will be denoted as 'lags' and those representing future deaths as 'leads'.[11] About 4.4% of the respondents in the cross-section had an adult death in the 9 months *before* the interview and 3.4 % had an adult death in the 9 months *after* the interview. In contrast, fewer than 1% of the elderly had lost their spouse in the 6 months before the interview. To allow for a different impact for poor and non-poor households, in one specification we interact the 'leads' and 'lags' of adult deaths with the value of durable goods per adult household member.

Household assets. We use three measures of household assets as a measure of wealth: the quality of housing (whether the dwelling has other than a dirt floor), the amount of land owned by the household, and the value of the household's durable goods (radios, bicycles, TVs, etc) in 1000 Tanzanian shillings (Tsh) per adult household member.[12] About 14% of the elderly lived in a dwelling with a non-dirt floor and the average respondent lived in a household that owned about 5 hectares of land. The mean value of assets per adult in the wave 2 cross-section is 10,228 Tsh or about US$30. About half of the elderly (56%) lived in households with no reported durable goods. We also include a dummy variable equal to one if the head owns the dwelling. This variable would reflect both decision-making power in the household. Nearly two-thirds of the respondents owned their dwelling.

Individual characteristics. These include sex, age, whether the respondent had any formal schooling, and whether he/she is widowed. About 53% of respondents were female and the average age was 64 years. Only about a quarter (23%) of elderly women had any education, while 79% of elderly men had some schooling and about a third (31%) had completed 5 years or more. More than half of the

[11] The death 'leads' are censored by the end of the survey – that is, for the last interview we do not know about future deaths, and for the next to the last interview, we do not know about deaths in 7-9 month's time. We include control variables for the censoring of future deaths due to attrition or the end of the survey.

[12] The KHDS collected household expenditure data, which could be used as a proxy for household 'permanent income' or well-being. However, it would also include spending on inputs to health such as food or medical care, which are endogenous inputs into the health of the elderly. We use an exchange rate of 337 Tsh/$US.

elderly women (53%) were widows and only a third (35%) were currently married, while 80% of elderly men were currently married and only 14% were widowers. We also include the number of living children of each elderly person, which can be considered a proxy for the extent of his or her economic safety net. Women had an average of 4.5 living children and men had an average of 8.7.

Household composition. The number of prime-aged adults is a proxy for the supply of adult time in economic activities, including home production and child care. The number of children under 7 is a proxy for the demand for the respondent's time in providing child care. The average elderly respondent lived in a household with 4 adults aged 15-50, 2 teens aged 7-14 and one child aged 6 or younger. During the first wave of interviews, nearly three-quarters of adults over 50 (73%) lived in households with all three generations and 10% lived in households with prime-aged adults only (Ainsworth and Dayton 2000). The relation of the respondent to the household head is likely to affect decision-making in resource allocation within the household. Nearly two-thirds were the head of their household, including virtually all of the elderly men (96%) and a third of the elderly women (35%). A third of the women were the spouse of the head (34%) and one in five was the mother of the head. The head, on average, was 61 years old and had 3.4 years of schooling.

Household sanitation. Potable water and adequate sanitation facilities are key health inputs that should lower morbidity, including diarrhea, and improve BMI. Only 19% of the elderly lived in dwellings with piped water or a covered well; 4% lived in a dwelling with no toilet or latrine.

Community health and infrastructure. The community adult mortality rate (age 15 and older) per 1000 population in that age group is based on the results of a house-to-house enumeration conducted by the research team for sampling purposes in 1991. The overall adult mortality rate of 16/1000 is roughly three times higher than we would have expected in the absence of AIDS, although it is somewhat inflated by the inclusion of people over 50. About 22% of respondents were in communities reporting a recent epidemic. Community infrastructure variables include whether the road is passable all year and whether there is a health facility within 5 kilometers of the community. Almost half (46%) of the elderly lived in a community where the road was impassable for at least part of the year, three-quarters lived within 5 km of a health facility and about a quarter lived in urban areas.

Regional and seasonal control variables. Not shown in Table 2 are regional and seasonal control variables: the district of residence, the month of the interview, the year of the interview (or 'passage', to measure secular trends), the order of the interview (or 'wave', to account for improvements in interviewer and respondent performance), and the latitude and longitude of the center of the cluster (GPS coordinates). We also include dummy variables to control for censoring in our ability to observe future deaths because of the end of the survey or sample attrition. Results for these variables are not shown to conserve space and can be obtained from the authors.

Household transfer income. Private or public transfers can be used to mitigate the impact of adult deaths. The theoretical model includes a term for 'exogenous' income in the reduced form. We use two measures: (a) receipt of transfers from individuals to everyone in the household *except* the elderly respondent; and (b) receipt at the household level assistance from government and NGOs in the past 6 months/since the last wave.[13] These are both expressed in logarithmic form and interacted with a dummy variable equal to one if an adult died in the household since the previous interview or 6 months before the first interview, to detect whether the elderly in households with a death fare differently from the elderly in households without a death in terms of the impact of transfers. Other household members received on average 8,141 Tsh ($24) in private transfers in the past 6 months, excluding transfers to the elderly respondent, and their households received 1,824 Tsh ($5.40) in NGO and government assistance. Ninety percent of the elderly lived in households in which other members received private transfers and three-quarters were in households that received some NGO or government assistance.

[13] In this dataset, non-poor households are more likely than poor households to receive both public/NGO and private transfers and within each of these income groups, households that had a recent death are more likely to receive both types of transfer than households that did not have a death (Lundberg et al 2000, Table 2). The largest differential is among non-poor households receiving private transfers – 61% with a death received private transfers compared to 46% that had no death. Among poor households, the figures for receipt of private transfers are 57% in the case of an adult death and 43% of those without a death.

Econometric issues

We are interested in the determinants of both long-run levels and short-run changes in BMI. The basic linear model of the determinants of the level of BMI includes a vector of the exogenous explanatory variables, x_{it}, and an error term, ν_{it}. The error term can be further decomposed into two components – the unobserved time-invariant individual health endowment, η_i, and a time-varying idiosyncratic error term, ε_{it}, that we assume is uncorrelated with the regressors x_{it}.

(3) $H_{it} = \alpha + \beta x_{it} + \nu_{it}$, $\nu_{it} = \eta_i + \varepsilon_{it}$, $\text{Cov}(x_{it}, \varepsilon_{it}) = 0$, all s, t

In this model, the coefficients are estimated from variation in the levels of BMI in the cross section of individuals and across time periods. Provided that there is no correlation between η_i and the explanatory variables x_{it} , ordinary least squares (OLS) estimates of equation (3) by pooling the data across individuals and time will be consistent and unbiased. However, the presence of the individual effect in the error term will create positive serial correlation in the error terms across time periods, leading to incorrect standard errors and inferences (Wooldridge 2000). Under these circumstances, GLS estimation of a random effects (RE) transformation of the data will produce consistent estimates and serially uncorrelated errors (Greene 1993, Hsiao 1996). However, if the unobserved individual effect is correlated with any of the explanatory variables in any of the time periods, the RE coefficient estimates will be inconsistent. Indeed, for this datatset, Hausman tests indicated that the RE parameter estimates were inconsistent (Hausman 1978). A fixed effects (FE) transformation of the data would provide consistent estimates by essentially removing the time-invariant individual effect that poses the correlation problem, but FE has the disadvantage of dropping all other time-invariant variables from the regression as well. We therefore present OLS estimates of the determinants of BMI on a single wave of the longitudinal data (the second observation for each individual), which permits consistent estimation of the coefficients of time-invariant variables if there is no correlation between the error term and the regressors, but on a much smaller sample than the complete dataset. The standard errors are not subject to serial correlation problems and have been corrected for heteroskedasticity using the Huber-White correction (STATA Corporation 1997).

In estimating the determinants of the change in BMI in adjacent periods, we take advantage of the panel nature of the dataset by estimating a 'first differenced' (FD) model in which the short-term (6-month) change in BMI is tregressed on the change in all other time varying variables:

(4) $H_{it} - H_{it-1} = \beta (x_{it} - x_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1})$

The time-invariant unobserved component of the error term is eliminated, yielding consistent estimates even if the individual effect and the regressors are correlated (Wooldridge 2000). However, like FE it also sweeps away all time invariant unobservable variables at the individual, household, and community level and greatly reduces the variation in the explanatory variables (compared to the regression on BMI levels) resulting a loss of efficiency. FD can also greatly reduce the variation in the data. We use three first differences--(wave 2 – wave 1), (wave 3 – wave 2) and (wave 4 – wave 3)—and estimate the model using OLS, correcting the standard errors for serial correlation and heteroskedasticity. We include dummy variables for the second and third differences (with the first difference left out) to control for secular trends (Wooldridge 2000).

A final issue is the possibility that adult mortality in the respondent's household is not exogenous to the health of the elderly – that is, that there is a correlation between the death and some unobservable in the regression, calling into question the line of causation and the consistency of the estimates. This is a legitimate concern. First, there's substantial evidence that HIV infection and adult AIDS mortality are not random events. In many studies in Sub-Saharan Africa the risk of HIV infection is positively correlated with socioeconomic status and in the KHDS sample, adults who died from AIDS were younger and more educated than those who died from other causes (Ainsworth and Semali 1998). Second, about a third of all of the prime-aged adult deaths recorded in the households during the survey were persons who moved back into the household between waves and died before they could be recorded on the household roster (Ainsworth and Semali 1995). Most were children of the head or of the head's spouse, but not all children of the head or spouse who died returned. Thus, there's the real possibility that the decision to return to a household for terminal care is related to the receiving household's or the returning individual's economic circumstances.[14]

We have dealt with this in three ways. First, we include in the regressions all explanatory variables that were significant in a separate regression of the probability of a death in the household between the first and fourth interview.[15] Second, we allow the impact of adult deaths to depend on the household's wealth, by interacting the death variables with one of the asset variables. Third, we interact the death with the distance in time from the interview, and the timing can be presumed to be exogenous.

IV. Results

OLS regression results for the *level* of BMI are presented in the first column of Table 3 on a single wave of data and of the *changes* in BMI in columns 2-4. Turning first to BMI levels, the recent adult mortality variables are not statistically significant.[16] The elderly in households with more assets had higher BMI: those in dwellings with concrete, wood, or tile floors had a BMI 1.3 points higher than the elderly in households with dirt floors and a 10,000 Tsh increase in the value of durable goods per adult (about $30, a doubling of the mean) is associated with BMI 0.07 points higher.[17] Although not statistically significant, the elderly who owned their home had a BMI 0.8 points higher than those who did not and an elderly person in a household with 25 acres of land would have a BMI one point higher

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[14] In the US, the elderly who owned their own home were much more likely to have adult children living with them (Borsch-Supan et al 1996). In one pattern of two-generation households, the elderly head (or couple) is wealthier than the adult children who co-reside (Borsch-Supan 1989). In the other pattern, the younger generation is the head and main earner and the co-resident elderly are poorer and often single.

[15] For the sample of all households observed four times with non-missing values of the explanatory variables (n=754) we ran a probit of the probability of an adult death between the first and last observation (about 2.5 years) on characteristics of the household in wave 1, including characteristics of the head (age, gender, education, ownership of the dwelling), household assets (land, flooring, durables/adult), household economic activities, sanitation (water, toilet), household composition, community-level variables (adult death rate, AIDS problems, distance to market and health care, quality measures at the nearest health facility, recent epidemics, the % of the community with safe drinking water), and district/geographic regional dummy variables. The pseudo R-squared was 0.105. Ownership of the dwelling by the head, durable goods/adult, the number of prime-aged household members, and living near a health facility raised the probability of observing an adult death in the household. The presence of any nurse at the nearest health facility was also positively correlated, but not quite statistically significant. Safe drinking water in the household, the number of elderly and young children, and living in Biharamulo district or urban areas outside of Bukoba (compared to living in Bukoba Rural distric) reduced the probability of observing an adult death.

[16] These results are unchanged when household assets are excluded from the regression.

[17] Household assets were also found to be a significant determinant in wasting (the equivalent of low BMI in children) of children under 5 in Kagera (Ainsworth and Semali 2000; Dayton 1999).

Table 3: Regression results: Levels and changes in BMI

	Levels		*Changes*					
Explanatory variable	(1)		(2)		(3)		(4)	
Adult mortality and interactions	**ß**	**T**	**ß**	**T**	**ß**	**t**	**ß**	**t**
past3mo	0.008	(0.01)	-0.265	(0.96)	-0.173	(0.53)	-0.686	(2.00)
past6mo	1.243	(0.79)	0.084	(0.48)	0.209	(1.09)	-0.299	(1.11)
past9mo	0.338	(0.25)	-0.024	(0.17)	-0.025	(0.16)	-0.093	(0.66)
future3mo	0.200	(0.40)	-0.031	(0.13)	0.203	(0.72)	0.094	(0.38)
future6mo	-1.018	(0.53)	0.062	(0.18)	0.546	(1.24)	0.076	(0.22)
future9mo	-0.567	(0.51)	-0.162	(0.68)	-0.007	(0.25)	-0.076	(0.30)
past3_dur					0.008	(0.46)		
past6_dur					-0.054	(1.07)		
past9_dur					0.003	(0.15)		
futr3_dur					-0.153	(2.25)		
futr6_dur					-0.134	(2.31)		
futr9_dur					-0.117	(1.61)		
Household assets								
Goodfloor	1.276	(1.96)						
Landown	0.038	(1.31)						
Durbadlt	0.007	(1.81)	-0.002	(1.04)	-0.002	(1.04)	-0.003	(1.27)
Homeown	0.843	(1.33)						
Headage	-0.015	(1.00)	0.030	(3.63)	0.028	(3.25)	0.029	(3.53)
Headeduc	0.004	(0.04)	0.176	(4.41)	0.159	(3.54)	0.175	(4.47)
Demographic characteristics of respondent								
Female	1.340	(2.38)						
Educ	-0.004	(0.01)						
Ownkids	0.103	(3.25)	-0.007	(0.08)	0.013	(0.15)	-0.020	(0.21)
kids_fem	0.065	(0.72)	-0.170	(0.90)	-0.230	(1.22)	-0.115	(0.60)
Widow	-0.078	(0.20)						
Household composition								
Head	-0.325	(0.46)	0.509	(1.74)	0.450	(1.47)	0.521	(1.85)
Parents	-0.659	(0.86)	0.568	(1.93)	0.555	(1.78)	0.547	(1.89)
Nadults	0.045	(0.46)	0.003	(0.11)	-0.002	(0.07)	-0.006	(0.23)
Nteens	0.066	(0.55)	-0.091	(2.31)	-0.090	(2.29)	-0.099	(2.49)
Nkids	-0.236	(1.80)	-0.018	(0.46)	-0.023	(0.58)	-0.028	(0.72)
Household sanitation								
goodh20	-0.048	(0.13)						
Notoilet	-0.659	(0.91)						
Community health & infrastructure								
Hlthfac	-0.654	(1.62)						
Admrt	0.027	(0.82)						
Rdimpass	-1.130	(3.11)						
Epidemic	-0.463	(1.30)	-0.084	(1.77)	-0.077	(1.61)	-0.074	(1.55)
Urban	1.281	(2.75)						
Household transfer income								
Pvttransfers							0.027	(2.41)
trans_dth							0.037	(1.23)
Assistance							-0.002	(0.23)
asst_dth							0.027	(0.70)
Constant	17.775	(6.47)	-0.944	(0.88)	-0.977	(0.90)	0.894	(0.84)
R-squared	0.24		0.04		0.05		0.05	
Joint tests								
adult death leads & int'actions	0.7199		0.8115		0.0452		0.9061	
adult death lags & int'actions	0.8805		0.7530		0.9074		0.4201	
Assets	0.0036				0.1347			
HH composition	0.2983		0.1207		0.1123		0.0608	
private transfers & interaction							0.0169	
assistance & interaction							0.7776	
Observations	586		1512		1512		1512	

Notes: Included but not reported in col (1): age, district, passage, wave, month of interview, latitude, longitude, controls for censoring of future deaths; and in cols (2)-(4): age, passage, wave, month of interview, controls for censoring of future deaths, time elapsed between interviews. Figures in parentheses are T-statistics. Standard errors have been corrected for heteroskedasticity and serial correlation.

than someone in a household with none. More land could potentially result in greater farm work by the elderly, but the positive coefficient suggests that this is outweighed by the benefits of wealth in improving health outcomes.

Elderly women had higher BMI than did men, consistent with patterns seen in other developing and industrialized countries. Not reported in the table, BMI rose with age, peaking at ages 60-64 before declining. Formal schooling was not significantly associated with BMI, although the level of schooling in the sample was quite low. The elderly with 10 living children have a BMI one point higher than those with no living children. This impact holds equally for elderly men and women and is consistent with the literature pointing to the benefits of large family size in terms of old age security and well being in Sub-Saharan Africa. Controlling for these other variables, widows and widowers,[18] household heads, and the parents of the head had BMI no different than others.

Among the household composition variables, only young children have a significant negative relation with BMI. This is consistent with a story in which the elderly are physically taxed by their responsibilities for child care *or* in which the household preferentially allocates resources to the health of the young over the elderly. Surprisingly, the elderly in households with more prime-aged adults did not have higher BMI.[19] This suggests either that there is no substitutability of labor between the elderly and prime-aged adults or that the additional work of the elderly when faced with a scarcity of prime-aged adults does not worsen their health status. Using the same dataset, Beegle (1998) found that adults aged 51-65 in households with a prime-aged adult death in the past year increased their time spent on housework, but were no more likely to engage in farm work as a result of the death.

The elderly in urban areas had a BMI 1.3 points higher than those in rural areas but there was no significant relation between BMI and the proximity of a health facility.[20] BMI was not affected by the

[18] In an additional specification (not shown), we found that the elderly who lost their spouse in the past 6 months did not have significantly lower BMI levels.
[19] When household size is held constant (not shown), an increase in the number (or share) of prime-aged adults is associated with higher BMI. However, the negative coefficient on household size almost exactly equals the positive coefficient on prime-aged adults, so the net effect of an additional adult in the household on BMI is nil.
[20] The negative sign suggests that the elderly living within 5 km of a health facility have *worse* physical health than those living more distant. However, this pattern could also be observed if the less healthy elderly chose to live with relatives who are closer

1991 adult mortality rate in the community or an epidemic in the previous 6 months. However, BMI was lower by about 1.1 points in communities where the road is completely impassable during certain times of the year, compared to communities where the road was passable year round.[21] This might explain the lack of impact of proximity to a health facility: in communities where the road is impassable, the distance to a health facility and its quality are irrelevant. This finding presents an interesting paradox: Better infrastructure facilitates mobility, which has been implicated in raising the risk of acquiring HIV. Yet for many, especially the poor, the lack of basic road infrastructure is a major impediment to economic opportunities, better access to social services, and improved health outcomes.

Turning to short-run changes in BMI (Table 3, columns 2-4), the results in column 2 imply that there are no changes in BMI associated with a recent past or future adult death. However, when we allow the impact of adult deaths to vary by the level of assets in the household a more nuanced story emerges (column 3). There is no impact of a recent past or future adult death on the BMI of the elderly in the poorest households. However, in non-poor households, in which the BMI of the elderly is initially higher, we see a significant negative impact on BMI in the months prior to the adult death with a recovery back to normal levels after the death. This could be explained by a diversion of household resources to the medical care of the AIDS patient and/or increased demands on the time of the elderly to care for sick AIDS patients. In a similar vein, the recent death of a spouse (not shown) reduces BMI among all elderly and the impact on the non-poor elderly is greater.[22] Becoming the head or the parent of the head of household in the past 6 months is associated with a rather large increase in BMI of about half a point. Since the KHDS did not follow the elderly when they moved, in all of these cases the elderly became the head or parents of the head when a non-resident child left the household or died (in the first instance) or joined their household (in the second). Increases in the age and education of the head are also associated

to a health facility. Thus, the result should not properly be interpreted as an 'impact' of the proximity of health care. In a specification not shown here, BMI was not associated with indicators of health care quality at the nearest facility.

[21] At the time of the KHDS fieldwork in 1991-94, the quality of the road infrastructure in Kagera was extremely poor. The 100 km road between Bukoba town and the Ugandan border could take 5 hours or more to travel during the rainy season and the was sometimes completely cut off. (Personal observation, Ainsworth).

[22] The coefficient on spouse death in the past six months is –0.086 (T=.27) and for spouse death interacted with durable goods is -.053 (T=1.62); the coefficients are jointly significant (F(2,595)=9.54) at p<.0001. The first coefficient is the impact of a spouse death on the poor, and the impact on the non-poor is the sum of the two coefficients.

with increased BMI. On the other hand, an increase in the number of children 7-14 living in the household was associated with a decline in BMI, again suggesting a diversion of resources to invest in the young. Finally, an epidemic of infectious disease in the community in the past 6 months is associated with a decline in BMI of the elderly, as we would expect.

The results in columns (2) and (3) show little or no impact of adult deaths on BMI, except for the impact of future deaths on the non-poor elderly. However, this impact could be underestimated if households with an adult death are receiving public and private transfers to mitigate the impact of an adult death. In column (4) we have added to the regression private transfers received in the past 6 months by all household members *except* the elderly member and assistance from government programs or non-governmental organizations (NGOs) to the household, both of which are interacted with a dummy variable equal to one if there was a death since the previous wave. When we control for receipt of transfers, the coefficient on a recent adult death in the past 3 months becomes statistically significant, showing a large decline of –0.7 points among both the poor and non-poor. The elderly in households that received *private* transfers had significant increases in BMI, and the increase was even greater if the household receiving transfers also had an adult death. The elderly in households receiving NGO and government assistance did not have a detectable change in BMI, though the level of these public transfers was very low compared with private transfers.

A final reason why the impact of adult deaths may be underestimated would be if adult deaths raised the probability of the death of the elderly with low BMI. In that case, the elderly who survive in households with adult deaths will be those who had a better health endowment and higher BMI, resulting in a positive correlation between BMI and adult deaths. This hypothesis seems to be one that we can rule out, however: the elderly in households that experienced a prime-aged adult death were not more likely to die in the course of the longitudinal survey.[23]

[23] Of the 697 people over the age of 50 ever observed, 34 died during the survey, five of them in households with a prime aged adult death. While the occurrence of an adult death during the survey had no relation with the probability of death of the elderly adult, higher BMI *did* reduce the risk of death (probit coefficient of –0.0812, T=2.585).

V. Conclusions and implications for policy

The elderly in non-poor households have higher BMI, but their households are more likely to have an adult death and they are more likely to suffer declining BMI before the death. Elderly in both poor and non-poor households experience a significant drop in BMI following an adult death, but BMI recovers over time and there is no long-run association with BMI levels and recent adult deaths. There is no significant impact of the community adult mortality rate on the BMI of the elderly, controlling for these other determinants. These mortality impacts on BMI are independent of the effects of deaths on reducing income and assets, but the parameter estimates on deaths remain substantially the same when assets are excluded from the regression. Private transfers received by other household members raise the BMI of the elderly, even more so when there has been a recent adult death. There is no evidence of the impact of NGO or public assistance to the household on changes in BMI. The elderly with more living children are physically better off, but increases in the number of teenagers in the household are associated with declines in BMI.

Improving the incomes and assets of the poor are key to improving the overall level of BMI of the elderly. In this dataset, 36% of the elderly in poor households (households with no reported durable goods) had BMI below 18.5, compared to 23% of those in non-poor households. Among those in dwellings with dirt floors, 32% had low BMI, compared to 17.5% of those in dwellings with improved floors. The results showed consistent and relatively strong impacts of greater assets on higher BMI. Improvements in the road infrastructure of Kagera region would also have major benefits to the welfare of the elderly, raising BMI levels by one point. Improving the physical well-being of the elderly would be only one of the many benefits of these two policies.

In terms of reducing the short-run fluctuations in BMI among the elderly, prevention of communicable disease is key. We have not been able to pinpoint the reasons behind the fluctuations in BMI around the time of the adult death – some may be economic (diversion of household resources to the patient or a reduction in household human and financial resources) and some may be emotional (grief and depression following an adult death). Prevention of HIV/AIDS could directly reduce this source of the fluctuations in elderly BMI. In addition, the results highlight the benefits to the physical well–being of the elderly (not just the well-being of children) of immunization and other campaigns to control communicable disease epidemics, since a recent epidemic was consistently associated with lower BMI. It is not evident from these results that a public-assistance type intervention could be justified or effective in mitigating the short-run adverse impacts of prime-aged adult deaths on the elderly. Such a program would have to be based on a better understanding of the mechanisms reducing elderly BMI in the short run, the impact of the proposed program on elderly BMI, and the impact and costs of alternative uses of the funds.

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