7-26-2016

# Cognitive Health among Older Adults: Evidence from Rural Sub-Saharan Africa

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**Abstract**
Cognitive health is an important dimension of well-being in older ages, but few studies have investigated cognitive health in sub-Saharan Africa's (SSA) growing population of mature adults (= persons age 45+). We use data from the Malawi Longitudinal Study of Families and Health (MLSFH) to document the age and gender patterns of cognitive health, the contextual and life-course correlates of poor cognitive health, and the understudied linkages between cognitive and physical/mental well-being. Surprisingly, the age-pattern of decline in cognitive health for both men and women is similar to that observed in the U.S. We also find that women have substantially worse cognitive health than men, and experience a steeper decline of cognitive ability with age. Strong social ties and exposure to socially complex environments are associated with higher cognitive health, as is higher socioeconomic status. Poor cognitive health is associated with adverse social and economic well-being outcomes such as less nutrition intake, lower income, and reduced work efforts even in this subsistence agriculture context. Lower levels of cognitive health are also strongly associated with increased levels of depression and anxiety, and are associated with worse physical health measured through both self-reports and physical performance.

**Keywords**
Cognitive Health, Aging, Sub-Saharan Africa, Mental Health, Physical Health

**Disciplines**
Demography, Population, and Ecology | Gerontology | Psychiatry and Psychology | Public Health | Social and Behavioral Sciences | Sociology

**Comments**
Payne, Collin F., Iliana V. Kohler, Chiwoza Bandawe, Kathy Lawler, and Hans-Peter Kohler. 2016. "Cognitive Health among Older Adults: Evidence from Rural Sub-Saharan Africa." *University of Pennsylvania Population Center Working Paper (PSC/PARC)* WP2016-3. http://repository.upenn.edu/psc_publications/3.

# Cognitive Health among Older Adults: Evidence from Rural Sub-Saharan Africa

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July 26, 2016

Abstract: Cognitive health is an important dimension of well-being in older ages, but few studies have investigated cognitive health in sub-Saharan Africa's (SSA) growing population of mature adults (= persons age 45+). We use data from the Malawi Longitudinal Study of Families and Health (MLSFH) to document the age and gender patterns of cognitive health, the contextual and life-course correlates of poor cognitive health, and the understudied linkages between cognitive and physical/mental well-being. Surprisingly, the age-pattern of decline in cognitive health for both men and women is similar to that observed in the U.S. We also find that women have substantially worse cognitive health than men, and experience a steeper decline of cognitive ability with age. Strong social ties and exposure to socially complex environments are associated with higher cognitive health, as is higher socioeconomic status. Poor cognitive health is associated with adverse social and economic well-being outcomes such as less nutrition intake, lower income, and reduced work efforts even in this subsistence agriculture context. Lower levels of cognitive health are also strongly associated with increased levels of depression and anxiety, and are associated with worse physical health measured through both self-reports and physical performance.

Key Words: Cognitive health, aging, sub-Saharan Africa, mental health, physical health

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## Introduction

Why are some persons maintaining high levels of cognitive abilities at older ages, while others experience cognitive decline, various forms of dementia, and other memory loss as they age? This variability in the level of cognitive health and its pace of decline with age is pervasive, and its determinants have received extensive attention by researchers, policy-makers and providers of elderly care. For example, a recent National Academy of Science report calls for a societal commitment to cognitive aging as a public health issue that requires prompt action across many sectors (Blazer et al., 2015). This need to address cognitive health (CH) as a major public health concern is no longer restricted to high income countries: across the world, longer life expectancies and lower fertility have given rise to growing aging populations (UNPD, 2015), and by 2050 over 70% of global dementia cases will occur in low- and middle-income countries (LMICs) (Prince et al., 2013).

Recent revisionist perspectives that have suggested that global aging is less of a threat to economic growth and well-being than previously thought emphasize that this conclusion is contingent on mature and older individuals maintaining high levels of cognitive functioning and economic activity levels (Lee and Mason, 2011; Skirbekk et al., 2012). But how this aim of successful cognitive aging can be achieved in LMICs is far from clear. While there has been increasing attention on the determinants of cognitive skill formation at young ages in LMICs (Hanushek and Woessmann, 2008), to date, the evidence-base on cognitive aging and variability of CH among older individuals is almost exclusively derived from high-income countries. The knowledge gap about CH among older individuals is widest in sub-Saharan Africa (SSA), where very few population-based studies of aging and cognition exist (Lekoubou et al., 2014).

Achieving the aim of successful cognitive aging in SSA faces major challenges. The poor evidence basis limits the ability of research to inform policies and health system in-

vestments. The evidence about cognitive aging from high income contexts, and the policy and health recommendations countries derived from this evidence, are unlikely to generalize to SSA low-income country (LIC) settings: older individuals in SSA have widely divergent life-histories from those in high-income settings, including increased exposure to chronic undernutrition and infectious diseases, economic shocks, severe poverty, and high levels of uncertainty, all of which are linked to reduced cognitive abilities and accelerated cognitive aging (Haan et al., 2011; Lynch et al., 1997; Madsen, 2016). But there are also possible protective factors: lower levels of social isolation, lower levels of cognitive ability at adulthood, higher levels of physical activity, high levels of social and economic engagement even among older adults, and shorter life-expectancies that imply strong mortality selection among survivors to old age. These and related factors might suggest that cognitive aging might not be as pronounced as has been documented in higher-income contexts (Ellwardt et al., 2013; Haslam et al., 2014; Salthouse, 1991).

Poor CH in SSA LICs is likely to have substantial repercussions for individual well-being and day-to-day social and economic functioning, arguably even more so than in higher income contexts, as health services and infrastructure for addressing and ameliorating cognitive decline and related aspects of aging are insufficient (Frost et al., 2015). Poor CH is therefore seen as an important factor contributing to persistent global inequality (Hanushek and Woessmann, 2008), and older individuals, especially in SSA LICs, may play an important role in this link due to their almost universal labor force participation (ILO, 2016), their pivotal caretaking roles in families affected by HIV/AIDS (Zagheni, 2011; Zimmer and Teachman, 2009), and their contributions to downward intergenerational transfers (Kohler et al., 2012; Lee and Mason, 2011). SSA LICs can ill-afford a productivity gap resulting from cognitive limitations among mature and older adults.

What is urgently needed, therefore, is an evidence base for documenting CH among older individuals in SSA LICs, and understanding the determinants and consequences of cognitive aging among individuals who experienced life-histories that are distinctly different from the extensively-studied aging populations in high-income countries. For example: How variable is CH among mature and older adults in SSA LICs, and how does it differ by gender? Does cognitive aging follow a different trajectory in SSA LICs than in more developed contexts? How are education and socio-economic status associated with CH among the elderly in this context? Do closer family networks and increased social participation buffer against cognitive decline? And, what are the repercussions of poor CH for individual well-being, work efforts, depression, anxiety, and physical health in a poor SSA mature adult population?

Our analyses use one of the very few population-based studies of CH among *older* individuals in a SSA LIC, the 2012—13 rounds of the Malawi Longitudinal Study of Families and Health (MLSFH), to provide a first picture of CH in a population-based sample of older individuals in rural SSA. Because our data are collected within a 1-year period, we cannot (yet) study the *dynamic process* of cognitive aging, as has been done with longitudinal studies in high-come countries. As a proxy for the cognitive aging process, however, our analyses can study *CH across age* for mature and older adults, they can link CH among mature and older adults to social and economic adversities, gender, family contexts and life-course transitions. By focusing on an important understudied population, our analyses implement the recommendations of the recent National Academy of Science Report (Blazer et al., 2015) that stressed the need to collect and disseminate population-based data on cognitive aging across a wide range of contexts, including high-risk and underserved populations from diverse contexts that have often been neglected in prior research.

## Background

Cognition covers many mental abilities and processes, including decision making, memory, attention, and problem solving (Blazer et al., 2015). Cognitive ability refers to the ability of individuals to adequately perform cognitive tasks and processes, and is determined by anatomy and physiology of the brain, sensory abilities, environmental conditions and social processes. The ability to perform well on these multiple dimensions of cognition is defined as *cognitive health*, and adequate cognitive health has been shown to be critical for successfully engaging in the various activities involved in daily functioning (Moritz et al., 1995). Cognitive health also is an important factor in the development of functional impairments and physical disabilities (Fitzpatrick et al., 2007; Watson et al., 2010). Recent research has also focused on the process of *cognitive aging*, defined as the gradual – yet highly variable – changes in cognitive functions that occur as people get older (Blazer et al., 2015). This decline in specific brain functions occurs independent of disease processes in the brain, such as neurodegeneration from Alzheimer's disease or stroke, and this decrease in cognitive functioning is a hallmark of aging and predicts mortality (Fitzpatrick et al., 2007).

Existing research on cognition in SSA has primarily focused on estimating the incidence and prevalence of dementia (Lekoubou et al., 2014). While understanding this prevalence is important, this research overlooks the wide range of cognitive abilities in the older population, the social determinants of CH in SSA, and the implications of variability in CH for day-to-day activities and well-being among older individuals. Moreover, the survey instruments used in these studies are designed mainly to capture clinical dementia (Guerchet et al., 2014; Paddick et al., 2015; Prince et al., 2011), rather than population-level variability of CH. Dementia represents only a small subset of this population-level distribution of CH, and our measures of CH have therefore been designed to capture the full range of CH present among older individuals in a SSA LIC.

While little research has addressed the determinants of this within-population variability in CH in SSA LICs, related research from middle- and high-income countries offers potential clues. For example, social participation and group engagement have been related to better CH, particularly at older ages (Ellwardt et al., 2013; Haslam et al., 2014), as has relatively high life-course socioeconomic status (Hurst et al., 2013; Staff et al., 2016). High levels of socioeconomic status in adulthood may also mediate the relationship between early-life conditions and late-life cognitive function (Lyu and Burr, 2016). Higher levels of schooling are also linked to both better CH and slower rates of cognitive aging (Cook and Fletcher, 2015), and this education-cognition nexus is possibly even more important in LMIC contexts than high-income countries (Huang and Zhou, 2013). Cognitive reserves, measuring the ability of individuals to cope better with adverse influences on CH, have been shown to vary significantly among individuals, particularly at older ages and often as a function of individuals' life course (Stern, 2009). In all of the above processes, genetic disposition and gene-environment interactions are likely to play important roles, and recent research in neuroscience and neuroepigenetics has started to succeed in unpacking the mechanisms through which common genetic variation, environmental conditions, and lifestyles interact and affect adult cognitive development (Cook and Fletcher, 2015; Heckman, 2007; Lindenberger, 2014).

Because of its centrality for individuals' well-being and social/economic activities, cognitive health is increasingly recognized as an important dimension and integral part of global population health (NIA, 2012). Yet, especially as populations are aging worldwide, poor cognitive health continues to be an insufficiently understood aspect of the global burden of disease (Murray et al., 2012) with important implications for well-being, social participation and overall economic development (Sosa et al., 2012).

## Context

Malawi is a relatively poor SSA country, ranked 174 of 187 in terms of the human development index (UNDP, 2014). In rural areas, where the study population of the MLSFH is based, the majority of individuals engage primarily in home production of crops, complemented by some market activities. HIV/AIDS prevalence is 11% (Malawi DHS, 2011), though HIV+ rates are much lower in the older population. Rural Malawians also live in conditions similar to other rural populations in SSA LICs, characterized by high levels of poverty, episodic malnutrition, poor sanitation, a high prevalence of infectious diseases and endemic parasites, and limited access to health care facilities (H-P Kohler et al., 2015). The Malawian population, similarly to other SSA countries, is also increasingly bearing the double burden of infectious diseases and non-communicable diseases (Msyamboza et al., 2011), with the latter now accounting for 28% of total deaths (WHO, 2014). Older adults can expect to live a large proportion of their later years subject to physical limitations on their activities (Payne et al., 2013). The inability to carry out daily work due to physical and cognitive declines affects social participation and social acceptance of older individuals, and mature adults often express this as a major aging-related concern (Freeman, 2016).

## Methods

### Data

The MLSFH cohorts were selected to represent the rural population, where the majority of Malawians (85%) live (WHO, 2014). A "*Cohort Profile*" of the MLSFH, providing detailed discussion of MLSFH sampling procedures, survey methods, survey instruments, and analyses of attrition has been published in the *International Journal of Epidemiology* (H-P Kohler et al., 2015). In 2012-13, the MLSFH mature adult survey focused explicitly

on mental and cognitive health, non-communicable diseases, and their risk factors in the population aged 45+ (I. Kohler et al., 2015); $N_{2012}$ = 1,246 with a mean age = 59.7; $N_{2013}$ = 1,234 with a mean age = 61.0). Pertinent information and additional detail on the MLSFH mature adult population are provided in Appendix Text A.1-A.3.

**Measures**

*Cognitive assessment of elderly Malawians*

Cognitive aging is not easily defined by clear thresholds on cognitive tests, particularly in environments where most established cognition scales are difficult to implement because of low schooling levels. This is especially the case in SSA LICs, where the current evidence basis about CH is weak, because many factors – including culture, education, work activities, environmental context, and access to health care – influence test performance and norms (Busch et al., 2006; Chandra et al., 2014). Locally adapted measures and assessments of CH are therefore important, rather than merely an application of western scales and cut-points. As MLSFH was not able to implement an instrument previously validated in this context, the team developed and pre-tested a comprehensive instrument designed to capture a wide span of CH, from high cognitive functioning to cognitive impairment. The survey instrument was developed to be suitable for a little-schooled or illiterate study population, and implementable by well trained, albeit lay MLSFH interviewers (details on survey implementation are available in Appendix Text A.1).

After extensive testing and development, the MLSFH implemented a modified version of the International Cognitive Assessment (ICA), a brief screening test designed to be relatively culture-free and appropriate for populations with limited access to formal schooling. It assesses six cognitive domains: basic language ability, orientation, visual/constructional skills, attention/working memory, executive functions, and delayed memory (recall/recognition). The maximum ICA score is 30, corresponding to highest

(best) cognitive assessment. The full ICA questionnaire and details on how the ICA was modified for our study context are included as Appendix B, and additional details on ICA administration are included in Appendix Text A.2. Appendix Table 1 presents a brief overview of the summary statistics and correlations for the total ICA score and the sub-scores.

Our analyses use each respondent's best ICA score between the two MLSFH waves as our primary measure of CH. The reason for doing so is that relying on the higher of the two measures results in a more conservative and robust-to-measurement-error indicator of CH. There is no systematic trend in the wave of highest score: 46% of the highest ICA scores came from the 2012 interview, and 54% from the 2013 interview. All analyses of the pooled 2012-13 MLSFH adjusted for clustering within respondents.

*Cognitive ability categories*

The ICA score is analyzed in two ways—as a continuous measure, allowing us to exploit the full variation in the ICA, and as a categorical measure that classifies ICA into five levels of ***cognitive ability***. In lieu of pre-established and validated ICA classifications for our study context, our categorical analyses use the youngest subset of the 2012-2013 MLSFH respondents to construct locally-relevant thresholds for the classification of cognitive ability. These individuals are the least cognitively impaired in our sample, and at prime adult ages 45-54 years old, they provide a suitable reference population for assessing CH. Specifically, the ICA score is classified based on the distribution of highest score from the 2012—13 MLSFH population aged 45-54 (N=442), excluding HIV+ individuals (N=28). Cognitive ability categories are as follows: the 25$^{th}$ percentile of this distribution is the cut-point for *low cognitive ability*, the 5$^{th}$ percentile is the cut-point for *mild cognitive impairment*, and the 1$^{st}$ percentile of this distribution is the cut-point for *moderate to severe cognitive impairment*. In addition, the 75$^{th}$ percentile of the distribution of 45-54 year-olds was used as a cut-point for *high cognitive ability*. Threshold ICA scores

were 26.5 or above for *high cognitive ability*, 26 to 21 for *average cognitive ability*, 20.5 to 16 for *low cognitive ability*, 15.5 to 12 for *mild cognitive impairment*, and below 12 for *moderate to severe cognitive impairment*. To avoid contamination by using the same population to define and analyze the CH classification, all analyses using our categorical assessment of cognitive ability are restricted to the population 55+ (while our analyses of the continuous ICA score include all respondents aged 45+). Our findings are robust with respect to modification of this classification scheme (see Appendix Materials).

*Determinants and correlates of cognitive health*

The MLSFH contains extensive measures of various determinants and correlates of CH, including:

*Social participation, social environment, and socioeconomic status:* The 2012 MLSFH asked a set of questions on social participation, including total membership in village groups, number of visits to the market in the past month, and number of social events attended in the past month (including dances, drama performances, political meetings, and funerals). These sorts of participatory activities have been linked with improved cognition in late life (Ellwardt et al., 2013; Hsu, 2007), and group engagement in particular has previously shown strong and lasting effects with increasing age (Haslam et al., 2014). In addition, the total number of household members was measured, as well as the total number of the respondent's children living in the same household or same village. These measures all relate to the social complexity of an individual's environment, which is known to be strongly associated with cognition and cognitive decline in later life (Seeman et al., 2001).

*Long-term changes in socioeconomic status (SES):* The MLSFH has collected information on the roofing material of each household in the survey since 2001, and thus our analyses can test for differences in CH among individuals who have experienced different trajectories in household SES. Additional income is very often used to improve housing in

Malawi, so a change in roof material from non-metal to metal acts as a strong proxy for a rise in household wealth (for example, in a 2012 survey of MLSFH interviewers—who are drawn from the rural regions represented in the study—70% of interviewers (20 of 29) reported using their previous MLSFH-related earnings on repairing or adding to their homes).

*Social and economic wellbeing outcomes:* Protein intake (important in the Malawian context characterized by frequent food shortages and crises) was measured as the number of days in the last week with chicken, fish or meat consumption. Respondents reported their total earnings in the past 12 months; this variable was transformed using the inverse hyperbolic sine transformation to normalize the income distribution and account for individuals with zero reported earnings (Burbidge et al., 1988). Binary indicators for any/no reported earnings and any/no reported savings were additionally tested. Total work efforts are measured as the total number of hours of farm and household work reported in the past week.

*Mental health:* In 2012 and 2013, the MLSFH collected multiple measures of mental health (see (I. Kohler et al., 2015) for a detailed discussion). Subjective life satisfaction was based on the question: "How satisfied are you with your life, all things considered?", with responses ranging from 1 = very unsatisfied to 5 = very satisfied. Depression and anxiety were measured with the PHQ9 and GAD7 modules of the Patient Health Questionnaire (PHQ) (Kroenke et al., 2010), where higher scores denote worse depression and anxiety. The MLSFH additionally collected the SF-12 health survey (Gandek et al., 1998), from which the SF-12 mental health score was derived. Lower SF-12 mental health scores denote worse overall mental health. Overall life satisfaction and the SF-12, PHQ9, and GAD7 scores are used as continuous outcomes.

*Physical health:* General self-rated health was reported as 1 = poor to 5 = excellent. Respondents were asked if they had accomplished less or had work limitations due to

physical health over the past four weeks, with responses ranging from 1 = none of the time to 5= all of the time. Frequency of pain interfering with work was measured with responses from 1 = not at all to 5 = extremely. Measured 2012-13 indicators of physical health include: body mass index (BMI), grip strength (in kg), and systolic blood pressure (2013 only).

**Analyses**

The association between ICA score and baseline characteristics was estimated using linear regression, and the marginal means of CH outcomes were estimated in age-, gender- and schooling-specific strata based on linear regressions of the total ICA score on a cubic function of age with controls for region and MLSFH wave. Analyses of attrition among the MLSFH mature adult population are provided in Appendix Text A.4.

The associations between ICA score and measures of social environment, social participation, and socioeconomic status were estimated using multiple regression. Regressions were used to estimate the associations between CH—measured as continuous ICA score and as cognitive ability categories—and individual well-being, mental health, and physical health. Differences in this relationship by gender—that is, whether the relationship between ICA score and economic well-being, mental health, and physical health differed between men and women—were tested using a Female × ICA interaction term. All analyses were pooled across the 2012 and 2013 MLSFH mature adult survey, and where appropriate, standard errors were adjusted for clustering within respondents. All multivariate analyses control for age, age$^2$, female, female × age, schooling, roof material, region, and MLSFH wave. Age was centered on its sample mean in all regressions, as was the continuous ICA score.

## Results

*Descriptive analysis*

Columns 1-3 of Table 1 present the baseline summary statistics of the MLSFH mature adult sample in 2012. The mean age of respondents was about 60, with a similar age distribution between men and women. Schooling attainment varied substantially by gender—most of the sample would have been of schooling age over 40 years ago, during a time with limited access to schooling in rural areas and substantial gender differences in schooling expectations in Malawi (Banda, 1982). Just over 30% of the sample population lived in a household with a metal or tile roof, and about 30% of our sample is Muslim. Almost all the men in the MLSFH population were currently married, in contrast with only about 60% of the women (a 2/3 majority of the non-married are widowed, with the remainder being divorced or separated). Only about 5% of the study population tested HIV+, possibly reflecting high levels of mortality among the HIV+ members of these cohorts. Similar distributions across the study population are observed in 2013.

Column 4 presents regression coefficients of a multivariate regression of total ICA score on baseline sample characteristics. Increasing age is associated with declines in CH, with declines accelerating at older ages. Formal schooling is strongly associated with higher total ICA score. The combined regression suggests that women have lower ICA scores even after controlling for differences in exposure to formal schooling. Living in a household with a metal or tile roof was associated with higher ICA score, though Muslim religion and marital status were not. Overall, there do not appear to be any systematic differences in total ICA score between the HIV- and HIV+ populations, though the sample sizes of the HIV+ population are quite small (34 HIV+ men, 38 HIV+ women). The remainder of our analyses will combine the HIV+ and HIV- populations, though all of our key findings hold in analyses restricted to the HIV- sample.

Our categorical measure of cognitive ability indicates a substantial burden of poor CH in our study population (bottom pane of Table 1), particularly among women. There are substantial gender differences in cognitive ability classification—only 36% of women have average or high cognitive ability (ICA score >=21), compared with 70% of men. About 30% of the sample is classified as having low cognitive ability (ICA scores range from 16 to 20.5). About 19% of the sample have mild or moderate to severe cognitive impairment, though again these proportions are substantially higher for women (27%) than for men (10%).

*Age patterns of ICA score*

Panel A of Figure 1 depicts the gender-specific age pattern of total ICA score, documenting a general decline in CH with age. The figure indicates a strong gender gap and a widening of gender differences with age. Declines in CH with age are substantial: the average ICA score for a 70-year old woman is about 4 points lower than that of a 55-year old woman (corresponding to 1.2 times the standard deviation of the ICA score among 45—55 year olds), with smaller age-declines observed among men. Panel B of Figure 1 indicates that the standard deviation rises steadily with age, and this increase is stronger among men than women. Panel C of Figure 1 indicates that CH differs substantially by schooling attainment, and individuals with more schooling appear to delay their cognitive decline.

The life-long exposure to adverse conditions among our study participants might suggest a more rapid decline in CH than among individuals in high-income countries. While a definite test of this hypothesis requires longitudinal data, a comparison of cross-sectional CH patterns suggest that this is not necessarily be the case. Specifically, Figure 2 shows a comparison between the MLSFH and two US samples in the overall age-pattern of z-scored summary indices of cognition—the *Brief Test of Adult Cognition by Telephone* from the Midlife Development in the United States (MIDUS II) sample

(Ryff and Lachman, 2009), and an index combining scores for 6 domains of the *Woodcock Johnson Psychoeducational Test Battery* with the most overlap with the ICA—auditory working memory, number series, picture vocabulary, retrieval fluency, spatial relations, and visual matching score—from the Cognition and Aging in the USA (CogUSA) national sample (McArdle, John et al., 2015). Patterns in average CH (left panel) are quite similar between the two US samples and the MLSFH sample—all three populations see a marked and steady decline in cognitive z-score by age. Differences mainly arise in the standard deviation by age: variability around the mean increases with age in the MLSFH and CogUSA samples, but declines slightly in the MIDUS II sample. Appendix Table 2 also compares the cognitive ability classification measure (estimated as described above) between these three samples; the proportion of individuals falling into each classification at each age is fairly similar across these three samples.

To explore within-population variation in the rate of cognitive decline by age, Table 2 reports analyses of the ICA age gradient, allowing for differences in the ICA age gradient by schooling, gender and roof material. The Age × Female interaction term (Column 2) shows that CH declines more rapidly for women, with women experiencing a 40% steeper age gradient than men. This results in the widening gender-gap among older individuals (Figure 1A). Having any schooling is associated with higher ICA scores (Table 1, Column 4), but we find no support for significant Schooling × Age (Column 4) or Schooling × Roof Material interactions (Column 5). Appendix Table 3 tests for gender differences in the effect of schooling and roof material, as well as a three-way interaction between gender, schooling, and age. There are no significant differences in the effect of these variables between men and women.

*Association between ICA score, social environment, social participation, and socioeconomic status*

Table 3 presents the associations between measures of an individual's current social environment and their ICA score, controlling for sample characteristics. Column 1 tests two measures of an individuals' social environment—the total number of people living in their household, and the number of own children sharing the household or living within the same village. The number of own children living nearby is significantly associated with increased total ICA score, though larger household size is not. Column 2 tests three measures of social participation—number of social events attended in the past month (drama performances, dances, political meetings, and funerals), number of visits to the market in the past month, and total membership in village groups and committees. Increased market attendance and participation in village groups/committees is associated with substantially higher CH. These activities are strongly participatory—negotiating prices, purchasing goods, and participating in village governance are all complex and demanding process. Simply attending social events does not appear to be associated with CH, however. All of these associations remain in the regression combining the measures of social environment and social participation (Column 3).

The long-term associations between changes in SES and CH are presented in Table 4. Information back to 2001 is available for the subset of the MLSFH sample who were enrolled at the start of the MLSFH, but is not available for the MLSFH parent sample which was added in 2008, see Kohler et al. 2015 and Appendix A.1 for details on the sample. Current household SES is strongly associated with ICA score—living in a household that transitions from having a thatch or mud roof in 2001 to a metal roof in 2012 (Column 1), or living in a household with a metal roof at both waves, is associated with a 0.8 point increase in total ICA score compared to an individual with a non-metal roof at both waves. Column 2 tests whether duration of exposure to a high SES envi-

ronment was associated with higher ICA scores. Each additional year of living in a metal-roofed house was associated with a 0.09 point increase in ICA score. Similar associations are present when looking at the full MLSFH mature adult sample with a shorter time horizon—living in a household that gains or retains a metal roof is associated with a higher ICA score compared to those with a non-metal roof at both waves or those who move from a dwelling with a metal roof to one without (Column 3).

*Association of cognitive score with well-being*

Table 5 reports the results of multivariate regression models investigating the association of CH with indicators of individual social/economic well-being. In Panel 1, the ICA score is included as a continuous measure, using the complete 45+ MLSFH mature adult population and allowing for differences by gender, and in Panel 2, the categorical cognitive ability measure is included based on the classification described above and focusing on respondents age 55+. Total ICA score is weakly associated with fewer days with protein consumption, and lower ICA is strongly associated with lower earnings, a lower likelihood of having savings, and fewer hours of work efforts per week. Women report substantially higher work efforts than men and slightly lower earnings and protein consumption, but there is no evidence that the relationship between CH and these well-being outcomes differs between men and women (as shown by the lack of support for the female × ICA score term).

Panel 2, focused on respondents aged 55+, shows the corresponding analyses using our categorical measure of cognitive ability; main results for three alternative parameterizations of ICA categories are included as Appendix Tables 10-12. Individuals with moderate to severe impairment and mild impairment are found to have substantially lower protein intake, lower earnings, and lower savings rates. Individuals with mild or moderate to severe cognitive impairment are far less likely to have any labor earnings (odds ratios are 0.29 for mild and 0.23 for moderate to severe impairment compared to those

with average ability). Work efforts are substantially lower for those with mild impairment, and controlling for demographic factors, individuals with mild impairment reported an average of 5.6 fewer hours per week of work effort in their own household or farm compared to those with average cognitive ability. Work efforts were also lower in the moderately/severely impaired group, though this difference was not significant. Individuals classified as having high cognitive ability had significantly higher protein consumption and substantially higher odds of having savings, but high cognitive ability was not associated with higher work efforts or earnings.

*Association of cognitive health with mental health*

Table 6 provides the associations between CH and four measures of mental health. Controlling for basic demographic characteristics, lower ICA is strongly associated with worse SF-12 mental health, GAD7 anxiety, and PHQ9 depression scores, as well as lower life satisfaction, (Panel 1). Women have slightly worse overall mental health (SF-12) than men, and report lower life satisfaction and higher anxiety and depression symptoms. However, there is no evidence that the association between ICA score and mental health differs between men and women.

In Panel 2, all levels of cognitive impairment are found to be significantly associated with worse mental health outcomes. For example, controlling for demographic characteristics, mild impairment is associated with almost a 50% increase in PHQ9 score, and moderate to severe impairment is associated with a 70% increase in PHQ9 score, a substantial jump given that a score of 5 or more represents a diagnosis of mild depression. Mild and moderate to severe impairment are also associated with substantially higher GAD7 scores, again a quite substantial increase given that a score of 5 or higher is interpreted as having mild anxiety. Poorer CH is also strongly associated with worse SF-12 mental health scores. Even individuals in the low cognitive ability classification have, on average, significantly worse mental health scores than those with average cognitive

ability. Though lower levels of cognitive ability are associated with more depression and anxiety symptoms and poorer overall mental health, high cognitive ability does not appear to have any protective effects—those with high ICA scores do not have substantially better mental health compared to those with average cognitive ability.

*Association of cognitive health with physical health*

Table 7 provides the associations between CH and a number of markers of physical health. Two types of health outcomes are used: self-reports of subjective physical health (self-rated health, accomplishing less and work limitations due to physical health, pain interfering with work efforts), and measured markers of physical health (grip strength, BMI, and systolic blood pressure). In Panel 1, a higher ICA cognitive score is strongly associated with better self-rated health, fewer limitations on work and daily activities, less interference from pain in daily work, and higher grip strength. ICA score is not significantly associated with blood pressure, though the direction of the coefficient suggests that there may be a weak association between improved CH and lower systolic blood pressure. Women report somewhat worse physical health on all measures and have a lower grip strength, though they also have a significantly higher BMI than men. Again, there is little evidence that the relationship between ICA score and physical health differs between men and women.

Nearly all physical health measures show a clear gradient with decreasing cognitive ability (Panel 2). Self-rated health, physical limitations on work and daily activities, pain, and grip strength are all significantly worse among those with cognitive impairments, but most are also significantly worse among those with low cognitive ability. Poorer CH is somewhat associated with lower BMI (in the subsistence agriculture context of the MLSFH where calorie deficiency is a pressing concern, higher BMI is a positive outcome), though this difference is only significant for the low ability and moderately to severely impaired groups. Individuals with high cognitive ability had better

self-rated health, and significantly higher grip strength. However, high ability does not appear to protect individuals from physical limitations—individuals with high cognitive ability reported comparable levels of physical and pain limitations on work activities to those with average ability.

## Discussion

The CH of aging populations is increasingly recognized as a major challenge in LMICs. Despite this growing global relevance, little is currently known about cognition and cognitive aging among mature older adults in SSA. In this paper, we present a first set of analyses of the CH of a mature- and older-adult sample in rural Malawi, and seek to understand both the correlates and consequences of poor CH in this LIC setting. Given the general lack of knowledge about CH in SSA LICs, these findings, even if they are descriptive in nature, are important in terms of highlighting the similarities and differences in CH patterns and correlates between SSA LICs and middle/high-income countries where most current research is based.

*Key results*

Our results show that many mature adults in rural Malawi experience poor CH, and that CH declines substantially with age for both men and women. The age-related pattern of decline in CH in the MLSFH sample is remarkably similar to the pattern seen in studies of cognition in the United States. Some differences in CH may have had their roots relatively early in life, as indicated by the association of formal schooling with better overall CH and a less-steep age-gradient. In line with research from other contexts, CH appears to be strongly associated with the "richness" of an individual's social environment—increasing presence of close social relationships and complex, participatory social activities such as market visits and village group memberships are associated with higher cognitive scores (Haslam et al., 2014). Both current and past socioeconomic status are strongly associated with the ICA score: individuals living in wealthier house-

holds (those with a metal/tile roof) had substantially higher ICA scores than those with non-metal roofs, and more time spent living in a high SES household was associated with higher ICA scores.

Our analyses provide evidence that CH is closely intertwined with the day-to-day well-being of mature adults: CH is strongly associated with many key aspects of daily life such as physical and mental well-being, consumption and productivity. Men and women with cognitive impairments have more symptoms of depression and anxiety, worse physical health outcomes, and substantially lower economic productivity and financial security. These negative outcomes of poor CH occur not only among the most cognitively impaired; even individuals with moderately lower cognitive ability have significantly lower subjective life satisfaction and self-rated health, higher symptoms of depression and anxiety, are more limited due to physical health, and have lower grip strength and lower BMI than individuals with average cognitive ability. Though low cognitive ability is associated with a wide variety of adverse outcomes, high cognitive ability is only moderately protective. Compared to those with average ICA performance, older individuals with high levels of cognitive functioning have a higher rate of savings, better nutritional intake, and better self-rated health and grip strength. However, having high cognitive ability does not appear to protect individuals from experiencing physical limitations or depression/anxiety symptoms any more than those with average ability.

Poor CH is much more frequent among women than men, though controlling for schooling attainment reduces this gap. This finding is in line with other research on cognition and aging in LMICs that has found substantial gender differentials in cognitive decline (Lee et al., 2011; Maurer, 2011; Zhang, 2006). Despite differences in levels, CH has similar associations with well-being, mental health, and physical health outcomes for both men and women.

*Study limitations*

Some limitations of our analyses include: First, our measure of CH is not directly comparable to other pre-established scales of cognition—though the ICA addresses many of the same domains of CH as other scales, the study team made considerable adaptations to these measures to render them suitable for a low-literacy, low-education rural SSA context. As such, our prevalence estimates for mild and moderate to severe cognitive impairment are not directly comparable to other contexts. Our cognitive ability measure is based on the distribution of ICA score from the youngest subset of the MLSFH study population rather than clinically established and validated thresholds (though analyses of several varying threshold schema found very similar results, see Appendix Tables 9-11). This being said, the validity of our categorical cognitive ability classification is strongly suggested by the fact that both the overall trend in cognitive decline with age and the distribution of our categorical measure were similar to patterns observed in two major studies of old-age cognition in the US (see Figure 2 and Appendix Table 2). The one-year gap between MLSFH waves is also insufficient to estimate longitudinal age-trajectories of CH; future waves of data will be needed to understand the age dynamics of cognition and cognitive aging in this population.

*Conclusions*

CH has been a neglected dimension of overall health in SSA and other LICs by both academic and policy communities. Our findings suggest that it represents an important dimension of overall health and well-being in SSA, and that there is a strong need for policy responses and interventions targeted towards improving CH in childhood, sustaining CH in older ages, and supporting those with cognitive impairments.

**References**

Banda, K.N., 1982. A Brief History of Education in Malawi. Dzuka Publishing Company.

Blazer, D.G., Yaffe, K., Liverman, C.T. (Eds.), 2015. Cognitive Aging: Progress in Understanding and Opportunities for Action. National Academy Press, Washington, DC.

Burbidge, J.B., Magee, L., Robb, A.L., 1988. Alternative Transformations to Handle Extreme Values of the Dependent Variable. J. Am. Stat. Assoc. 83, 123–127. doi:10.2307/2288929

Busch, R.M., Chelune, G.J., Suchy, Y., 2006. Using norms in neuropsychological assessment of the elderly, in: Geriatric Neuropsychology: Assessment and Intervention. Guilford Publications.

Chandra, V., Ganguli, M., Ratcliff, G., Pandav, R., Sharma, S., Belle, S., Ryan, C., Baker, C., DeKosky, S., Nath, L., 2014. Practical issues in cognitive screening of elderly illiterate populations in developing countries. Aging Clin. Exp. Res. 10, 349–357. doi:10.1007/BF03339881

Cook, C.J., Fletcher, J.M., 2015. Can education rescue genetic liability for cognitive decline? Spec. Issue Educ. Attain. Adult Health Context. Causality 127, 159–170.

Ellwardt, L., Aartsen, M., Deeg, D., Steverink, N., 2013. Does loneliness mediate the relation between social support and cognitive functioning in later life? Soc. Sci. Med. 98, 116–124. doi:10.1016/j.socscimed.2013.09.002

Fitzpatrick, A.L., Buchanan, C.K., Nahin, R.L., DeKosky, S.T., Atkinson, H.H., Carlson, M.C., Williamson, J.D., Investigators, for the G.E. of M. (GEM) S., 2007. Associations of Gait Speed and Other Measures of Physical Function with Cognition in a Healthy Cohort of Elderly Persons. J. Gerontol. A. Biol. Sci. Med. Sci. 62, 1244–1251.

Freeman, E., 2016. Understanding HIV-related stigma in older age in rural Malawi. Soc. Sci. Med. 164, 35–43. doi:10.1016/j.socscimed.2016.07.006

Frost, L., Navarro, A.L., Lynch, M., Campbell, M., Orcutt, M., Trelfa, A., Dotchin, C., Walker, R., 2015. Care of the Elderly: Survey of Teaching in an Aging Sub-Saharan Africa. Gerontol. Geriatr. Educ. 36, 14–29. doi:10.1080/02701960.2014.925886

Gandek, B., Ware, J.E., Aaronson, N.K., Apolone, G., Bjorner, J.B., Brazier, J.E., Bullinger, M., Kaasa, S., Leplege, A., Prieto, L., Sullivan, M., 1998. Cross-Validation of Item Selection and Scoring for the SF-12 Health Survey in Nine Countries: Results from the IQOLA Project. J. Clin. Epidemiol. 51, 1171–1178. doi:10.1016/S0895-4356(98)00109-7

Guerchet, M., Mbelesso, P., Ndamba-Bandzouzi, B., Pilleron, S., Desormais, I., Lacroix, P., Aboyans, V., Jésus, P., Desport, J.-C., Tchalla, A.E., Marin, B., Lambert, J.-C., Clément, J.-P., Dartigues, J.-F., Preux, P.-M., the EPIDEMCA group, 2014. Epi-

demiology of dementia in Central Africa (EPIDEMCA). SpringerPlus 3, 338. doi:10.1186/2193-1801-3-338

Haan, M.N., Al-Hazzouri, A.Z., Aiello, A.E., 2011. Life-span Socioeconomic Trajectory, Nativity, and Cognitive Aging in Mexican Americans. J. Gerontol. B. Psychol. Sci. Soc. Sci. 66B, i102–i110. doi:10.1093/geronb/gbq071

Hanushek, E.A., Woessmann, L., 2008. The Role of Cognitive Skills in Economic Development. J. Econ. Lit. 46, 607–668. doi:10.1257/jel.46.3.607

Haslam, C., Cruwys, T., Haslam, S.A., 2014. "The we's have it": Evidence for the distinctive benefits of group engagement in enhancing cognitive health in aging. Soc. Sci. Med. 120, 57–66. doi:10.1016/j.socscimed.2014.08.037

Heckman, J.J., 2007. The economics, technology, and neuroscience of human capability formation. Proc. Natl. Acad. Sci. 104, 13250–13255. doi:10.3386/w13195

Hsu, H.C., 2007. Does social participation by the elderly reduce mortality and cognitive impairment? Aging Ment. Health 11, 699–707. doi:10.1080/13607860701366335

Huang, W., Zhou, Y., 2013. Effects of education on cognition at older ages: Evidence from China's Great Famine. Soc. Sci. Med. 98, 54–62.

Hurst, L., Stafford, M., Cooper, R., Hardy, R., Richards, M., Kuh, D., 2013. Lifetime Socioeconomic Inequalities in Physical and Cognitive Aging. Am. J. Public Health 103, 1641–1648. doi:10.2105/AJPH.2013.301240

International Labour Organization, 2016. World Employment and Social Outlook: Trends 2016. International Labour Department, Geneva.

Kohler, H.-P., Watkins, S.C., Behrman, J.R., Anglewicz, P., Kohler, I.V., Thornton, R.L., Mkandawire, J., Honde, H., Hawara, A., Chilima, B., Bandawe, C., Mwapasa, V., Fleming, P., Kalilani-Phiri, L., 2015. Cohort Profile: The Malawi Longitudinal Study of Families and Health (MLSFH). Int. J. Epidemiol. 44, 394–404. doi:10.1093/ije/dyu049

Kohler, I., Payne, C., Bandawe, C., Kohler, H.-P., 2015. The Demography of Mental Health Among Mature Adults in a Low-Income High HIV-Prevalence Context. PSC Work. Pap. Ser.

Kohler, I.V., Kohler, H.-P., Anglewicz, P., Behrman, J.R., 2012. Intergenerational transfers in the era of HIV/AIDS: Evidence from rural Malawi. Demogr. Res. 27, 775–834.

Kroenke, K., Spitzer, R.L., Williams, J.B.W., Löwe, B., 2010. The Patient Health Questionnaire Somatic, Anxiety, and Depressive Symptom Scales: a systematic review. Gen. Hosp. Psychiatry 32, 345–359. doi:10.1016/j.genhosppsych.2010.03.006

Lee, J., Shih, R.A., Feeney, K.C., Langa, K.M., 2011. Cognitive Health of Older Indians [WWW Document]. URL http://www.rand.org/pubs/working_papers/WR889.html (accessed 6.6.16).

Lee, R.D., Mason, A., 2011. Generational Economics in a Changing World. Popul. Dev. Rev. 37, 115–142. doi:10.1111/j.1728-4457.2011.00380.x

Lekoubou, A., Echouffo-Tcheugui, J.B., Kengne, A.P., 2014. Epidemiology of neurodegenerative diseases in sub-Saharan Africa: a systematic review. BMC Public Health 14, 653. doi:10.1186/1471-2458-14-653

Lindenberger, U., 2014. Human cognitive aging: Corriger la fortune? Science 346, 572–578. doi:10.1126/science.1254403

Lynch, J.W., Kaplan, G.A., Shema, S.J., 1997. Cumulative Impact of Sustained Economic Hardship on Physical, Cognitive, Psychological, and Social Functioning. N. Engl. J. Med. 337, 1889–1895. doi:10.1056/NEJM199712253372606

Lyu, J., Burr, J.A., 2016. Socioeconomic Status Across the Life Course and Cognitive Function Among Older Adults: An Examination of the Latency, Pathways, and Accumulation Hypotheses. J. Aging Health 28, 40–67. doi:10.1177/0898264315585504

Madsen, J.B., 2016. Barriers to Prosperity: Parasitic and Infectious Diseases, IQ, and Economic Development. World Dev. 78, 172–187. doi:10.1016/j.worlddev.2015.10.032

Malawi DHS, 2011. Malawi Demographic and Health Survey 2010. National Statistical Office (NSO) and ICF Macro, Zomba, Malawi, and Calverton, Maryland, USA.

Maurer, J., 2011. Education and Male-Female Differences in Later-Life Cognition: International Evidence From Latin America and the Caribbean. Demography 48, 915–930. doi:10.1007/s13524-011-0048-x

McArdle, John, Rodgers, Willard, Willis, Robert, 2015. Cognition and Aging in the USA (CogUSA) 2007-2009.

Moritz, D.J., Kasl, S.V., Berkman, L.F., 1995. Cognitive Functioning and the Incidence of Limitations in Activities of Daily Living in an Elderly Community Sample. Am. J. Epidemiol. 141, 41–49.

Msyamboza, K.P., Ngwira, B., Dzowela, T., Mvula, C., Kathyola, D., Harries, A.D., Bowie, C., 2011. The Burden of Selected Chronic Non-Communicable Diseases and Their Risk Factors in Malawi: Nationwide STEPS Survey. Plos One 6, e20316.

Murray, C.J.L., Vos, T., Lozano, R., Naghavi, M., Flaxman, A.D., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J.A., et al. 2012. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010. Lancet. 380, 2197–2223. doi:10.1016/S0140-6736(12)61689-4

National Institute on Aging, 2012. Global Health and Aging.

Paddick, S.-M., Gray, W.K., Ogunjimi, L., lwezuala, B., Olakehinde, O., Kisoli, A., Kissima, J., Mbowe, G., Mkenda, S., Dotchin, C.L., Walker, R.W., Mushi, D., Collingwood, C., Ogunniyi, A., 2015. Validation of the Identification and Intervention for Dementia in Elderly Africans (IDEA) cognitive screen in Nigeria and Tanzania. BMC Geriatr. 15, 53. doi:10.1186/s12877-015-0040-1

Payne, C.F., Mkandawire, J., Kohler, H.-P., 2013. Disability Transitions and Health Expectancies among Adults 45 Years and Older in Malawi: A Cohort-Based Model. PLOS Med 10, e1001435. doi:10.1371/journal.pmed.1001435

Prince, M., Acosta, D., Ferri, C.P., Guerra, M., Huang, Y., Jacob, K.S., Llibre Rodriguez, J.J., Salas, A., Sosa, A.L., Williams, J.D., Hall, K.S., 2011. A brief dementia screener suitable for use by non-specialists in resource poor settings—the cross-cultural derivation and validation of the brief Community Screening Instrument for Dementia. Int. J. Geriatr. Psychiatry 26, 899–907. doi:10.1002/gps.2622

Prince, M., Bryce, R., Albanese, E., Wimo, A., Ribeiro, W., Ferri, C.P., 2013. The global prevalence of dementia: A systematic review and metaanalysis. Alzheimers Dement. 9, 63–75.e2. doi:10.1016/j.jalz.2012.11.007

Ryff, C.D., Lachman, M.E., 2009. National Survey of Midlife Development in the United States (MIDUS II): Cognitive Project, 2004-2006: Version 5.

Salthouse, T.A., 1991. Theoretical Perspectives on Cognitive Aging, Revised ed. edition. ed. Psychology Press, Hillsdale, N.J.

Seeman, T.E., Lusignolo, T.M., Albert, M., Berkman, L., 2001. Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. Health Psychol. 20, 243–255.

Skirbekk, V., Loichinger, E., Weber, D., 2012. Variation in cognitive functioning as a refined approach to comparing aging across countries. Proc. Natl. Acad. Sci. 109, 770–774. doi:10.1073/pnas.1112173109

Sosa, A.L., Albanese, E., Stephan, B.C.M., Dewey, M., Acosta, D., Ferri, C.P., Guerra, M., Huang, Y., Jacob, K.S., Jiménez-Velázquez, I.Z., Llibre Rodriguez, J.J., Salas, A., Williams, J., Acosta, I., González-Viruet, M., Guerra Hernandez, M.A., Shuran, L., Prince, M.J., Stewart, R., 2012. Prevalence, Distribution, and Impact of Mild Cognitive Impairment in Latin America, China, and India: A 10/66 Population-Based Study. PLoS Med 9, e1001170. doi:10.1371/journal.pmed.1001170

Staff, R.T., Chapko, D., Hogan, M.J., Whalley, L.J., 2016. Life course socioeconomic status and the decline in information processing speed in late life. Soc. Sci. Med. 151, 130–138. doi:10.1016/j.socscimed.2016.01.019

Stern, Y., 2009. Cognitive reserve. Neuropsychologia 47, 2015–2028. doi:10.1016/j.neuropsychologia.2009.03.004

UNDP, 2014. Human Development Report 2014. United Nations Development Programme, New York, NY.

UNDP, 2010. Malawi Millennium Development Goals Report. UNDP and Malawi Ministry of Development Planning and Cooperation, New York, NY, and Lilongwe, Malawi.

United Nations Population Division, 2015. World Population Prospects (No. ESA/P/WP.241.).

Watson, N.L., Rosano, C., Boudreau, R.M., Simonsick, E.M., Ferrucci, L., Sutton-Tyrrell, K., Hardy, S.E., Atkinson, H.H., Yaffe, K., Satterfield, S., Harris, T.B., Newman, A.B., Study, for the H.A., 2010. Executive Function, Memory, and Gait Speed Decline in Well-Functioning Older Adults. J. Gerontol. A. Biol. Sci. Med. Sci. glq111. doi:10.1093/gerona/glq111

WHO, 2014 Noncommunicable diseases country profiles. WHO. URL http://www.who.int/nmh/countries/en/ (accessed 3.7.16a).

Zagheni, E., 2011. The impact of the HIV/AIDS epidemic on kinship resources for orphans in Zimbabwe. Popul. Dev. Rev. 37, 761–783.

Zhang, Z., 2006. Gender differentials in cognitive impairment and decline of the oldest old in China. J. Gerontol. B. Psychol. Sci. Soc. Sci. 61, S107–115.

Zimmer, Z., Teachman, J., 2009. Household Composition among Elders in Sub-Saharan Africa in the Context of HIV/AIDS. J. Marriage Fam. 71, 1086–1099.

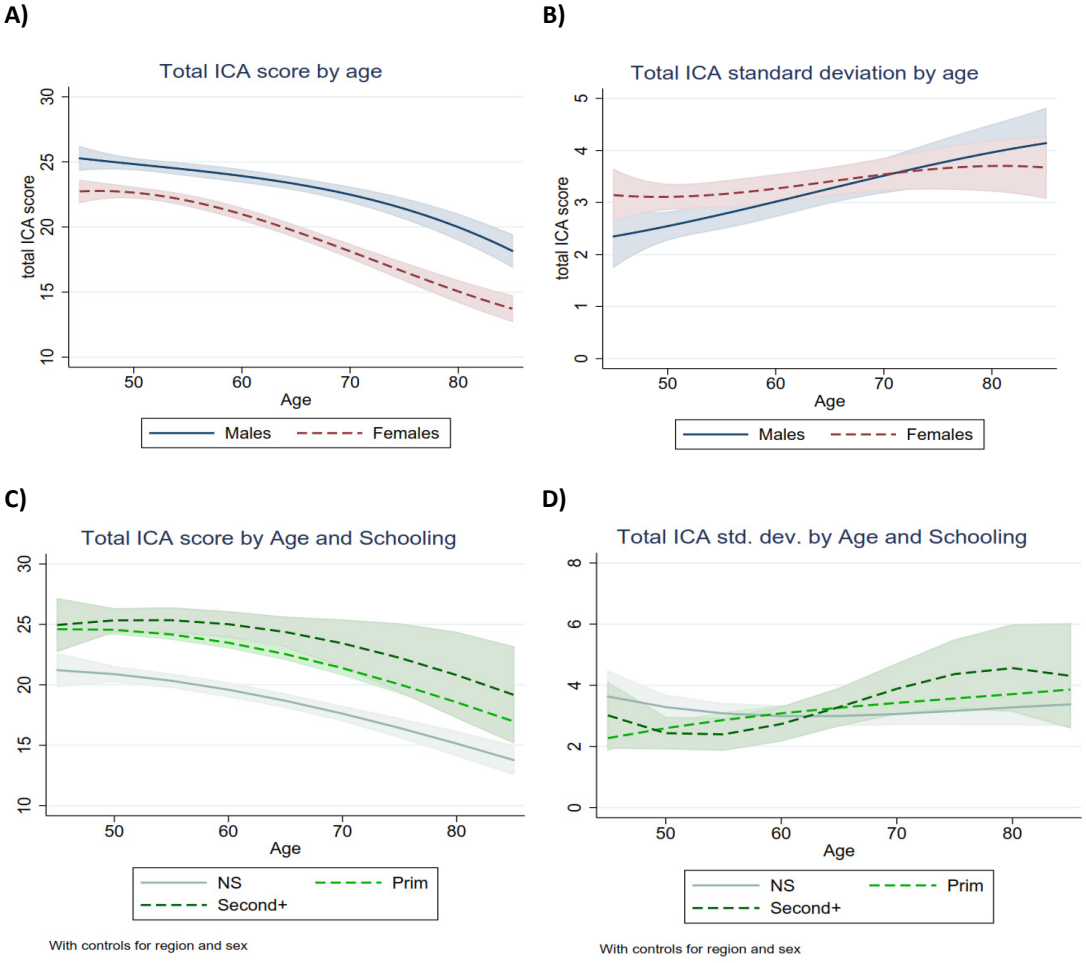
**Table 1: Sample characteristics and baseline associations with ICA score for the MLSFH study population aged 45+ in 2012**

| | (1) **Females** mean (sd) | (2) **Males** mean (sd) | (3) **Total** mean (sd) | (4) **ICA score** |
|---|---|---|---|---|
| # of observations | 711 | 535 | 1246 | |
| Age | 59.4 (11.3) | 60.7 (10.8) | 60.0 (11.1) | -- |
| Total ICA score | 20.4 (5.2) | 23.4 (4.4) | 21.7 (5.1) | -- |
| Age group | | | | |
| *45-54* | 0.42 | 0.33 | 0.38 | ref. |
| *55-64* | 0.29 | 0.34 | 0.31 | -0.91** |
| *65-74* | 0.17 | 0.21 | 0.19 | -3.26** |
| *75+* | 0.12 | 0.12 | 0.12 | -6.24** |
| Education level | | | | |
| *No formal education* | 0.48 | 0.20 | 0.36 | ref. |
| *Primary* | 0.50 | 0.68 | 0.58 | 2.83** |
| *Secondary or higher* | 0.02 | 0.11 | 0.06 | 5.51** |
| Region | | | | |
| *Central (Mchinji)* | 0.31 | 0.29 | 0.30 | ref. |
| *South (Balaka)* | 0.34 | 0.39 | 0.37 | 0.27 |
| *North (Rumphi)* | 0.34 | 0.32 | 0.33 | 0.57+ |
| Metal/tile roof | 0.30 | 0.32 | 0.31 | 0.93** |
| Muslim | 0.28 | 0.26 | 0.27 | -0.38 |
| Currently married | 0.63 | 0.95 | 0.77 | 0.33 |
| HIV positive | 0.04 | 0.05 | 0.05 | 0.26 |
| Female | -- | -- | 0.57 | -1.92** |
| Constant | | | | 21.7** |
| **Cognitive ability classification (Age 55+ only)** | | | | |
| *High ability (ICA ≥ 26.5)* | 8.6 | 27.3 | 17.2 | |
| *Average ability (ICA range 21-26)* | 27.7 | 42.4 | 34.4 | |
| *Low ability (ICA range 16-20.5)* | 36.7 | 21.0 | 29.5 | |
| *Mild impairment (ICA range 12-15.5)* | 14.1 | 5.7 | 10.3 | |
| *Moderate to severe impairment (ICA < 12)* | 12.9 | 3.6 | 8.6 | |

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Notes: Column 4 reports the coefficients of a multivariate regression of ICA score on respondent characteristics

**Figure 1: Total ICA Score by sex and level of schooling, MLSFH sample**




Notes: NS=No schooling, Prim=Some primary schooling (1-7 years), Second+= Some secondary or more (8+ years)

**Figure 2: Comparison of z-scored cognitive indices from MSLFH, CogUSA, and MIDUS II**

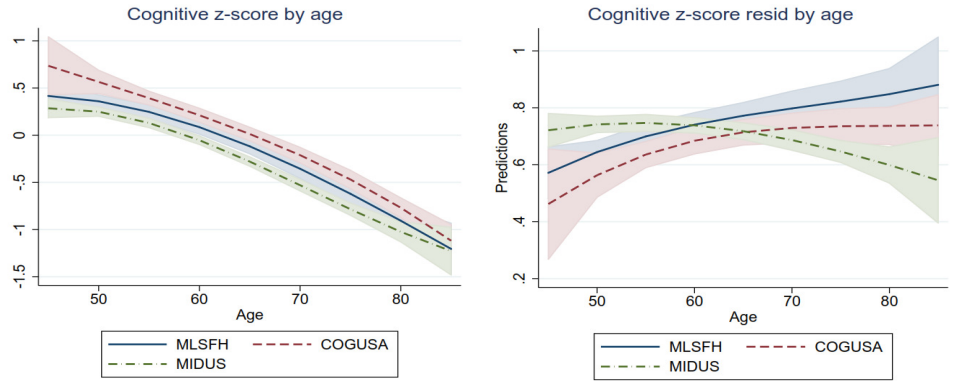


**Table 2: Linear age gradient in ICA score, MLSFH sample**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Age gradient (change in CH per year of age) | -0.21** | -0.17** | -0.16** | -0.16** | -0.16** |
| | (0.011) | (0.017) | (0.018) | (0.017) | (0.017) |
| Female × age gradient | | -0.069** | -0.060** | -0.067** | -0.058** |
| | | (0.022) | (0.023) | (0.022) | (0.022) |
| Schooling × age gradient | | | 0.63 | | 0.75 |
| | | | (0.53) | | (0.52) |
| Roof material × age gradient | | | | 0.41 | 0.23 |
| | | | | (0.43) | (0.42) |

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

**Table 3: Multivariate associations between ICA score, social environment, and social participation, MLSFH sample**

| | (1) | (2) | (3) |
|---|---|---|---|
| Total household size | 0.041 | | 0.038 |
| | (0.050) | | (0.050) |
| Number of proximate children | 0.10* | | 0.097+ |
| | (0.053) | | (0.052) |
| Social events attended past month | | -0.011 | -0.012 |
| | | (0.022) | (0.022) |
| Visits to market past month | | 0.071** | 0.072** |
| | | (0.016) | (0.016) |
| Village group memberships | | 0.25** | 0.22** |
| | | (0.081) | (0.081) |
| Additional controls included | Yes | Yes | Yes |
| Observations | 1190 | 1190 | 1190 |

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

**Table 4: Association between ICA score and Long-term Socioeconomic Status, MLSFH sample**

| | (1) | (2) | (3) |
|---|---|---|---|
| Years Included | 2001-2012 | 2001-2012 | 2008-2012 |
| Change in roof material | | | |
| *Non-metal at both waves* | Ref. | | Ref. |
| *Metal to non-metal* | --[a] | | 0.027 |
| *Non-metal to metal* | 0.83** | | 0.89** |
| *Metal at both waves* | 0.80+ | | 0.87** |
| Years with metal roof | | 0.088* | |
| Additional controls included | Yes | Yes | Yes |
| Observations | 805 | 805 | 1,246 |

+ p < 0.10 * p < 0.05, ** p < 0.01.
[a] Due to low cell size (n<10), this group was removed from the final analysis.

**Table 5: Association of cognitive health with protein intake, earnings, savings, and work efforts: pooled regressions for 2012 and 2013**

| | Protein intake | Earnings in past year | Any labor earnings past year | Any Savings | Work efforts (hours) |
|---|---|---|---|---|---|
| Mean of dep. Var. | 2.90 | 9.75 | 0.89 | 0.40 | 19.0 |
| Std dev | (1.93) | (3.65) | (0.31) | (0.49) | (12.8) |
| *Regression on:* | OLS | OLS | Logit | Logit | OLS |
| Panel 1: Total cognitive score | | | | | |
| *Total ICA Score* | 0.029+ | 0.082** | 0.044 | 0.066** | 0.41** |
| | (0.017) | (0.030) | (0.030) | (0.021) | (0.14) |
| *Female* | -0.32** | -0.97** | -0.32+ | 0.14 | 5.20** |
| | (0.089) | (0.16) | (0.17) | (0.11) | (0.76) |
| *Female × ICA score* | 0.011 | 0.0071 | 0.014 | 0.0012 | -0.19 |
| | (0.021) | (0.038) | (0.038) | (0.026) | (0.17) |
| Panel 2: Cognitive ability classification (ref: average ability) | | | | | |
| *High ability* | 0.41** | 0.019 | -0.22 | 0.58** | 0.53 |
| | (0.14) | (0.31) | (0.37) | (0.18) | (1.38) |
| *Low ability* | -0.14 | -0.68+ | -0.39 | -0.18 | -0.17 |
| | (0.14) | (0.39) | (0.37) | (0.17) | (1.19) |
| *Mild impairment* | -0.38+ | -2.01* | -1.24** | -0.56* | -5.63** |
| | (0.20) | (0.79) | (0.46) | (0.27) | (1.71) |
| *Mod. to sev. impairment* | -0.51* | -2.60* | -1.48* | -0.84* | -3.16 |
| | (0.22) | (1.20) | (0.63) | (0.39) | (2.05) |

+ p < 0.10 * p < 0.05, ** p < 0.01.
*Note*: additional coefficients are available in Appendix Tables 4 and 5

**Table 6: Association of cognitive health with life satisfaction, depression (PHQ9), anxiety (GAD7), and SF-12 mental health score, pooled regressions for 2012 and 2013**

| | Life satis-faction | PHQ9 depression score | GAD7 anxiety score | SF-12 mental health score |
|---|---|---|---|---|
| Mean of dep. Var. | 3.53 | 2.98 | 2.59 | 52.9 |
| Std dev | (0.97) | (3.79) | (2.82) | (10.1) |
| *Regression on:* | OLS | OLS | OLS | OLS |
| Panel 1: Total cognitive score | | | | |
| *Total ICA Score* | 0.032** | -0.15** | -0.12** | 0.49** |
| | (0.0081) | (0.035) | (0.027) | (0.092) |
| *Female* | -0.16** | 0.79** | 0.55** | -1.75** |
| | (0.045) | (0.18) | (0.14) | (0.48) |
| *Female × ICA score* | -0.0082 | 0.024 | 0.040 | -0.14 |
| | (0.010) | (0.043) | (0.032) | (0.11) |
| Panel 2: Cognitive ability classification (ref: average ability) | | | | |
| *High ability* | 0.0021 | -0.16 | -0.22 | 1.53+ |
| | (0.078) | (0.31) | (0.23) | (0.89) |
| *Low ability* | -0.26** | 0.72* | 0.40* | -2.12** |
| | (0.068) | (0.28) | (0.19) | (0.73) |
| *Mild impairment* | -0.33** | 2.10** | 1.68** | -5.09** |
| | (0.095) | (0.47) | (0.35) | (1.13) |
| *Mod. to sev. impairment* | -0.67** | 2.62** | 1.78** | -5.08** |
| | (0.12) | (0.66) | (0.45) | (1.72) |

+ p < 0.10 * p < 0.05, ** p < 0.01.
*Note*: additional coefficients are available in Appendix Tables 6 and 7

**Table 7: Association of cognitive health with physical health, pain, grip strength, BMI, and BP: pooled regressions for 2012-2013**

| | Self-rated health | Accomp-lished less, due to phys. health | Work limitation, due to phys. health | Pain interfered with work | Grip Strength | Body Mass Index | Blood pressure (systolic) |
|---|---|---|---|---|---|---|---|
| Mean of dep. Var. | 3.21 | 1.90 | 1.86 | 1.96 | 22.1 | 21.7 | 135.3 |
| Std dev | (0.96) | (1.10) | (1.07) | (1.18) | (6.31) | (3.90) | (25.6) |
| *Regression on:* | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Panel 1: Total cognitive score | | | | | | | |
| *Total ICA Score* | 0.045** | -0.042** | -0.043** | -0.047** | 0.26** | 0.049 | -0.31 |
| | (0.0081) | (0.010) | (0.0099) | (0.010) | (0.058) | (0.038) | (0.30) |
| *Female* | -0.21** | 0.23** | 0.26** | 0.28** | -5.40** | 1.43** | 0.61 |
| | (0.044) | (0.051) | (0.048) | (0.054) | (0.29) | (0.23) | (1.61) |
| *Female × ICA score* | -0.016 | 0.0090 | 0.010 | 0.0073 | 0.021 | 0.050 | 0.33 |
| | (0.0100) | (0.012) | (0.012) | (0.013) | (0.065) | (0.052) | (0.39) |
| Panel 2: Cognitive ability classification (ref: average ability) | | | | | | | |
| *High ability* | 0.18* | -0.030 | -0.031 | -0.059 | 1.36** | 0.093 | 0.50 |
| | (0.075) | (0.094) | (0.086) | (0.093) | (0.50) | (0.38) | (2.88) |
| *Low ability* | -0.22** | 0.18* | 0.17* | 0.14+ | -0.94* | -0.89* | 1.84 |
| | (0.071) | (0.076) | (0.075) | (0.083) | (0.46) | (0.36) | (2.55) |
| *Mild impairment* | -0.48** | 0.62** | 0.56** | 0.67** | -2.59** | -0.60 | 2.23 |
| | (0.099) | (0.12) | (0.12) | (0.13) | (0.51) | (0.54) | (3.71) |
| *Mod. to sev. imp.* | -0.59** | 0.80** | 0.77** | 0.75** | -3.24** | -1.02+ | -2.12 |
| | (0.13) | (0.18) | (0.17) | (0.19) | (0.71) | (0.56) | (5.36) |

+ p < 0.10 * p < 0.05, ** p < 0.01.
*Note*: additional coefficients are available in Appendix Tables 8 and 9

# Cognitive Health Among Older Adults: Evidence from Rural Sub-Saharan Africa

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July 28, 2016

## APPENDIX/SUPPLEMENTAL MATERIALS

A "*Cohort Profile*" of the MLSFH, providing detailed discussion of MLSFH sampling procedures, survey methods, survey instruments, and analyses of attrition has been published in the *International Journal of Epidemiology* (Kohler et al. 2015a). Essential information on the MLSFH, including a detailed description of the 2012–13 MLSFH mature adult surveys that provide the cognitive health measures used in this paper, is also reported in the Appendix A below. Appendix B includes the MLSFH adaptation of the International Cognitive Assessment (ICA) Questionnaire that was used in the MLSFH 2012–13 data collection to assess cognitive health. Appendix C includes additional tables that complement the tables reported the main text.

## A. THE MALAWI LONGITUDINAL STUDY OF FAMILIES AND HEALTH (MLSFH)

### A1. MLSFH sampling methods and related relevant data collection procedures

The ***Malawi Longitudinal Study of Families and Health*** (MLSFH) is a collaboration of the University of Pennsylvania with the College of Medicine and Chancellor College at the University of Malawi. A detailed description is available in a MLSFH Cohort Profile (Kohler et al. 2015a).

**MLSFH Study Areas:** The MLSFH is based in three districts in rural Malawi that have been the study sites since 1998: Rumphi in the north, Mchinji in the center, and Balaka in the south. In all of these three regions, the primary source of livelihood for MLSFH respondents is subsistence agriculture, augmented with small-scale trade of agricultural products and other goods. Transportation networks are relatively rudimentary with paved primary roads and generally unpaved secondary roads. Marriage is relatively universal in these rural Malawian regions, with more than 96% of women having ever married by age 25–29, and more than 95% of men having ever married by age 30–34 (Malawi DHS 2011). While the broad demographic, socioeconomic and epidemiological conditions are fairly

similar across the three MLSFH study regions, and also across other parts of rural Malawi, some noteworthy differences across the MLSFH regions include the following. Rumphi District, located in the northern region of the country, follows the patrilineal system of kinship and lineage where residence is ideally patrilocal, inheritance is traced through sons, and parents of a groom pay bridewealth. The northern district, inhabited primarily by Tumbukas, is predominantly Protestant. Mchinji District, located in the central region, follows a less rigid matrilineal system whereby residence may be matrilocal or patrilocal. The Center is primarily inhabited by Chewas, with almost equal proportions of Catholics and Protestants. Balaka District, which is located in the southern region, is primarily inhabited by Lomwes and Yaos and has the highest proportion of Muslims. The region follows a matrilineal system of kinship and lineage system where residence is ideally matrilocal, although it is not uncommon for wives to live at least some period of time in their husband's village. The Balaka region also exhibits a lower age of sexual debut and larger numbers of lifetime sexual partners than the other MLSFH study regions, and residents tend to be less educated and poorer than those living in the north, leading to higher levels of migration. HIV/AIDS prevalence in the southern region is significantly higher than in the northern and central region.

**Initial MLSFH Sample:** The original 1998 MLSFH target sample was 1,500 ever-married women age 15–49 (500 in each district), plus their husbands (for additional information, see http://malawi.pop.upenn.edu). In total, across all three regions, the MLSFH Round 1 in 1998 enrolled a sample of slightly more than 1,500 ever-married women aged 15–49 and close to 1,100 of their spouses residing in about 120 study villages.

**MLSFH Respondent follow-up, migration and vital status:** The MLSFH returned to the study areas in 2001, 2004, 2006, 2008 and 2010 to reinterview the MLSFH study population. For this purpose, the MLSFH maintained a respondent database that contained previously collected identifying information for each respondent (respondents name, compound name, village name and GPS coordinates, etc.). Using this existing identifying information, MLSFH interviewers attempted to contact and reinterview MLSFH participants in each of the follow-up years. If MLSFH participants were absent at the first interviewer visit, up to two additional follow-up visits were made. Except for a migration follow-up study in 2007, which is not part of the present analyses, MLSFH respondents were not followed if they had migrated outside of the MLSFH study villages. However, they remained in the MLSFH sampling frame, and were interviewed at subsequent MLSFH waves if they returned to the MLSFH study villages (as is common since a significant amount of migration is labor-related and thus temporary). On average, the MLSFH succeeded in re-interviewing between 75–85% of the respondents interviewed at the previous MLSFH waves. Conditional on successfully contacting a MLSFH respondents, refusals to participation in the MLSFH have been very low across all MLSFH waves ($< 3\%$ up to 2008, and $< 5\%$ in 2010). Comparisons of the MLSFH study population with nationally representative datasets are reported below (Ap-

pendix A3).

**MLSFH Sample Additions:** Additions to the MLSFH have occurred primarily through three mechanisms: new spouses, the 2004 adolescent sample, and the 2008 parent sample. We discuss these three mechanisms in turn. ***New spouses:*** The initial MLSFH sample in 1998 included 1,541 ever-married women aged 15–49 and their spouses. Up to the 2004 round of data collection, the MLSFH attempted to re-interview all of these initial MLSFH respondents and their current spouses; that is, if a MLSFH respondent divorced and remarried, or in the case of polygamous men, added an additional wife, the MLSFH added the current wife (all current wives) of the initial MLSFH participants. However, spouses who were not part of the initial MLSFH sample were not followed and retained in the MLSFH if they divorced or their spouses died. Starting with the 2006 MLSFH, the study retained all MLSFH study participants; that is, from 2006 onward, once an individual was interviewed for the MLSFH once, for instance after being enrolled as a new spouse, the MLSFH made an attempt to re-interview the respondent at all subsequent waves. ***2004 Adolescent Sample:*** In 2004, to compensate for the aging of the initial MLSFH sample and the underrepresentation of unmarried individuals at adolescent and young adult ages, the MLSFH added an adolescent sample ($N = 998$). Because of their young age, members of the adolescent sample are not included in the analyses of this paper. ***2008 MLSFH Parent Sample:*** To increase the suitability of the MLSFH to study intergenerational aspects and the health of older individuals in Malawi, a parent sample was added to the MLSFH in 2008. This new sample of parents of MLSFH respondents was drawn from family listings from MLSFH respondents in 2006 (because of the respondents' young age, parents of MLSFH respondents in the 2004 adolescent sample were not included). All living biological parents who resided in the same village as the respondent were included in the 2008 MLSFH new sample of parents. Based on this approach, parents of MLSFH respondents living in the MLSFH study villages were added to the 2008 MLSFH sample ($N = 549$). As a result, the age range covered by the MLSFH was substantially extended. Among approximately 3,800 respondents interviewed in the 2010 MLSFH, 44.1% were from the original MLSFH sample drawn in 1998, 19.5% were from the 2004 adolescent sample, 12.5% from the 2008 parent sample, and the remainder (23.9%) were new spouses that have been added during 2001–2010.

### A2. 2012 and 2013 MLSFH mature adults survey on mental and cognitive health

The 2012 MLSFH survey on mature adults focused on mental and cognitive health among MLSFH respondents aged 45 and older. The 2012 MLSFH Mature Adult Survey completed 1,266 surveys (clustered in 130+ villages) out of 1,402 MLSFH respondents in the MLSFH database who met the enrollment criteria for this survey: being age 45+ and having been interviewed in 2010 and 2008 (a restriction that ensured that at least three waves of MLSFH data were available for each participant in the 2012 MLSFH). That is, the 2012 Mature Adult Survey managed to find and enroll more than 90% of previously interviewed MLSFH mature adults. The 2013

MLSFH mature adult survey reinterviewed 1,203 (95%) of the 2012 respondents and the survey also enrolled some mature adult respondents who were absent in 2012 resulting in 1,257 respondents. The 2012–13 MLSFH mature adult surveys therefore provide a total baseline sample of about 1,300 observations (for 1,320 MLSFH mature adults, either 2012 or 2013 data is available). Appendix Table 13 reports the reasons for not being interviewed in the 2012 and 2013 mature adults surveys, indicating that mortality and temporary/permanent migration where the leading reasons for attrition from the 2012/13 target samples.

The ICA cognitive health score and ICA categorical measure is available for 1,241 respondents in 2012 (98% of total 2012 respondents) and 1,229 in 2013 (98% of total 2013 respondents). Missingness on the ICA score is primarily due to item non-response, though 8 individuals in the 2012 wave and 7 in the 2013 wave were excluded due to blindness. There were no significant differences in item non-response by gender and slightly higher item non-response among older than younger respondents.

Comparisons of our 2010 MLSFH mature adult analysis sample characteristics to the age 45+ rural sample of the nationally-representative 2010–11 Third Malawi Integrated Household Survey (IHS3) Malawi IHS (2012) also show that basic demographic and socioeconomic characteristics between our MLSFH study population and the IHS3 are overall quite similar (Payne et al. 2013). Individuals aged 65 and over in the MLSFH were somewhat more likely to have ever attended school that those in the IHS3, and differences arise in the distribution of religion, where Muslims are overrepresented in the MLSFH due to the fact that about 1/3rd of the MLSFH study population is from the primarily Muslim region of Balaka.

To document the longitudinal origin of the 2012–13 MLSFH mature adults sample, Appendix Table 14 reports the *first* available MLSFH survey round for participants in the 2012 MLSFH mature adult survey (MLSFH 7). It shows, that for more than 63% of the 2012 MLSFH participants, initial data are available from either 1998 or 2001. These mature adult respondents from 1998/2001 represent the relatively younger end of the MLSFH mature adult sample, with the 2012 interquartile age range for these respondents being 49–60 years (mean age: 55.4 years). The older part of the 2012 MLSFH mature adults sample, representing about 30% of the 2012 study population with an interquartile age range from 62–76 years (mean: 69.2), was mostly added in 2008 as part of the MLSFH Parent Sample (Appendix A1).

With more than 90% of the target samples interviewed in 2012 and 2013, attrition from the 2012–13 MLSFH mature adults target sample is not a major concern for the analyses in this paper. But arguably, concerns about attrition among the MLSFH mature adults extends beyond the attrition from the 2012/13 target sample, and possibly include concerns about selectivity due to the eligibility criteria for inclusion in the 2012–13 MLSFH mature adult target sample. Besides the age restriction ($\text{Age}_{2012} \geq 45$), this eligibility criteria included the requirement that a respondent was interviewed in both 2008 and 2010 MLSFH waves. This restriction was imposed to ensure that at least three waves of MLSFH data were available for

each participant in the 2012 MLSFH, thereby facilitating a sufficiently large sample size for longitudinal analyses 2008–12. To address concerns that attrition from the MLSFH resulted in selection for the target and final samples of the 2012–13 MLSFH mature adults surveys, we provide below (Appendix A4) detailed analyses of attrition, focusing particularly on attrition since 2008 when the MLSFH Parent Sample was added to the MLSFH study population. The conclusion based on our analyses of attrition is that, while the eligibility for the 2012 mature adult survey and general loss-to-follow-up implied that a sizable fraction of 2008 age-eligible respondents was not surveyed in the 2012 MLSFH mature adult survey, attrition among MLSFH mature adults 2008–12 does not seem to bias the coefficients of estimated relationships between cognitive health and its determinants that are highlighted in the analyses in this paper.

The aim of the 2012–13 MLSFH mature adult samples was to strengthen the abilities of the MLSFH to address questions about aging and non-communicable diseases within a longitudinal life-course framework in a low-income high-HIV prevalence context such as Malawi. In both 2012 and 2013, MLSFH mature adults were therefore interviewed using a questionnaire that continued key elements of the 2008 and 2010 data collections and added new detailed measures of physical, mental and cognitive health, including the ICA cognitive health instrument on which the analyses in this paper are based. The ICA cognitive assessment was administered in the local languages and the translation of the questionnaire into Chichewa, Yao, and Tumbuka was pretested during focus-group interviews and pilot tests, and reverse translations ensured the accuracy of the final instruments. In addition, respondents were interviewed by interviewers from the same region who spoke the same language as the respondents. Interviewers and their supervisors were extensively trained in the collection of these scales, and all instruments were piloted extensively before the data collection. In 2013, the second year of the data collection on mature adults, the team hired and re-trained the same interviewers from the previous year. The questions asked in the ICA did not vary between the 2012 and 2013 questionnaires, respondents were not provided with the correct answers to any questions.

Specifically, the measures of mental health and well-being collected as part of the 2012-13 MLSFH mature adult survey included (see also Appendix Table 15):
(1) For *mental health*, the 2012–13 MLSFH collected (*a*) continued measurement of the SF12 mental health score that is available since 2006; and (*b*) the depression and anxiety modules of the Patient Health Questionnaire-9 (PHQ-9) that allow assessment of both the presence and the severity of depression and anxiety disorders.
(2) For *cognitive health and cognitive ability*, the 2012–13 MLSFH collected measurements for (*a*) spatial/temporal orientation and language based on typical questions used in many different mental status examinations; visual/constructional test to assess space and object perception; and (*b*) visual/verbal memory, attention/working memory, memory/immediate and delayed recall and executive functioning that resemble many clinical tests assessing these functions, but with necessary

adaptations to low literacy levels. This section cognitive health of the 2012–13 MLSFH questionnaire is included in Appendix C.
(3) *Grip strength as a measurement of physical performance:* Grip strength was measured in both hands using a mechanical handheld dynamometer. Grip strength is important as an estimate of the isometric strength in the upper extremity, and it correlates highly with other muscle groups and is often seen as a measurement of overall strength and physical performance. The 2012–13 MLSFH grip strength measurements followed identical field procedures as those used by the Health and Retirement Study (HRS) and SHARE studies.
(4) *Additional selected measures of well-being*: The 2012–13 MLSFH mature adult surveys continued to collect the MLSFH instruments on subjective risks assessments and probabilistic expectations, social capital and resource networks, social, demographic and economic background, and work efforts, productivity and related income/expenditure measures (for additional detail, see Kohler et al. 2015a).
(5) *BMI, blood pressure and HIV testing:* Body mass index (BMI)—an important indicator of nutritional status—was obtained in 2012 and 2013 from *measured* height and weight, complementing earlier MLSFH BMI data for 2008. Blood pressure (three measurements) was obtained in 2013 using upper-arm blood pressure monitors. In addition, all mature adults who participated in the 2012 data collection were tested for HIV, updating earlier MLSFH HIV tests from 2004–08. Based on all available HIV tests 2004–20012, only 59 HIV+ mature adults (HIV prevalence = 4.8%) were interviewed in 2012 (31 woman and 28 males), reflecting possibly high mortality for HIV+ individuals in these cohorts prior to the availability of ART in the study region (ART started to be available in the MLSFH study regions only in 2008). HIV prevalence by age among the MLSFH mature adults in 2012 is reported in Appendix Table 16.

Prior to this 2012–13 MLSFH mature adult survey, no large-scale population-based data on cognitive health using established clinical scales was available for a poor rural sub-Saharan African mature-adult population. The 2012–13 MLSFH mature-adult surveys provide an important resource for understanding cognitive health in such contexts. The survey has also demonstrated that the collection of commonly-used survey-instruments for measuring cognitive function and its correlates is possible even in a subsistence-agriculture population that is characterized by high levels of poverty, low levels of schooling, high levels of illiteracy, and often poor health.

### A3. Comparisons of the MLSFH with national representative samples

While the initial sampling strategy of the MLSFH was not designed to be representative of the national population of rural Malawi, the initial sample characteristics closely matched the characteristics of the rural population of the 1996 Malawi Demographic and Health Survey (DHS) (Watkins et al. 2003). After three rounds of longitudinal data collection, despite attrition and the enrollment of new subjects, the 2004 MLSFH sample continues to be in close agreement in observable character-

istics with the nationally-representative 2004 Malawi DHS (rural sub-population) (Anglewicz et al. 2009; Kohler et al. 2015a). Similarly, comparisons of the 2010 MLSFH study population with the rural samples of the MDHS and IHS3 surveys reveal that the MLSFH study population continues to closely match the characteristics of nationally-representative cross-sectional surveys (Kohler et al. 2015a). Focusing on MLSFH respondents aged 45 and older, the 2010 MLSFH mature adult population—i.e., the study population that is used for the analyses here—also closely matches the rural subsample in the 2010 national-representative IHS3 survey in key observable characteristics (Payne et al. 2013) (differences arise in the distribution of religion, where Muslims are overrepresented in the MLSFH due to the fact that about 1/3rd of the MLSFH study population is from the primarily Muslim region of Balaka, and individuals aged 65 and over in the MLSFH were somewhat more likely to have ever attended school that those in the IHS3). In summary, however, neither the initial sample selection that restricted the MLSFH to three rural region, nor the MLSFH attrition and enrollment of new MLSFH respondents over time, seem to have importantly affected the MLSFH in terms of its ability to represent the rural population of Malawi. By design, the MLSFH is different from nationally-representative rural samples in terms of its age distribution and religious composition, and where appropriate, the MLSFH can be weighted to match the age distribution of rural Malawi. The MLSFH also contains a larger fraction of respondents who are currently married, which is likely due to the initial 1998 MLSFH sample that focused on ever-married women and their spouses and the fact that peri-urban regions are missing in the MLSFH.

### A4. Analyses of attrition in MLSFH Mature Adult sample

Any longitudinal data suffers some sample attrition, which can bias analyses if those who exit the study population are systematically different from those who do not, based on either observed or unobserved characteristics (Alderman et al. 2001; Fitzgerald et al. 1998; Thomas et al. 2012). Analyses of MLSFH survey attrition reported in the MLSFH Cohort Profile (Kohler et al. 2015a) indicate that, even though respondent characteristics often differ significantly between those who were lost to follow-up and those who were re-interviewed and attrition was often predicted by key respondent characteristics, the coefficient estimates for standard family background variables in regressions and probit equations for the majority of the outcome variables were not affected significantly by attrition. The analyses in the MLSFH Cohort Profile thus conclude that the attrition levels observed in the MLSFH may not necessarily represent a general problem for obtaining consistent estimates of the coefficients of interest for most of these outcomes. These results, which are very similar to those documented in related MLSFH studies (Anglewicz et al. 2009; Fedor et al. 2015) and related other longitudinal studies (Alderman et al. 2001; Falaris 2003; Fitzgerald et al. 1998), lend support to the value of longitudinal cohort studies and suggest that multivariate estimates of behavioral relations in such longitudinal studies may not necessarily be biased due to attrition.

We augment the MLSFH attrition analyses reported elsewhere with some specific attrition analyses for the MLSFH mature adults sample on which the analyses in this paper are based. The target sample for the 2012 MLSFH mature adult survey included MLSFH respondents aged 45+ and having been interviewed in 2010 and 2008 (see Appendix A2 for details). As indicated earlier, more than 90% of the target samples were interviewed in 2012 and 2013, and attrition from the 2012–13 MLSFH mature adults target samples is not a major concern for the analyses in this paper. However, to alleviate concerns that attrition from the MLSFH resulted in selection for the target and final samples of the 2012–13 MLSFH mature adults surveys, we provide in this section additional analyses of attrition. We focus particularly on attrition since 2008, when the MLSFH Parent Sample, which provides the older subset of MLSFH mature adults (Appendix Table 14), was added to the study population.

The 2010 and 2012 survey outcomes for all 2008 MLSFH respondents who were eligible for the 2012 mature adult survey based their age is reported in Appendix Table 17. Among all age-eligible 2008 respondents, 340 were not included in the 2012 mature adult survey because they were not interviewed in 2010, and 61 respondents could not be included because they had died as of 2010. Among the 1,477 age-eligible 2008 respondents who were interviewed in 2010, and thus met all additional eligibility criteria for the 2012 mature adult survey, 1,266 were successfully surveyed in 2012, 43 had died by 2012, 75 were excluded based on missing information on key variables, and 93 were not found or not surveyed for other reasons.

Appendix Table 18 shows that 2008 age-eligible respondents who were surveyed in the 2012 mature adult survey were somewhat younger than those who were not surveyed in 2012. They were more likely to be currently married, were less likely to be from the central and more likely to be from the northern region, were less likely to be HIV+, had slightly higher levels of subjective well-being, and were of slightly better physical health. Several of these univariate differences between attritors and non-attritors are related to the age and regional pattern of attrition, and in all cases in Appendix Table 18, the differences in 2008 respondent characteristics are no longer statistically different after controlling for region, age, age$^2$ and gender. In multivariate analyses (Appendix Table 19), age, region and being HIV+ are primary predictors of not being surveyed in 2012. Attrition is therefore mostly predicted by a set of fixed/predetermined respondent characteristics that are also strongly associated with mortality during 2008–12. Our analyses also suggest that attrition among MLSFH mature adults aged 45+ is less selective than attrition in the overall MLSFH where selective migration a is more important factor for loss-to-follow-up among younger respondents (Anglewicz et al. 2015; Kohler et al. 2015a).

The 2012–13 waves of the MLSFH are the first ones to include measures of cognitive health. Early waves of the MLSFH include the SF12 survey instrument, providing a measure of mental health that is reasonably strongly correlated with cog-

nitive function in the 2012–13 MLSFH data (correlation coefficient with ICA cognitive health score is equal to 0.25–0.28 among 2012–13 mature adults). While it is therefore not possible to compare the 2012–13 cognitive health measures for mature adults with earlier rounds of MLSFH, we provide analyses of mental health to address possible concerns about selective attrition. Specifically, in our final attrition analyses, we assess if the analyses of the determinants and correlates of mental health in this paper are potentially affected by attrition among the MLSFH mature adults. Following earlier analyses of attrition in the MLSFH and other longitudinal cohort studies (Alderman et al. 2001; Anglewicz et al. 2009; Fedor et al. 2015; Fitzgerald et al. 1998; Kohler et al. 2015a), this assessment is based on regressions of 2008 mental-health measures—SF12 mental health score, subjective well-being and a depression/anxiety index (DAX) (Kohler et al. 2015b)[1]—for age-eligible 2008 MLSFH respondents ($\text{Age}_{2008} \geq 41$) on individual characteristics (measured in 2008), including an interaction of all included characteristics with an indicator for not being surveyed in the 2012 mature adult survey (Appendix Table 20). If the estimated relationships for these outcome variables differ between MLSFH respondents who are retained in the sample and those who are lost to follow-up, the interaction effects with attrition would be individually or jointly significant (this is referred to as the BGLW test for selective attrition; see Becketti et al. 1988). The bottom rows of Appendix Table 20 report the fraction of age-eligible 2008 respondents that are *not* surveyed in 2012, and F-tests for the null hypothesis that all interaction effects are jointly equal to zero. None of the individual interaction effects is significant at the 5% level, and the $H_0$ that all interaction effects are jointly zero is not rejected in any of the models in Appendix Table 20. While we cannot perform these analyses using pre-2012 measures of cognitive health in the MLSFH, the mental-health-related attrition analyses in Appendix Table 20 are strongly suggestive that similar findings would hold also for cognitive health.

In summary, two factors contribute to the fact that not all 2008 MLSFH respondents who meet the age-eligibility criteria for the 2012 mature adult survey were actually interviewed in 2012: (1) conventional attrition due to mortality, migration, refusal to be interviewed and other loss-to-follow-up, and (2) the additional eligibility criteria that required that members of the 2012 target sample had to be interviewed in both 2008 and 2010 MLSFH waves (imposed to ensure that ensured that at least three waves of MLSFH data were available for each participant in the 2012 MLSFH). Our analyses of attrition combined both of these reasons, and in-

[1]The depression/anxiety index (DAX) developed in Kohler et al. (2015b) is derived from two questions that are part of the SF12: *"Q1: How much time of the time during the past 4 weeks have you felt calm and peaceful?"* and *"Q2: How much of the time during the past 4 weeks have you felt downhearted and depressed?"*. Both questions are specifically related to depression and anxiety, and are available in the MLSFH since 2006 as part of the SF-12 module. The response categories range from 1 ="*All of the time*" to 5 = *"None of the time"*. The DAX is then computed as follows: DAX = 0 (*no depression/anxiety*) when Q1 $\leq$ 2 and Q2 $\geq$ 4; DAX = 2 (*moderate/severe depression/anxiety* if Q1 $\geq$ 4 and Q2 $\leq$ 2; and DAX = 1 (*mild depression/anxiety*) otherwise. This DAX index is related to the SF12 mental health score, with a correlation of about -.8 in our data, but it has the advantage for our analyses that it is more explicitly focused on depression and anxieity.

vestigated whether attrition—specified here as the fact that an age-eligible 2008 MLSFH respondent was *not* surveyed in 2012—resulted in selection and potential biases of our findings based on the 2012–13 mature adult surveys.

Overall, our analyses of attrition in the MLSFH mature adult data 2008–12 (Tables 14–20) confirm our earlier findings that attrition in the MLSFH does not pose an important concern for analyses such as those pursued in this paper. 2008 MLSFH respondents who met the age-eligibility for the 2012 mature adult survey, but were not interviewed in 2012, differ moderately in observed characteristics—including age, region of residence and HIV status—from those who were interviewed (Appendix Table 18). Controlling for age, region and gender, none of the differences in 2008 respondent characteristics between attritors and non-attritors remain statistically significant, and neither 2008 mental/physical health is a predictor of not being surveyed in 2012 (Appendix Table 19). Selective attrition based on observed characteristics is therefore less marked among the MLSFH mature adult population investigated in this paper as compared to the overall MLSFH study population—in part because older individuals aged 45+ are less mobile than younger individuals in the MLSFH.

Despite the fact that attrition during 2008–12 is predicted by some individual characteristics (Appendix Table 19), the coefficient estimates in relationships between mental health and individual characteristics are not affected by attrition. Specifically, for all of the mental health outcomes in Appendix Table 20, the null-hypothesis that the estimated coefficients in these relationships are identical for attritors and non-attritors is not rejected (BGLW test for selective attrition). While corresponding analyses cannot be performed for cognitive health, our mental-health-related attrition analyses are strongly suggestive that similar findings would hold also for cognitive health.

Our analyses of attrition therefore allow the conclusion that, while the eligibility for the 2012 mature adult survey and general loss-to-follow-up implied that a significant fraction of 2008 age-eligible respondents was not surveyed in the 2012 MLSFH mature adult survey, attrition among MLSFH mature adults 2008–12 does not seem to bias the coefficients of our estimated relationships between cognitive health and its determinants.

## REFERENCES

Alderman, H., J. R. Behrman, H.-P. Kohler, J. Maluccio, and S. C. Watkins. 2001. "Attrition in longitudinal household survey data: Some tests for three developing country samples." *Demographic Research* 5(4):79–123. doi:10.4054/DemRes.2001.5.4.

Anglewicz, P., J. Adams, F. Obare, H.-P. Kohler, and S. Watkins. 2009. "The Malawi Diffusion and Ideational Change Project 2004–06: Data collection, data quality and analyses of attrition." *Demographic Research* 20(21):503–540. doi:10.4054/DemRes.2009.20.21.

Anglewicz, P., M. VanLandingham, L. Manda-Taylor, and H.-P. Kohler. 2015. "Cohort profile: The Migration and Health in Malawi (MHM) Study." Population Studies Center, University of Pennsylvania, Working Paper #15-4, http://repository.upenn.edu/psc_working_papers/62/.

Becketti, S., W. Gould, L. Lillard, and F. Welch. 1988. "The Panel Study of Income Dynamics after fourteen years: An evaluation." *Journal of Labor Economics* 6(4):472–492.

Falaris, E. M. 2003. "The effect of survey attrition in longitudinal surveys: Evidence from Peru, Côte d'Ivoire and Vietnam." *Journal of Development Economics* 70(1):133–157. doi:10.1016/S0304-3878(02)00079-2.

Fedor, T. M., H.-P. Kohler, and J. R. Behrman. 2015. "The impact of learning HIV status on marital stability and sexual behavior within marriage in Malawi." *Demography* 52(1):259–280. doi:10.1007/s13524-014-0364-z.

Fitzgerald, J., P. Gottschalk, and R. Moffitt. 1998. "An analysis of sample attrition in panel data – the Michigan Panel Study of Income Dynamics." *Journal of Human Resources* 33(2):251–299.

Kohler, H.-P., S. C. Watkins, J. R. Behrman, P. Anglewicz, I. V. Kohler, et al. 2015a. "Cohort profile: The Malawi Longitudinal Study of Families and Health (MLSFH)." *International Journal of Epidemiology* 44(2):394–404. doi:10.1093/ije/dyu049. Working paper version available at http://repository.upenn.edu/psc_working_papers/46.

Kohler, I. V., C. F. Payne, C. Bandawe, and H.-P. Kohler. 2015b. "The demography of mental health among mature adults in a low-income high HIV-prevalence context." Population Studies Center, University of Pennsylvania, PSC Working Paper Series, WPS 15-1, http://repository.upenn.edu/psc_working_papers/59/.

Malawi DHS. 2011. *Malawi Demographic and Health Survey 2010 (Final Report)*. Zomba, Malawi, and Calverton, Maryland, USA: National Statistical Office (NSO) and ICF Macro. http://www.measuredhs.com.

Malawi IHS. 2012. "Malawi Integrated Household Survey 2010–11." Malawi National Statistical Office, Zomba, Malawi, and The World Bank, Washington, DC, http://microdata.worldbank.org/index.php/catalog/1003.

McArdle, J., W. Rodgers, and R. Willis. 2015. "Cognition and aging in the usa (cogusa) 2007-2009." (ICPSR 36053), http://www.icpsr.umich.edu/icpsrweb/NACDA/studies/36053.

Payne, C., J. Mkandawire, and H.-P. Kohler. 2013. "Disability transitions and health expectancies among adults 45 years and older mature in Malawi: A cohort modeling approach." *PLOS Medicine* 10(5):e1001,435. doi:10.1371/journal.pmed.1001435.

Reitan, R. M. 1979. *Manual for Administration of Neuropsychological Test Batteries for Adults and Children*. Neuropsychology Laboratory.

Ryff, C. D. and M. E. Lachman. 2009. "National survey of midlife development in the united states (midus ii): Cognitive project, 2004-2006." (Version 5, ICPSR 25281), http://www.icpsr.umich.edu/icpsrweb/NACDA/studies/25281.

Thomas, D., F. Witoelar, E. Frankenberg, B. Sikoki, J. Strauss, et al. 2012. "Cutting the costs of attrition: Results from the Indonesia Family Life Survey." *Journal of Development Economics* 98(1):108–123. doi:10.1016/j.jdeveco.2010.08.015.

Watkins, S., J. R. Behrman, H.-P. Kohler, and E. M. Zulu. 2003. "Introduction to "Research on demographic aspects of HIV/AIDS in rural Africa"." *Demographic Research* Special Collection 1(1):1–30. doi:10.4054/DemRes.2003.S1.1.

## B. MLSFH Adaptation of International Cognitive Assessment (ICA) Questionnaire

Because research on CH in SSA is very limited (and essentially non-existent in Malawi), the MLSFH was not able to implement an instrument previously validated in this context. Instead, the team developed and pre-tested a comprehensive instrument that was designed to capture a wide span of CH, from high cognitive functioning to cognitive impairment. The survey instrument was developed to be suitable for a little-schooled and sometimes illiterate study population, and implementable by well trained, albeit lay MLSFH interviewers.

After extensive testing and development, the MLSFH implemented a modified version of the International Cognitive Assessment (ICA), a brief screening test for adolescents and adults. The MLSFH adaptation of the ICA is included below. The ICA is designed to be relatively culture-free and appropriate for populations with limited access to formal schooling, and can be easily modified and adopted for specific countries and cultures. It assesses six cognitive domains: basic language ability, orientation, visual/constructional skills, attention/working memory, executive functions, and delayed memory (recall/recognition). The maximum ICA score is 30, corresponding to highest (best) cognitive assessment.

Examples of how the ICA was modified for our study context include: Basic language ability was assessed by having the respondent identify several pictures (shoe, banana, and snake), ability to precisely repeat a simple sentence, and ability to immediately recall five provided words. Orientation was assessed by asking the respondent to identify the current season and current president of Malawi. To assess visual/constructional skills and non-verbal memory, subjects were required to copy and draw from memory simple geometric designs. Attention and working memory were assessed using forward and backward digit recall and an auditory vigilance test for a spoken target number. Executive functioning was assessed using both verbal and visual measures including a visual vigilance test and a verbal fluency assessment. The visual sequencing portion of the ICA is a variation on several widely used visual sequencing tests (Trail Making Tests A and B, Color Trails) (Reitan 1979) designed to assess psychomotor speed, attention, sequencing, and visual scanning efficiency. Delayed recall was assessed at the end of the ICA questionnaire.

Appendix Table 1 provides summary statistics and correlations for the total ICA score and the sub-scores. The individual sub-scales in the ICA are predominantly correlated in the range of 0.3 to 0.5, suggesting that while they do have similar characteristics, each sub-score is measuring a distinctive element of CH. In separate analyses, the six ICA sub-scales had moderately high internal consistency (Cronbach's $\alpha = 0.75$). Interviewers screened subjects for visual and hearing impairments that might interfere with their ability to perceive stimuli or hear questions, and these individuals were removed from our analysis sample. Only a small number ($< 2\%$) of respondents were affected by this exclusion criteria, and ICA data are available for 1,241 of 1,266 respondents in 2012 and 1,229 of 1,257 in 2013.

# MLSFH Adaptation of International Cognitive Assessment (ICA) Questionnaire

## Section 2: Screening Questions

| | | |
|---|---|---|
| **SCR1** | **Kodi mumamva zanzi, kuwotcha kapena kubayabaya kwa zanzi m'manja mwanu kapena dzala zanu?**<br>*Do you have numbness, burning or tingling feelings in your hands or fingers?* | Yes……..1<br>No……..0 |
| **SCR2** | **Kodi mumamva kupweteka mmanja mwanu kapena dzala zanu kosakhala chifukwa choti mwavulala posachedwa?**<br>*Do you have pain in your hands/fingers (not due to recent injury)?* | Yes……..1<br>No……..0 |
| **SCR3** | **Kodi ndikovuta kwa inu kuti mugwiritse ntchito manja anu monga kuwongola manja kapena kukunga chibakera?**<br>*Is it difficult for you to use your hands (e.g. straighten hands or make a fist)?*<br>**INTERVIEWER: Please demonstrate hand positions.** | Yes……..1<br>No……..0 |
| **SCR4** | **INTERVIEWER: Is respondent missing any fingers?** | Yes……..1<br>No……..0 |
| **SCR5** | **INTERVIEWER: Do the respondent's joints of the hands/fingers look enlarged or crooked like the photos of hands with arthritis?**<br>(Note: check pictures in training manual Appendix A) | Yes……..1<br>No……..0 |
| **SCR6** | **INTERVIEWER: Is respondent obviously blind?** | Yes……..1 → **SCR10**<br>No……..0 |
| **SCR7** | **Kodi mumavutika kuwona?**<br>*Do you have difficulty seeing?* | Yes……1<br>No……..0 |
| **SCR8** | **INTERVIEWER:** As you hold one finger directly in front of the respondent about one arm length from their face, ask the respondent:<br>**Kodi mukuona dzala zingati?**<br>*How many fingers do you see?* | Zero……..0 → **SCR9**<br>One……..1 → **SCR9**<br>Two or more……..2 |

| | | | |
|---|---|---|---|
| **SCR8a** | **Tsekani diso lanu lakumanzere. Kodi mukuona dzala zingati?**<br>*Please cover your left eye. How many fingers do you see?*<br>**Tsekani diso lanu lakumanja. Kodi mukuona dzala zingati?**<br>*Please cover your right eye. How many fingers do you see?* | **1. Left eye covered**:<br>Zero……..0<br>One……..1<br>Two or more……..2<br>Blind……..3 | **2. Right eye covered**:<br>Zero……..0<br>One……..1<br>Two or more……..2<br>Blind……..3 |

**SCR9** **INTERVIEWER**: Demonstrate with the sample pictures on **card #0 SCR9**.
**Kadi lililonse lili ndi zithunzi ziwiri. Chithuzi chimozi chili ndi chilembo pakati, ndipo chinacho chilibe**
*Each card has two pictures. One picture has a figure in the center, and the other picture does not.*
**INTERVIEWER**: Show the respondent the vision screening cards (1-6), one pair at a time.
**Lozani chithunzi chimene chili ndi chilembo**
*Point to the picture with the figure in it.*
**INTERVIEWER**: Repeat this for each card. If correct, circle the number of the card below.

| **Card** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| Correct response | Bottom | Top | Top | Bottom | Top | Bottom |

Total number correct……. [_____]

| | | |
|---|---|---|
| **SCR10** | **Kodi mumavutika kumva? Mwachisanzo pamene akubanja kwanu/ anzanu akamakulankhulisani, kapena pamene mwana wapafupi nanu akulira, kapena kumva zinyama?**<br>Do you have trouble hearing? For example, when family/friends talk to you, when a baby is crying, or when hearing animals? | Yes……1<br>No……..0 |
| **SCR11** | **Kodi dzanja limene mumagwilisira ntchito kwambiri ndi liti? Mwachisanzo dzanja lomwe mumagwilisa ntchito kugwira mpeni mukama dula nyama kapena masamba pokonza chakudya, kapena pozimeta.**<br>*Which is your dominant hand? For example, which hand do you use to hold a knife when cutting meat or vegetables to prepare food, or shaving yourself.* | Right hand……..1<br>Left hand……..2<br>Both hands equally dominant……3 |

## Section 3: Language and Orientation

**INTERVIEWER: If respondent is obviously blind, do not administer. Go to question ICA_L3**.

**Tsopano ndikuwonetsani zithunzi.**
*Now I will show you some pictures.*

| | | |
|---|---|---|
| **ICA_L1** | **INTERVIEWER**: Show respondent **card #7** (**ICA_L1)**. Point to each picture on the card and say:<br>**Ndiuzeni dzina laichi**<br>*Tell me the name of this.* | **Incorrect Correct**<br>a) **Nsapato** shoe……..0……1<br>b) **Nthochi** banana……0……1<br>c) **Njoka** snake……..0……1 |
| **ICA_L2** | **INTERVIEWER**: Show respondent **card #8 (ICA_L2)**<br>**Yang'anani zithunzi zakuda ndi zoyera zozungulira ndi zamakona anayi. Ndikupemphani kuti muzigwire chimodzimodzi ndi momwe nditakuwuzireni**<br>*Look at these black and white circles and squares. I want you to touch them exactly as I tell you to.*<br>**INTERVIEWER**: Then slowly and clearly read aloud (one at a time) each of the sentences on the right side of the page. If the respondent asks for the command to be repeted, you may repeat the command **ONE TIME** only. | **Incorrect / Correct / Correct w/ Repetition**<br>**a) Gwirani chizindikiro choyera, chozungulira ndipo chaching'ono**<br>*Touch the small white circle*…….0 1 2<br>b) ***Gwirani chizindikiro chamakona anayi chimene chili pakati pa zizindikiro zozungulira***<br>*Touch the square in between the circles*……..0 1 2<br>c) ***Poyamba gwirani chizindikiro chachikulu, chakuda ndipo chamakona anayi kenako kachizindikiro kamakona anayi koyera komanso kakang'ono.***<br>*Touch first the large black square, then the smaller white square*…….0 1 2 |
| **ICA_L3** | **Ndikuwerengarani chiganizo. Ndikamaliza ndikupemphani kuti mubwereze <u>chimodzimodzi</u> ndi momwe ndiwerengere.**<br>*I am going to read a sentence. When I finish, repeat it after me, <u>exactly</u> as I say it.*<br>**INTERVIEWER:** Read the sentence aloud slowly and clearly. If necessary, you may repeat the sentence **<u>ONE TIME</u>**.<br>**"Mwana akuthamangitsa mbuzi"**<br>*"The child is chasing the goat."*<br>☐ **Kumbukirani chiganizochi chifukwa ndizakupemphani kuti muchinenenso kanthawi kena. (INTERVIEWER:** Make sure you place a check mark in the box**)**<br>Remember this sentence for later because I will ask you to recall it later. | Incorrect……..0<br>Correct ..……..1<br>Correct with repetition.……2 |
| **ICA_O1** | **Kodi mtsogoleri wadziko lino pakali pano ndani?**<br>*Who is the President of Malawi now?* | Incorrect……0<br>Correct… ……1 |
| **ICA_O2** | **Nyengo ino ndi nyengo yanji?**<br>*What season is it?* | Incorrect……0<br>Correct ……1 |

## Section 4: Visual/Constructional

**ICA_VC1** **INTERVIEWER**: If respondent is obviously blind, do not administer. Go to **SECTION 5, QUESTION ICA_M1.**

**INTERVIEWER**: Point to the sample item on **card #9 ICA_VC1.**

**Muli dontho limodzi muchithunzi chamakona anayi chomwe chili pansipa ndi madontho angapo muchithunzi chamakona anayi chomwe chilipamwambapa. Lodzani dontho muchithunzi chamakona anayi chimene chilipamwambapa lomwe lilipamalo ofanana ndi dontho lomwe liri muchithunzi chapansichi.**
*There is one dot in the bottom square and several dots in the top square. Point to the dot in the top square that is in the SAME location as the dot in the bottom square.*

**INTERVIEWER:** If the respondent points to the correct dot say, **Ncholondola** *(That is correct).* If the respondent makes an error or is unable to identify the correct dot, point to the correct dot and say, **Dontho lomwe liri pamalo ofanana ndi dontho lomwe liri muchithunzi chapansipa chamakona anayi. Madontho ena awiri Sali olondola chifukwa lina liri kutali kumbali yamanzere ndipo lili mmwamba kwambiri kuchokera pansi, ndipo dontho lina liri kutali mbali yakumanja ndipo liri mmwamba kwambiri kuchokera pansi.**
*This dot is in the same location as the dot in the bottom square. The other two dots are not correct because one is too far on the left and too high from the bottom, and the other one is too far on the right and too high from the bottom.*

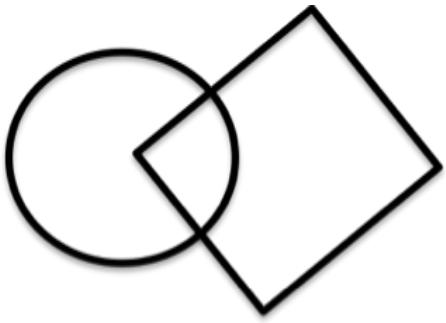
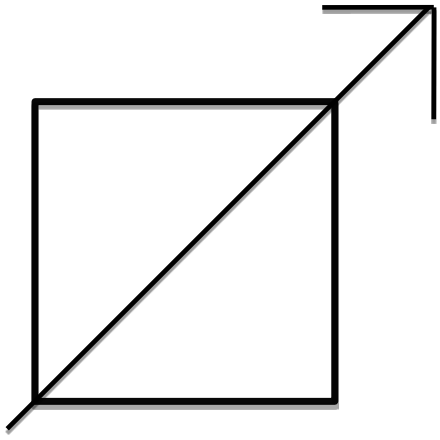
**INTERVIEWER:** Administer the following two questions for Figures A and B.
**Muli dontho limodzi muchithunzi chamakona anayi chomwe chili pansipa ndi madontho angapo muchithunzi chamakona anayi chomwe chilipamwambapa. Lodzani dontho muchithunzi chamakona anayi chimene chilipamwambapa lomwe lilipamalo ofanana ndi dontho lomwe liri muchithunzi chapansichi.**
*There is one dot in the bottom square and several dots in the top square. Point to the dot in the top square that is in the SAME location as the dot in the bottom.*

**INTERVIEWER**: Do **NOT** identify the correct dot after the respondent makes his/her choice.

| | **Incorrect** | **Correct** |
|---|---|---|
| a) Figure A | 0 | 1 |
| b) Figure B | 0 | 1 |

**ICA_VC2** **INTERVIEWER**: Provide the respondent with a pencil. Point to the first figure below.
**Jambulani chithunzi ndipo muyetsetse kuti chifanane ndi chithunzi ichi m'malo omwe mwapatsidwa pansipa**
*Draw the same figure as accurately as you can in the space below.*

**INTERVIEWER**: If the respondent is not accustomed to using a pencil, then instruct him/her to draw the figure with their finger/stick in the dirt/sand. Repeat instructions for the second figure.

| **FIGURE A** | **FIGURE B** |
|---|---|
|  |  |

**ICA_VC2** (continued) After both figures have been drawn, say:
**Chonde kumbukirani zithunzizi chifukwa mupemphedwanso kuti mujambule nthawi ina osawonera. (INTERVIEWER: Please mark a check in the box)** ☐
*Please remember these figures because I will ask you to draw them later from memory.*

**INTERVIEWER:** If the respondent cannot use a pencil, then have him/her draw the figures in the dirt. Copy their drawing in the space above and mark "On the ground" in **ICA_VC3,** and then erase the figures by smoothing the dirt/sand.

**Figure A Scoring Criteria**
All lines are drawn
No extra lines are added
The circle should be to the left of the diamond, shape is round and closed, an oval shape is acceptable
The diamond shape has four corners and is in the correct orientation
**The two figures overlap**

**Figure B Scoring Criteria**
All lines are drawn
No extra lines are added
The drawing is a square or rectangle
The arrow bisects 2 corners of the square
The arrow points above the upper right corner of the square

| | Incorrect | Correct |
|---|---|---|
| a) Figure A | 0 | 1 |
| b) Figure B | 0 | 1 |

| | |
|---|---|
| **ICA_VC3 INTERVIEWER: Where did the respondent draw the figures?** | On the ground……0<br>On the paper……1 |

## Section 5: Memory

**Awa ndi mayeso okhuzana ndikukumbukira, ndikuwerengerani mndandanda wa mawu, ndikamaliza kuwerenga mawuwa kuchokera pamndandandawu, mundiwuze mawu amene mungakumbukire m'mene mungathere mndandanda wa momwe mungawa tchulire mawuwa ulibe tchito.**
*"This is a memory test. I am going to read a list of words. After I read all the words from the list, tell me as many words as you can remember. The o you say them does not matter."*

**INTERVIEWER**: Read aloud the list of the five words below at a rate of one word per second. For each word correctly recalled, writ 1 in the box below. For each word incorrectly recalled, write a 0 in the box below. At the end of the trial, count the number of words correctly recalled in **trial 1** and enter in **ICA_M1f**. After the respondent has told you all the words he/she can remember, say:

**Ndikuwerengerani mndandanda omwe wuja wamau, yesani kukumbukira ndipo munditchulire mawuwa m'mene mungathe Yesesani kutchura onse omwe mukukumbukira, ngakhale mawu omwe munatchura poyambirira paja. mndandanda wa momwe mungawa tchulire mawuwa ulibe tchito.**
*"I am going to read the same list of words. Try to remember and tell me as many words as you can. Make sure you say all the words you remember, even words that you said the first time. The order does not matter."*

**INTERVIEWER**: For each word correctly recalled, write a 1 in the box below. For each word incorrectly recalled, write a 0 in the box below. At the end of the trial, count the number of words correctly recalled in **trial 2** and enter in **ICA_M1f**.

| **Scoring** | **ICA_M1** | **ICA_M1a** | **ICA_M1b** | **ICA_M1c** | **ICA_M1d** | **ICA_M1e** | **ICA_M1f** |
|---|---|---|---|---|---|---|---|
| | | **Mwezi** Moon | **Basiketi** Basket | **Chobiriwira** Green | **Dzanja** Hand | **Mayi** Mother | **TOTAL** |
| **Incorrect = 0 Correct = 1** | **Trial 1** | | | | | | |
| | **Trial 2** | | | | | | |

**Yesetsani kukumbukira mawuwa chifukwa ndikufunsaninso kuti muwakumbukire pamapeto pama yesowa (INTERVIEWER Please mark a check in the box.)** ☐
*"Try to remember these words because I will ask you to recall them again at the end of the test."*

## Section 6: Attention/Working Memory

**ICA_AM1** **Ndikutchulirani mundandanda wa manambala, mubwereze kutchura manambalawa chimodzimodzi m'mene atchulidwire.**
*I am going to read some numbers. When I finish, repeat the numbers in the SAME order.*
**INTERVIEWER**: Read numbers at the rate of one number per second. **Do NOT** repeat numbers.

**5 – 1 – 3 – 6 – 2**

Incorrect…….0
Correct……...1

**ICA_AM2** **Ndikutchulirani mndandanda wamanambala, mubwerenze kutchura manambalawa motembenuza, kapena kuti chobwerela m'mbuyo. Mwachitsanzo, ndikanena kuti 7-3, inu muziti 3-7.**
*I am going to read some numbers. When I finish, repeat the numbers to me backwards, that is, in reverse order. For example, if I say 7-3, you would say [pause] 3-7.*
**INTERVIEWER**: Read numbers at the rate of one number per second. **Do NOT** repeat the numbers.

**4 – 6 – 1** **(Note: correct response is 1 – 6 – 4)**

Incorrect…….0
Correct……...1

**ICA_AM3** **Ndikutchurilani mndandanda wa manambala. Nthawi iliyonse yomwe ndingatchure kuti 2, muziwomba m'manja kamodzi, musaombe m'manja ndikatchura nambala ina iliyonse kupataula 2.**
*I am going to read a list of numbers. Every time I say the number TWO (2), clap your hands once. Do NOT clap for any other numbers.*
**INTERVIEWER**: Read numbers at the rate of one per second. Mark **all** numbers at which the respondent claps.

7 1 **2** 4 1 7 **2 2** 5 3 6 1 **2** 6 **2** 3 3 4 **2 2 2** 5 **2** 6 1 3 **2 2** 5 4

**All number "2"s are circled or 1 error**…….1
**Two or more errors**……0

## Section 7: Executive Functions

**ICA_E1** INTERVIEWER**: If respondent is obviously blind, do not administer. Go to question ICA_E2.**

**Ndikuwonetsani chala chimodzi kapena zala ziwiri. Ndikakuwonesani chala chimodzi, ombani m'manja kamodzi, ndikakuwonetsani zala ziwiri musawombe m'manja.**
*I am going to show you one or two fingers. If I show one finger, you clap your hands once. If I show two fingers, you should not clap.*
**INTERVIEWER**: To ensure that the respondent understands the task, demonstrate the task 2 times and have the respondent respond. When it is clear that the respondent understands the task, show him/her the number of fingers as in the sequence below (e.g., 2 fingers, 1 finger, 2 fingers, etc). **Please mark all numbers at which the respondent claps.**

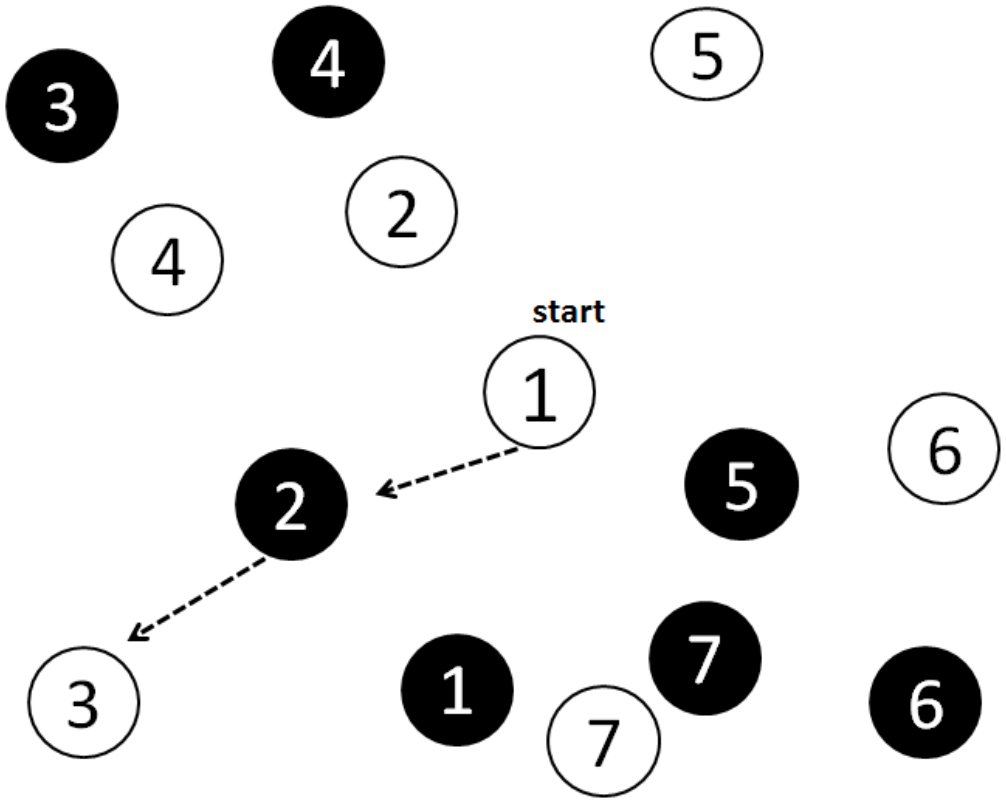
**INTERVIEWER**: **Do NOT** say the numbers out loud.

2 1 2 1 1 2 1 2 1 2 2 2 1 2 1 1 2 1 1 1

**INTERVIEWER**: An error occurs when the respondent does not clap when you present one finger. An error occurs when the respondent claps when you show two fingers.

**No errors or one error**……..0
**Two or more errors**……..……1

| | | |
|---|---|---|
| **ICA_E2** | **Ndiwuzeni nyama zosiyana siyana zochuluka m'mmene mungathere mwachangu m'ene mungazitchulire kufikira nditakuwuzani kuti musiye.**<br>*Tell me as many different animals as you can as quickly as you can say them, until I tell you to stop.*<br><br>**INTERVIEWER**: Set timer for 1 minute.<br><br>**Yambani** *Start!*<br><br>**INTERVIEWER**: Write down the respondent's answers in the space below. Stop respondent at 1 minute. Only count each animal once. | Total number of animals……. [_____] |
| **ICA_E3a** | **INTERVIEWER**: If respondent is obviously blind, do not administer. Go to question **ICA_D1.**<br>**Welengani kuyambira 1 mpaka 7.**<br>*Please count aloud from 1 to 7.* | Incorrect…….0 → **ICA_E4**<br>Correct …….1 |
| **ICA_E3b** | **Kodi mukhoza kuzindikira manambala kuyambira 1 mpakana 7?**<br>*Can you recognize the numbers from 1 to 7?* | Yes……..1<br>No……...0 → **ICA_E4** |
| **ICA_E3c** | **Apa pali zithunzi zozungulira zakuda ndi zoyera zomwe ziri ndi manambala mkati mwawo. Ndikufuna inu kuti mulumikize zithunzi zozungulira pogwiritsa ntchito pensulo mu ndondomeko yake kuchokera kuchoyera kupita kuchakuda. Muchokere kuchozungulira choyera chomwe chili ndi wani (1) kupita kuchozungulira chakuda chomwe chili 2. Ndipo mupitiliza kufikira nambala yomaliza. Muyambire apa (Mulodzereni wayankhayo pomwe pali 1) ndipo lumikizani nambala mundondomeko posemphanisa zozungulira zoyera ndi zakuda.**<br>*Here are black and white circles with numbers in them. I want you to use the pencil to connect the circles in order by going from white to black. Go from the white circle with 1 to the black circle with 2 and so on until you reach the last number. Begin here* **(INTERVIEWER: point to white circle with "1")** *and connect the numbers in order, alternating white and black circles.*<br><br>**INTERVIEWER: Do NOT** correct if the respondent makes an error. Do not allow respondent to erase errors. If the respondent corrects an error – it is still scored as incorrect. | Incorrect…….0<br>Correct……...1 |



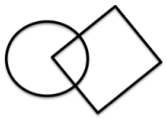
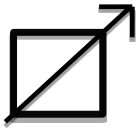

| | | |
|---|---|---|
| **ICA_E4** | **INTERVIEWER**: Verify from SCR11 on pg. 8 which is the respondent's dominant hand (_____hand). ***Copy the opposite hand into the spaces below and record in ICA_E4a***. If response was "both hands equally", then ask respondent to use his left hand and copy "left" into the space below. Demonstrate the three hand positions. | Total number of correct sequences……..[___] |

| | | |
|---|---|---|
| | **1)** Clench hand to make a fist on a flat surface<br>**2)** Put hand on flat surface with palm down<br>**3)** Put hand perpendicular with fifth digit (little finger) on flat surface.<br>**Gwirlitsani tchito mkono wanu _____ kuti mubwelenze zomwe ndakuwonetsani zija kawri**<br>*Please use your _____ hand and copy the demonstrated hand positions two times.*<br>**INTERVIEWER**: Set timer for 10 seconds.<br>**Tsopano gwiritsani ntchito mkono wanu wa _____ kuti mupange zomwe ndakuwonetsani zija mmene mungathere**<br>*Please now perform the demonstrated hand positions with your _____ hand as many times as you can.*<br>(Note: For a flat surface, use a table, the ground, or clipboard. Every time the respondent does the correct sequence, make a tallymark/slash (\|\|\|) in the space below. | **ICA_E4a**<br><br>Which hand did respondent use?<br><br>Left ……..1<br>Right……...2 |
| **ICA_E5** | **PRACTICE TEST:**<br><br>**INTERVIEWER**: Show **sample card #10 (ICA_E5)**. Point to the two items in the top row of the sample card and ask: **Izi ndizofanana chifukwa zonse ndi? (***These are all alike because they are all what?)*<br><br>**INTERVIEWER:** If respondent is not able to recognize a picture, the interviewer should provide the name of the picture (for both the sample and test items).<br><br>**INTERVIEWER**: If the respondent responds correctly (fruit), say:<br>**Inde mukulondola zonsezi ndizipatso.** (*Yes, that is correct. They are all fruit.)*<br><br>**INTERVIEWER**: If the respondent does not respond or gives an incorrect answer, explain:<br>**Izi ndizofanana chifukwa zonse ndi zipaso. Yang'anani zithunzi izi zomwe zili pansi ndipo lodzani chithunzi chimene chili mugulu lazithunzi zimene zili pamwambapa**<br>*They are all alike because they are all fruit. Look at the pictures in the lower row and point to the one that goes with the pictures above.*<br><br>**INTERVIEWER**: If the respondent points to the correct answer (mango), say:<br>**Inde mukulondola chifukwa ndichipatso.** (*Yes, that is correct because it is a fruit)*<br><br>**INTERVIEWER**: If the respondent makes an error by picking a picture other than the fruit or is not sure of the correct answer, point to the mango and say:<br>**Ili ndi bango ndichipatsonso. Ndichimodzi mwazipatso zili pamwambapa**<br>*This is a mango, it is also a fruit. So it goes with the fruit category.* | |
| | **TEST:**<br><br>**INTERVIEWER**: First, show the respondent **card #11 (ICA_E5a)**, by pointing and say:<br>**Zithunzi zonse zili pamwambapa zimagwira ntchito imodzi, sankhani chithunzi chimodzi kuchokera pazithunzi pansiapa chimene chili mgulu limodzi ndi zithunzi zomwe zili pamwambapa**<br>*All of the pictures on the top are alike in some way, pick the one picture from below that goes with the items above.*<br><br>INTERVIEWER**: Do not provide any additional help or correct the respondent's answers. Show the respondent card #12 ICA_E5b and repeat the test.**<br><br>a) Incorrect……0 Correct……1 b) Incorrect……..0 Correct……..1 | |

## Section 8: Memory Delayed Recall

| | | |
|---|---|---|
| **ICA_D1** | **Mbuyomu ndinakuwuzani kuti muzikumbukira chiganizo chinachake.Tsopano mundibwelezele chiganizo chija**<br>*Earlier, I told you to remember a sentence. Can you please repeat this sentence?*<br><br>**INTERVIEWER**: The correct response is **Mwana akuthamangitsa mbuzi** *("The child is chasing the goat*"). **Do NOT** say the sentence to the respondent. Record response below. Response is correct if close to the original sentence. It is correct if the respondent provides the main idea or basic meaning of the sentence. For example, responses like "**The goat was chased by the child**" or "**Children chased the goats**" are correct.<br><br>**Record response:**_____ | Incorrect……0<br>Correct……..1 |
| **ICA_D2** | **INTERVIEWER**: If respondent is obviously blind, do not administer. Go to question **ICA_D3a.**<br>INTERVIEWER: Give the respondent a pencil and say:<br>**Kumbukirani munajambula mowonera zithunzi ziwiri m'mbuyomu, zomwe ndinakupemphani kuti muzizikumbukira. Tsopano muzijambulenso zithunzi ziwiri zija munsimu.**<br>*You copied two figures earlier, which I asked you to remember. Draw both figures below.*<br><br>INTERVIEWER: If the respondent first drew the figure on sand/dirt, then instruct him/her to draw it again with their finger/stick in the dirt/sand. If the respondent draws the figures in the dirt, copy their drawing in the space above, and then erase the figures by smoothing the dirt/sand. | |

| |
|---|
| Both figures wrong..... 0<br>Only Figure A correct..... 1<br>Only Figure B correct..... 2<br>Both figures correct ..... 3 |

| | | |
|---|---|---|
| **ICA_D2 (continued)** | **Figure A Scoring Criteria**<br>All lines are drawn<br>No extra lines are added<br>The circle should be to the left of the diamond, shape is round and closed, an oval shape is acceptable<br>The diamond shape has four corners and is in the correct orientation<br>**The two figures overlap**<br><br>**Figure B Scoring Criteria**<br>All lines are drawn<br>No extra lines are added<br>The drawing is a square or rectangle<br>The arrow bisects 2 corners of the square<br>The arrow points above the upper right corner of the square | **A**<br>  <br>**B**<br>  |
| **ICA_D2c** | **INTERVIEWER**: Show respondent **card #13 (ICA_D2c).**<br>**Ndichiti mwazithunzi izi mukuganiza kuti ndichomwe ndinakupemphani kuti muzichikumbukira? Lodzani chomwe mwachikumbukira.**<br>*Which of these figures do you think was the one that I asked you to remember? Point to the one that you recognize.* | Incorrect……..0<br>Correct……1 |
| **ICA_D2d** | **INTERVIEWER**: Show respondent **card #14 (ICA_D2d).**<br>**Ndichiti mwazithunzi izi mukuganiza kuti ndichomwe ndinakupemphani kuti muzichikumbukira? Lodzani chommwe mwachikumbukira.**<br>*Which of these figures do you think was the one that I asked you to remember? Point to the one that you recognize.* | Incorrect…….....0<br>Correct……1 |

**ICA_D3a** **Ndinawerenga mndandanda wamawu m'mbuyomu amene ndinakupemphani kuti muziwakumbukira, nditchulireni mawu amene mukuwakumbukira m'mene mungathere.**
*I read a list of words to you earlier, which I asked you to remember. Tell me as many of those words as you can remember.*
**INTERVIEWER**: Record if the word was recalled or not. Prompt if the respondent remembers any more words. If no then go to question ICA_D3b for the words that have not been recalled. It does not matter what order the words are recalled.

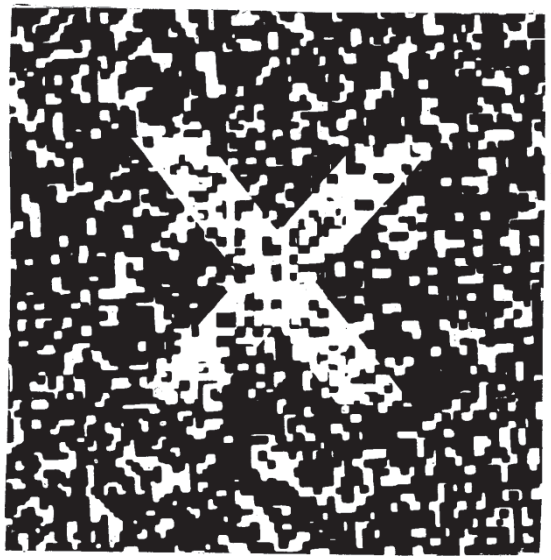
| **ICA_D3a** | **ICA_D3a1** | **ICA_D3a2** | **ICA_D3a3** | **ICA_D3a4** | **ICA_D3a5** |
|---|---|---|---|---|---|
| | **Mwezi** Moon | **Basiketi** Basket | **Chobiriwira** Green | **Dzanja** Hand | **Mayi** Mother |
| *Not recalled = 0*<br>*Correct = 1* | | | | | |

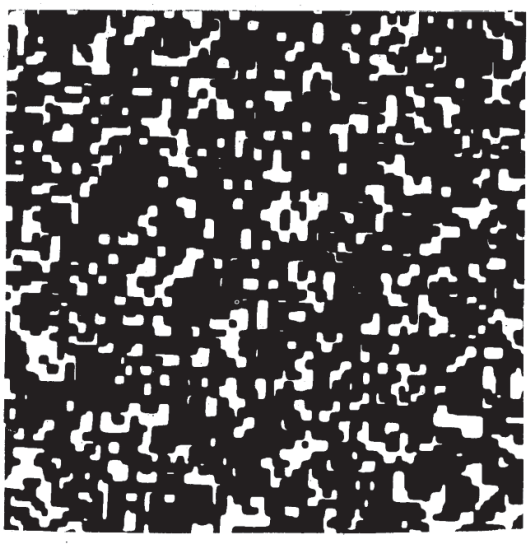
**ICA_D3b** **INTERVIEWER**: For words that were scored as "0" in ICA_D3a, ask:
**Mwa mawu awa ndi ati amene mukuganiza kuti anali pa mndandanda wa mawu amene ndinakuwuzani kuti muziwakumbukira, anali (tchurani mau amene ali mubokosimo)?**
*Which of the following words do you think was on the list I asked you to remember,* was it **(**read list the words in the box)?
**INTERVIEWER**: Correct words are underlined.

| **ICA_D3b** | **ICA_D3b1** | **ICA_D3b2** | **ICA_D3b3** | **ICA_D3b4** | **ICA_D3b5** |
|---|---|---|---|---|---|
| | **Nyenyezi** (star)<br>**Dzuwa** (sun)<br>**Mwezi** (moon) | **Kapu** (cup)<br>**Basiketi** (basket)<br>**Bakuli** (bowl) | **Choyera** (white)<br>**Chobiriwira**(green)<br>**Chofiira** (red) | **Chala** (finger)<br>**Diso** (eye)<br>**Dzanja** (hand) | **Mayi** (mother)<br>**Chewali** (sister)<br>**Bambo** (father) |
| *Incorrect = 0*<br>*Correct = 1* | | | | | |

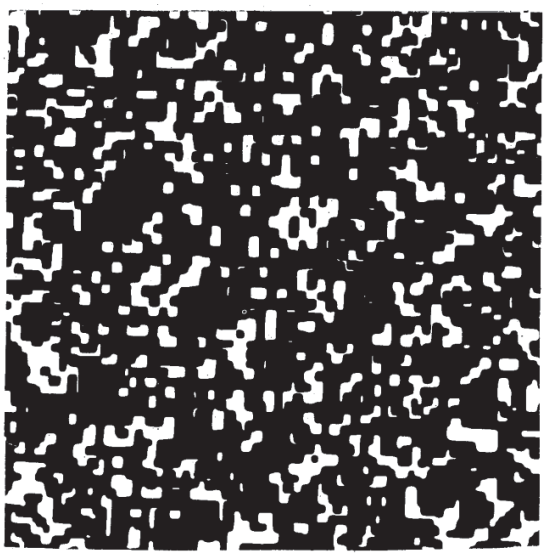
## Card 0 (SCR12)

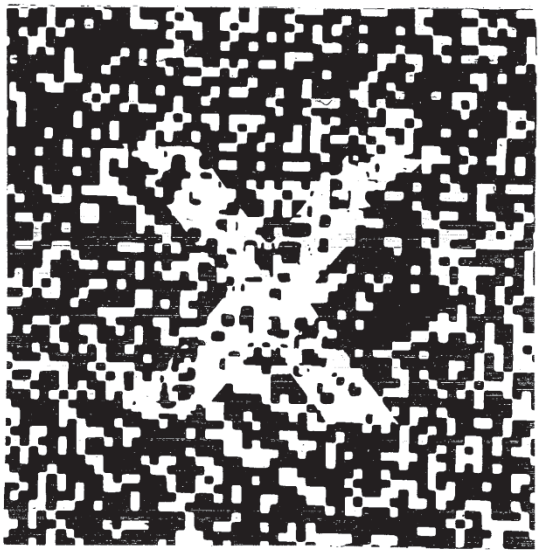
## SAMPLE ITEM



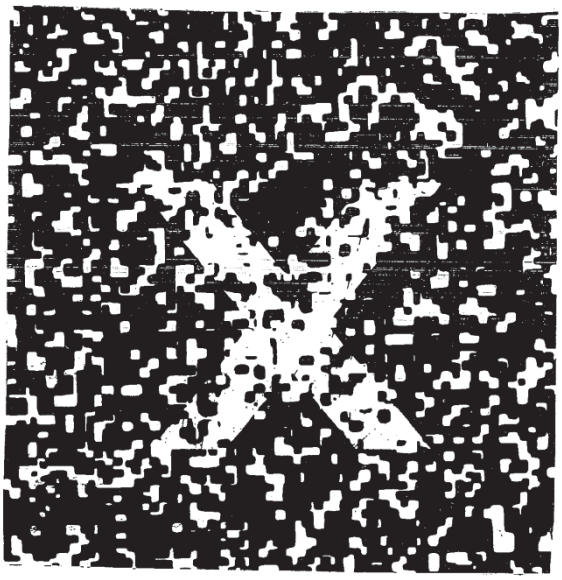


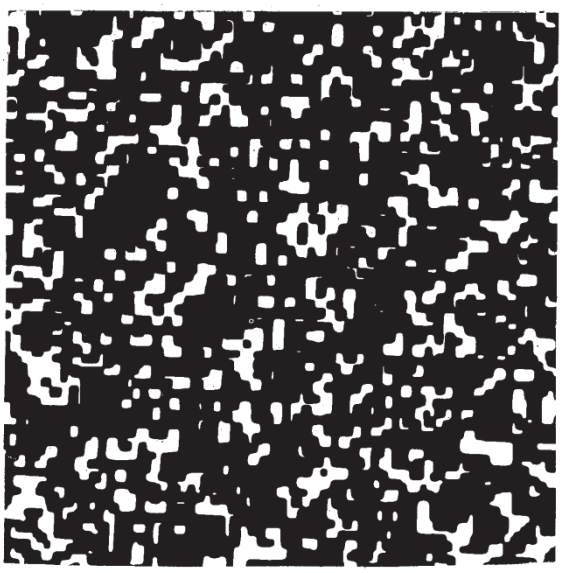
## Card 1



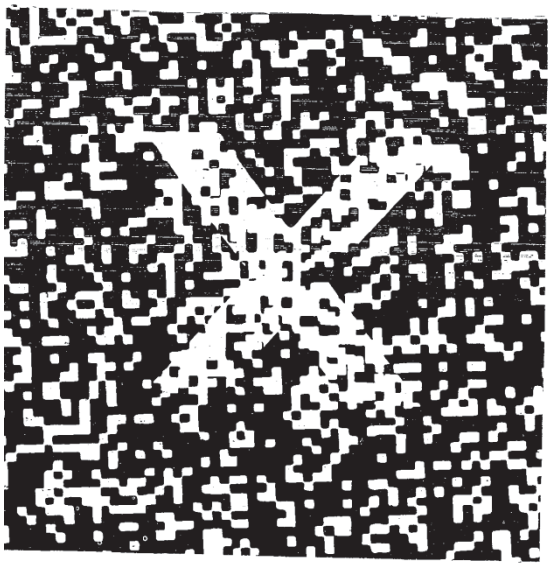


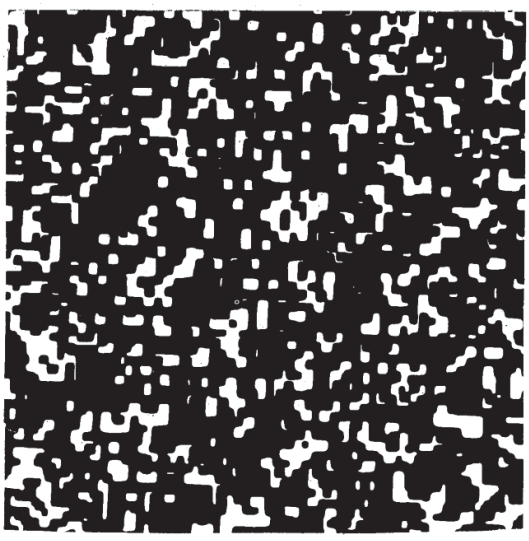
## Card 2



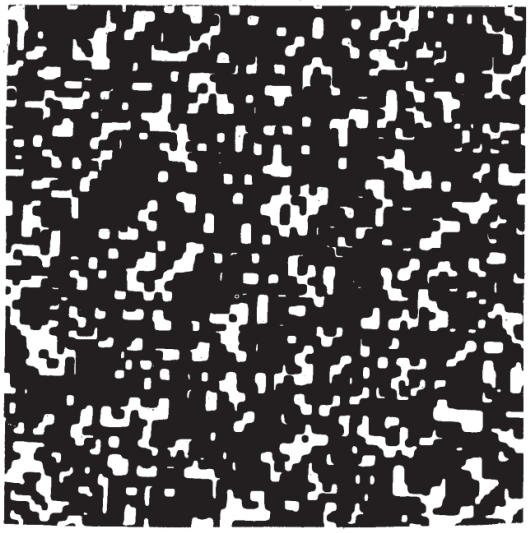


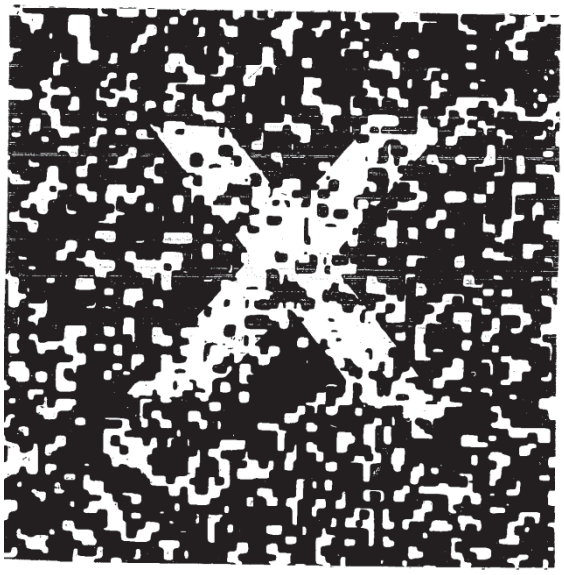
## Card 3



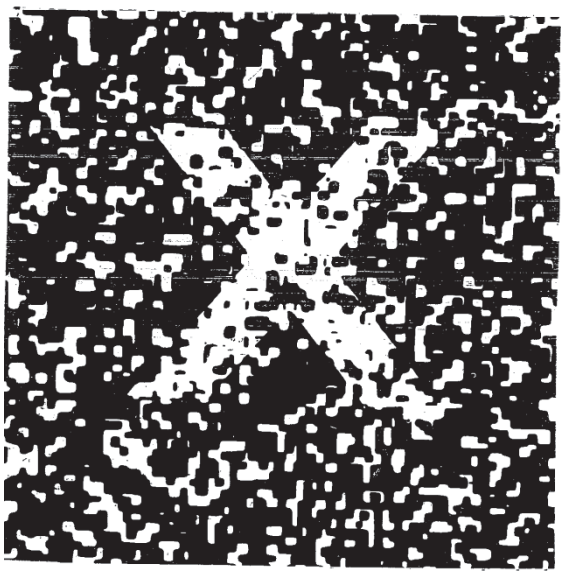


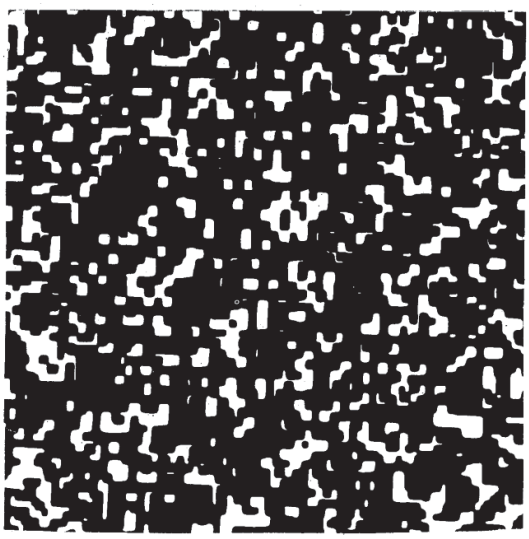
## Card 4



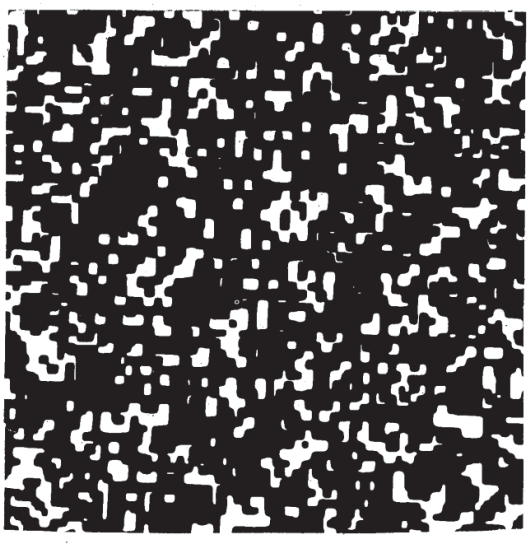


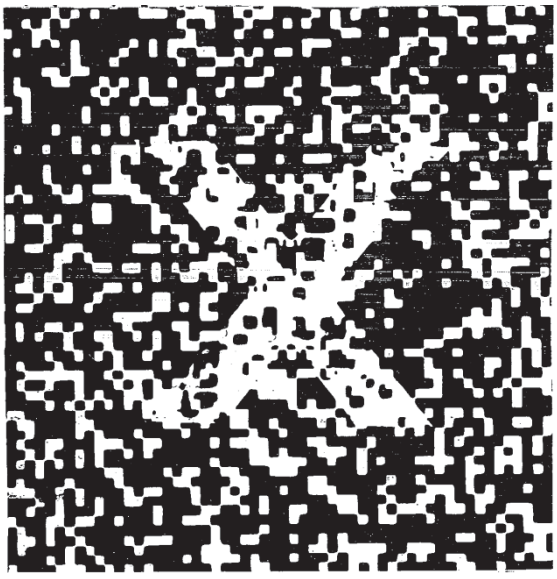
## Card 5



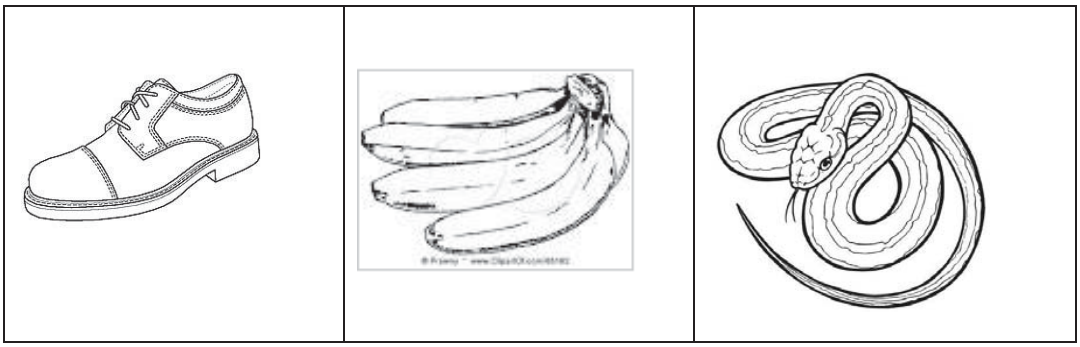


## Card 6

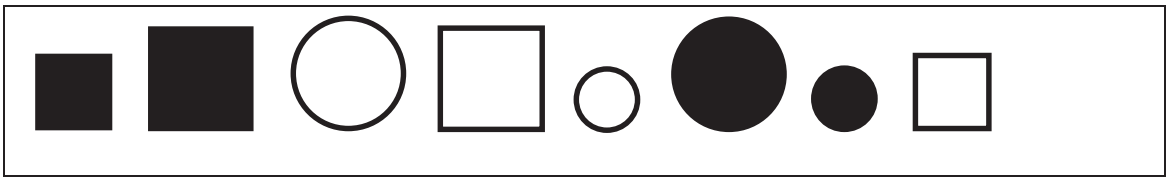




## Card 7 (ICA_L1)



## Card 8 (ICA_L2)



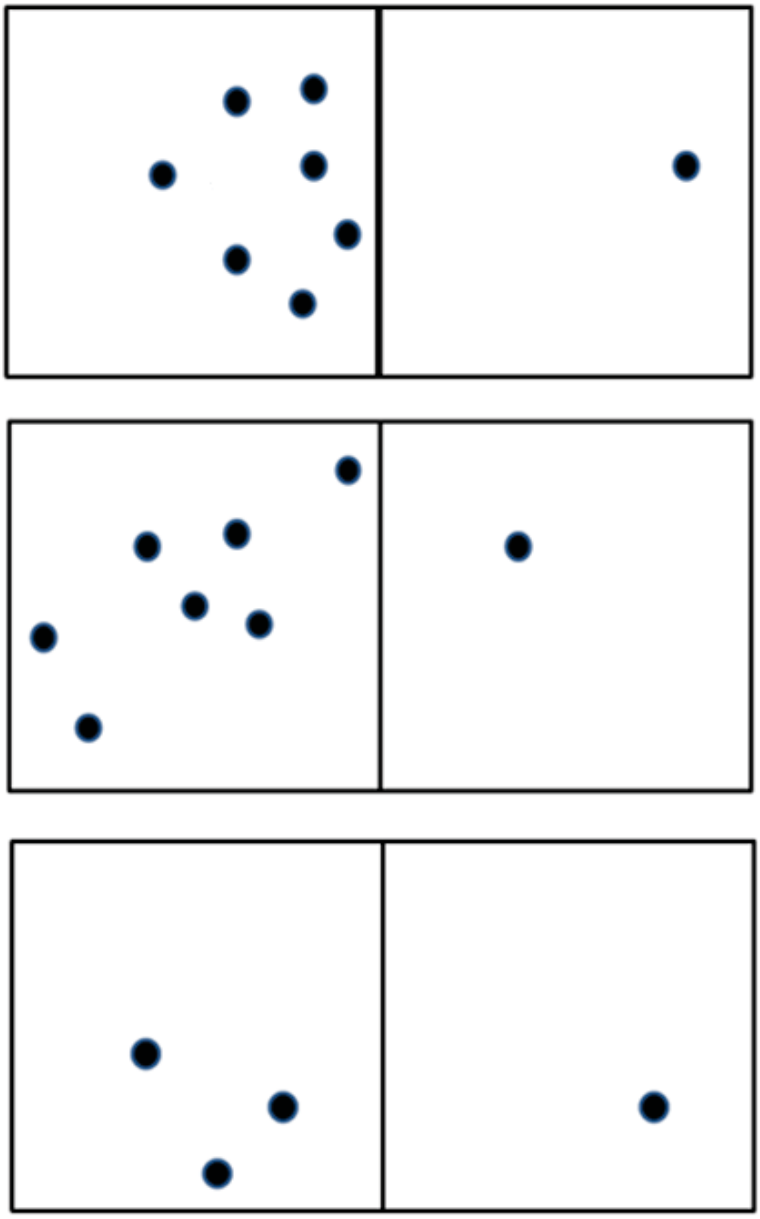
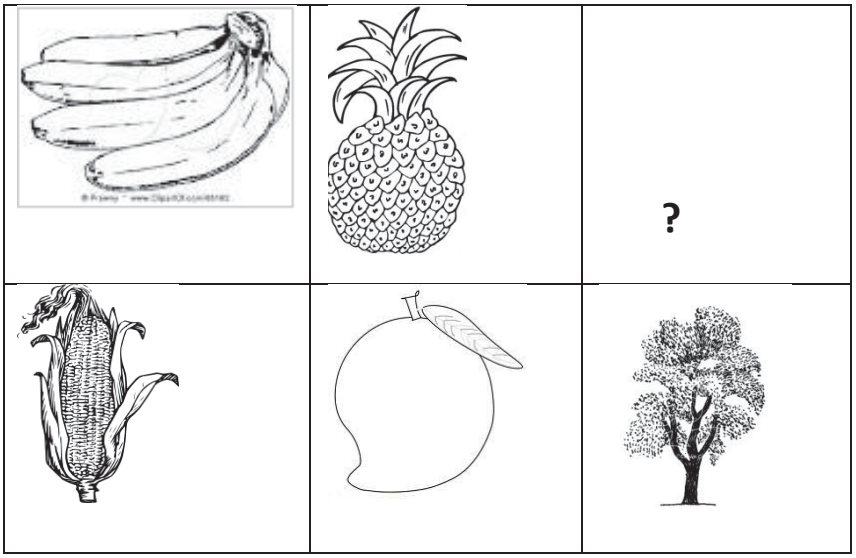


Figure B
Figure A
Sample

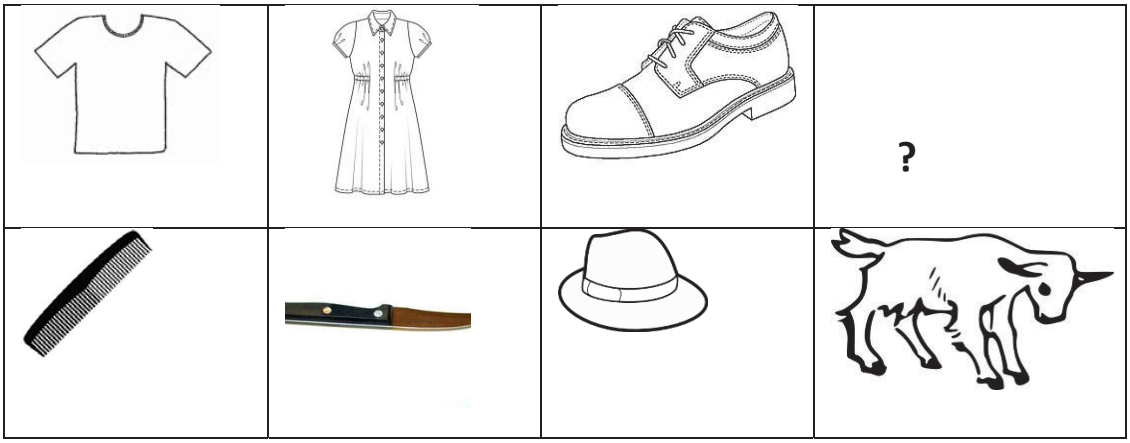
## Card 10 (ICA_EC5)

### Example



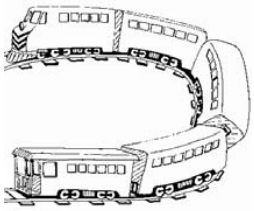
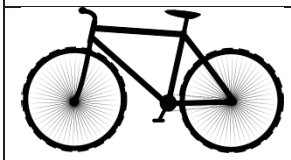
## Card 11

**ICA_E5a**

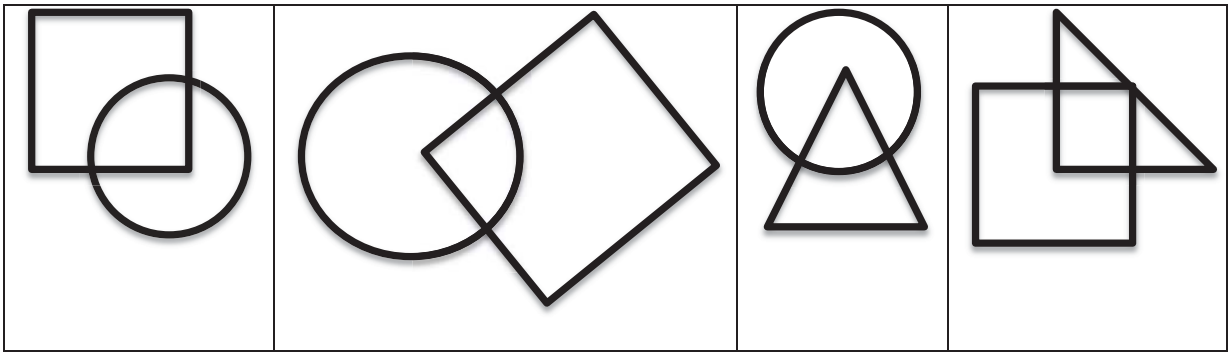


## Card 12

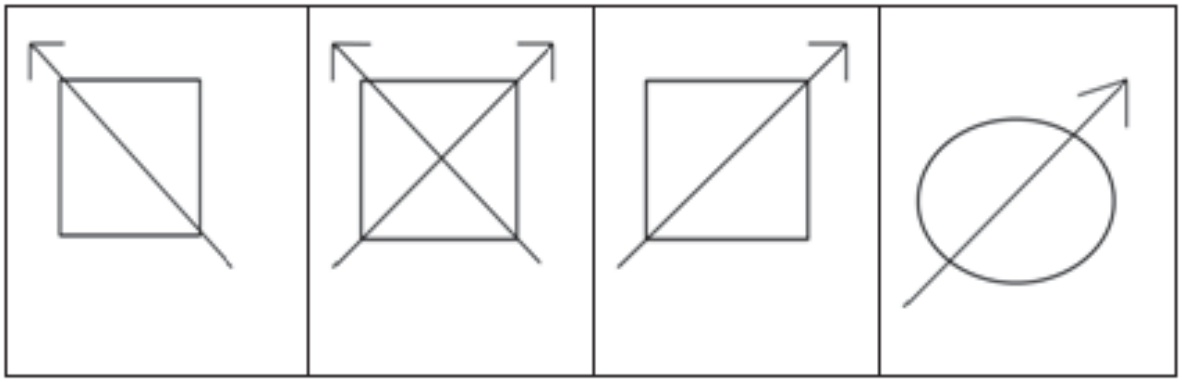
**ICA_E5b**

| | | | |
|---|---|---|---|
|  |  |  | ? |
|  |  |  |  |

## Card 13 (ICA_D2c)



## Card 14 (ICA_D2d)



# C. ADDITIONAL TABLES

**Appendix Table 1: Summary statistics for total ICA score and sub-scores**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Mean (std dev) | | | Corr. across measures | | | | |
| | Females | Males | Total | Lang. | Orient. | Visual | Atten. | Ex. func. |
| ICA language (7) | 6.37 | 6.67 | 6.5 | – | – | – | – | – |
| | (1.04) | (0.79) | (0.95) | | | | | |
| ICA orientation (2) | 1.82 | 1.93 | 1.86 | 0.29 | – | – | – | – |
| | (0.45) | (0.28) | (0.39) | | | | | |
| ICA visual (4) | 2.07 | 2.89 | 2.42 | 0.42 | 0.32 | – | – | – |
| | (1.31) | (1.13) | (1.30) | | | | | |
| ICA attention (3) | 1.49 | 1.91 | 1.67 | 0.33 | 0.26 | 0.47 | – | – |
| | (1.02) | (1.01) | (1.04) | | | | | |
| ICA exec. func. (6) | 4.31 | 4.91 | 4.57 | 0.47 | 0.35 | 0.48 | 0.47 | – |
| | (1.22) | (1.05) | (1.19) | | | | | |
| ICA memory (8) | 4.39 | 5.06 | 4.68 | 0.31 | 0.27 | 0.53 | 0.43 | 0.37 |
| | (2.11) | (2.05) | (2.11) | | | | | |
| Total ICA score (30) | 20.4 | 23.4 | 21.7 | – | – | – | – | – |
| | (5.21) | (4.41) | (5.09) | | | | | |
| # of observations | 711 | 535 | 1,246 | | | | | |

**Appendix Table 2: Comparison of Cognitive Ability Classification in MSLFH, CogUSA, and MIDUS II**

| Age | | MLSFH % | CogUSA % | MIDUS II % |
|---|---|---|---|---|
| **55-64** | (N) | (402) | (463) | (1029) |
| High cognitive ability | | 23.9 | 17.5 | 16.3 |
| Average cognitive ability | | 41.8 | 41.5 | 46.8 |
| Low cognitive ability | | 26.4 | 27.2 | 29.3 |
| Mild impairment | | 6.0 | 10.2 | 6.1 |
| Moderate to severe impairment | | 2.0 | 3.7 | 1.5 |
| **65-74** | (N) | (239) | (266) | (689) |
| High cognitive ability | | 13.8 | 4.9 | 6.4 |
| Average cognitive ability | | 31.0 | 37.6 | 37.0 |
| Low cognitive ability | | 35.6 | 28.2 | 39.2 |
| Mild impairment | | 11.7 | 20.7 | 13.6 |
| Moderate to severe impairment | | 8.0 | 8.7 | 3.8 |
| **75-84** | (N) | (119) | (197) | (338) |
| High cognitive ability | | 5.9 | 1.0 | 2.4 |
| Average cognitive ability | | 24.4 | 20.8 | 21.6 |
| Low cognitive ability | | 33.6 | 35.0 | 42.0 |
| Mild impairment | | 16.8 | 29.4 | 25.7 |
| Moderate to severe impairment | | 19.3 | 13.7 | 8.3 |

*Notes:* Cognitive ability categories are defined based on the distribution of the respective cognitive indicator among respondents aged 45-54 as follows: the 25th percentile of this distribution is the cut-point for low cognitive ability, the 5th percentile is the cut-point for mild cognitive impairment, and the 1st percentile of this distribution is the cut-point for moderate to severe cognitive impairment. In addition, the 75th percentile of the distribution of 45-54 year-olds was used as a cut-point for high cognitive ability. The CogUSA measure is a cognitive index combining scores for 6 domains of the Woodcock Johnson Psychoeducational Test Battery with the most overlap with ICA–auditory working memory, number series, picture vocabulary, retrieval fluency, spatial relations, and visual matching score–for the Cognition and Aging in the USA (CogUSA) national sample (McArdle et al. 2015). The MIDUS measure is the Brief Test of Adult Cognition by Telephone score for the Midlife Development in the United States (MIDUS II) sample (Ryff and Lachman 2009).

**Appendix Table 3: Gender differences in ICA score, MLSFH sample**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Female | -3.09** | -3.08** | -2.88** | -2.84** | -3.17** |
| | (0.23) | (0.23) | (0.44) | (0.45) | (0.27) |
| Female × age gradient | | -0.069** | -0.060** | -0.078+ | -0.067** |
| | | (0.022) | (0.023) | (0.046) | (0.022) |
| Female × schooling | | | 0.63 | 0.56 | |
| | | | (0.53) | (0.53) | |
| Female × schooling × age | | | | 0.015 | |
| | | | | (0.054) | |
| Female × roof material | | | | | 0.41 |
| | | | | | (0.43) |

*Notes:* Columns 1, 2, 3, 4, and 5 report the coefficients of a multivariate linear regression of total cognitive health (ICA score) on respondent characteristics. Model 1 controls for age and female, model 2 adds a female × age interaction, model 3 adds schooling (any vs none) and a female × schooling interaction, and model 4 adds a schooling × female × age three-way interaction to model 3, and model 5 adds a female × roof material interaction to model 2. All analyses additionally control for region. p-values for these regression coefficients are indicated as: + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

**Appendix Table 4: Association of cognitive score with protein intake, earnings, savings, and work efforts: Supplement to Table 5 (Panel 1)**

| | Food intake | Earnings (log) past year | Any labor earnings past year | Any Savings | Work efforts |
|---|---|---|---|---|---|
| *Regression on:* | OLS | OLS | Logit | Logit | OLS |
| Total ICA Score | 0.029+ | 0.082** | 0.044 | 0.066** | 0.41** |
| Female | -0.32** | -0.97** | -0.32+ | 0.14 | 5.20** |
| Female × ICA score | 0.011 | 0.0071 | 0.014 | 0.0012 | -0.19 |
| Age | -0.0096 | -0.028* | -0.027* | -0.0057 | 0.051 |
| $Age^2$ | -0.00048+ | -0.0017** | -0.00050 | -0.00062 | -0.0079** |
| Region (ref = central) | | | | | |
| *South* | 1.18** | -0.46* | -0.31+ | -0.032 | 0.038 |
| *North* | 0.14 | 0.35+ | 0.11 | 0.057 | 1.12 |
| Schooling (ref = none) | | | | | |
| *Primary schooling* | 0.18+ | 0.016 | -0.14 | 0.53** | -0.066 |
| *Secondary schooling* | 0.48* | 0.68* | 0.81 | 1.16** | 1.34 |
| Metal/tile roof | 0.43** | 0.37* | -0.070 | 0.39** | 2.15** |
| Wave (2 vs. 1) | -0.70** | -1.34** | -1.17** | 0.18* | -0.12 |
| Female × age | -0.0087 | -0.037* | -0.012 | -0.0079 | -0.18** |
| Constant | 7.66** | 20.4** | 11.6** | -2.34** | 15.7** |

*Notes:* p-values: * $p < 0.05$, ** $p < 0.01$. Analyses are pooled across 2012 and 2013 MLSFH mature adult survey. Standard errors are adjusted for clustering within respondents.

**Appendix Table 5: Association of cognitive score with protein intake, earnings, savings, and work efforts: Supplement to Table 5 (Panel 2)**

| | Food intake | Earnings (log) past year | Any labor earnings past year | Any Savings | Work efforts |
|---|---|---|---|---|---|
| *Regression on:* | OLS | OLS | Logit | Logit | OLS |
| Cognitive ability classification (ref: average ability) | | | | | |
| *High ability* | 0.41** | 0.019 | -0.22 | 0.58** | 0.53 |
| *Low ability* | -0.14 | -0.68+ | -0.39 | -0.18 | -0.17 |
| *Mild impairment* | -0.38+ | -2.01* | -1.24** | -0.56* | -5.63** |
| *Mod. to sev. impairment* | -0.51* | -2.60* | -1.48* | -0.84* | -3.16 |
| Age | -0.00056 | -0.020 | -0.025 | 0.016 | -0.10 |
| $Age^2$ | -0.00036 | -0.0013 | -0.00028 | -0.0010 | -0.0020 |
| Female | -0.16 | -0.75** | -0.25 | 0.34* | 5.31** |
| Region (ref = central) | | | | | |
| *South* | 1.13** | -0.40 | -0.15 | -0.11 | 0.17 |
| *North* | 0.11 | 0.46+ | 0.24 | 0.048 | 0.83 |
| Schooling (ref = none) | | | | | |
| *Primary schooling* | 0.22+ | 0.026 | -0.19 | 0.57** | 0.13 |
| *Secondary schooling* | 0.43+ | 0.98* | 1.23 | 1.14** | 1.52 |
| Metal/tile roof | 0.36** | 0.49* | 0.075 | 0.42** | 2.16* |
| Wave (2 vs. 1) | -0.77** | -1.47** | -1.15** | 0.11 | -0.28 |
| Female $\times$ age | -0.022+ | -0.052* | -0.019 | -0.030+ | -0.19* |
| Constant | 8.05** | 21.2** | 11.3** | -1.91* | 16.6** |

*Notes:* p-values: * $p < 0.05$, ** $p < 0.01$. Analyses are pooled across 2012 and 2013 MLSFH mature adult survey. Standard errors are adjusted for clustering within respondents.

**Appendix Table 6: Association of cognitive health with life satisfaction, depression (PHQ9), anxiety (GAD7), and SF-12 mental health score: Supplement to Table 6 (Panel 1)**

| | Life satisfaction | PHQ9 depression score | GAD7 anxiety score | SF-12 mental health score |
|---|---|---|---|---|
| *Regression on:* | OLS | OLS | OLS | OLS |
| Total ICA Score | 0.032** | -0.15** | -0.12** | 0.49** |
| Female | -0.16** | 0.79** | 0.55** | -1.75** |
| Female × ICA score | -0.0082 | 0.024 | 0.040 | -0.14 |
| Age | -0.014** | 0.046** | 0.032** | -0.074* |
| $Age^2$ | -0.000034 | 0.0018* | 0.0015** | -0.0034* |
| Region (ref = central) | | | | |
| *South* | 0.058 | -0.82** | -0.51** | 0.18 |
| *North* | -0.23** | -0.83** | -0.36* | -1.00+ |
| Schooling (ref = none) | | | | |
| *Primary schooling* | 0.026 | 0.58* | 0.26 | -1.26* |
| *Secondary schooling* | -0.077 | 0.29 | 0.094 | -0.57 |
| Metal/tile roof | -0.0080 | -0.37** | 0.019 | -0.12 |
| Wave (2 vs. 1) | 0.088+ | -0.078 | 0.054 | -0.30 |
| Female × age | -0.00055 | 0.0072 | 0.021 | -0.056 |
| Constant | 3.70** | 5.33** | 2.14** | 56.2** |

*Notes:* p-values: * $p < 0.05$, ** $p < 0.01$. Analyses are pooled across 2012 and 2013 MLSFH mature adult survey. Standard errors are adjusted for clustering within respondents.

**Appendix Table 7: Association of cognitive health with life satisfaction, depression (PHQ9), anxiety (GAD7), and SF-12 mental health score: Supplement to Table 6 (Panel 2)**

| | Life satisfaction | PHQ9 depression score | GAD7 anxiety score | SF-12 mental health score |
|---|---|---|---|---|
| *Regression on:* | OLS | OLS | OLS | OLS |
| Cognitive ability classification (ref: average ability) | | | | |
| *High ability* | 0.0021 | -0.16 | -0.22 | 1.53+ |
| *Low ability* | -0.26** | 0.72* | 0.40* | -2.12** |
| *Mild impairment* | -0.33** | 2.10** | 1.68** | -5.09** |
| *Mod. to sev. impairment* | -0.67** | 2.62** | 1.78** | -5.08** |
| Age | -0.021** | 0.084** | 0.051* | -0.16* |
| $Age^2$ | 0.00035 | 0.00040 | 0.00069 | 0.00048 |
| Female | -0.10 | 0.83** | 0.56** | -1.12 |
| Region (ref = central) | | | | |
| *South* | 0.089 | -1.10** | -0.78** | 0.57 |
| *North* | -0.25** | -0.71* | -0.18 | -2.07* |
| Schooling (ref = none) | | | | |
| *Primary schooling* | 0.062 | 0.46 | 0.081 | -0.33 |
| *Secondary schooling* | 0.14 | -0.38 | -0.52 | 2.47+ |
| Metal/tile roof | 0.13* | -0.33 | -0.066 | -0.54 |
| Wave (2 vs. 1) | -0.057 | -0.34+ | 0.064 | -0.28 |
| Female $\times$ age | 0.00032 | -0.013 | 0.0047 | -0.062 |
| Constant | 4.10** | 4.87** | 1.75+ | 57.8** |

*Notes:* p-values: * $p < 0.05$, ** $p < 0.01$. Analyses are pooled across 2012 and 2013 MLSFH mature adult survey. Standard errors are adjusted for clustering within respondents.

**Appendix Table 8: Association of total ICA score with physical health, pain, grip strength, BMI, and BP: Supplement to Table 7 (Panel 1)**

| | Self-rated health | Accomp-lished less, due to physical health | Work limitation,c due to physical health | Pain interfered with work | Grip Strength | Body Mass Index | Blood pressure (systolic) |
|---|---|---|---|---|---|---|---|
| *Regression on:* | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Total ICA Score | 0.045** | -0.042** | -0.043** | -0.047** | 0.26** | 0.049 | -0.31 |
| Female | -0.21** | 0.23** | 0.26** | 0.28** | -5.40** | 1.43** | 0.61 |
| Female × ICA score | -0.016 | 0.0090 | 0.010 | 0.0073 | 0.021 | 0.050 | 0.33 |
| Age | -0.021** | 0.020** | 0.022** | 0.017** | -0.22** | -0.014 | 0.69** |
| $Age^2$ | -0.00011 | 0.00068** | 0.00068** | 0.00077** | -0.00077 | 0.00080 | -0.017** |
| Region (ref = central) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *South* | 0.066 | -0.26** | -0.19** | -0.13* | -0.73* | -0.48+ | 4.24* |
| *North* | -0.13* | -0.059 | -0.0055 | -0.16* | -0.66* | 0.17 | -6.83** |
| Schooling (ref = none) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Primary schooling* | -0.037 | 0.037 | 0.021 | 0.100 | -0.47 | 0.43 | -0.74 |
| *Secondary schooling* | 0.047 | -0.022 | -0.0017 | -0.012 | 0.65 | 1.29* | 8.73* |
| Metal/tile roof | 0.051 | 0.097* | 0.080+ | 0.071 | 0.12 | 0.95** | 0.35 |
| Wave (2 vs. 1) | -0.30** | 0.046 | 0.040 | -0.042 | -0.021 | 0.052 | -0.0085 |
| Female × age | 0.0031 | 0.00028 | 0.000068 | 0.0035 | 0.080** | -0.026 | 0.13 |
| Constant | 5.60** | 1.42** | 1.38** | 2.06** | 26.0** | 19.9** | 138.0** |

*Notes:* p-values: * $p < 0.05$, ** $p < 0.01$. Analyses are pooled across 2012 and 2013 MLSFH mature adult survey. Standard errors are adjusted for clustering within respondents.

**Appendix Table 9: Association of total ICA score with physical health, pain, grip strength, BMI, and BP: Supplement to Table 7 (Panel 2)**

| | Self-rated health | Accomp-lished less, due to physical health | Work limitation,c due to physical health | Pain interfered with work | Grip Strength | Body Mass Index | Blood pressure (systolic) |
|---|---|---|---|---|---|---|---|
| *Regression on:* | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Cognitive ability classification (ref: average ability) | | | | | | | |
| *High ability* | 0.18* | -0.030 | -0.031 | -0.059 | 1.36** | 0.093 | 0.50 |
| *Low ability* | -0.22** | 0.18* | 0.17* | 0.14+ | -0.94* | -0.89* | 1.84 |
| *Mild impairment* | -0.48** | 0.62** | 0.56** | 0.67** | -2.59** | -0.60 | 2.23 |
| *Mod. to sev. impairment* | -0.59** | 0.80** | 0.77** | 0.75** | -3.24** | -1.02+ | -2.12 |
| Age | -0.027** | 0.025** | 0.029** | 0.031** | -0.29** | -0.065+ | 0.56* |
| $Age^2$ | 0.00030 | 0.00029 | 0.00024 | 0.00020 | 0.0010 | 0.0027+ | -0.012 |
| Female | -0.14* | 0.16* | 0.20** | 0.29** | -5.94** | 1.41** | -0.033 |
| Region (ref = central) | | | | | | | |
| *South* | 0.13+ | -0.31** | -0.25** | -0.21* | -0.73+ | -0.42 | 6.84* |
| *North* | -0.14+ | -0.0059 | 0.022 | -0.16+ | -0.81* | 0.035 | -5.74* |
| Schooling (ref = none) | | | | | | | |
| *Primary schooling* | -0.057 | -0.0028 | 0.000066 | 0.050 | -0.29 | 0.67+ | 0.80 |
| *Secondary schooling* | 0.19 | -0.23+ | -0.21 | -0.21 | 0.87 | 1.47* | 7.21 |
| Metal/tile roof | 0.049 | 0.072 | 0.077 | 0.024 | 0.25 | 1.22** | 0.63 |
| Wave (2 vs. 1) | -0.31** | 0.064 | 0.060 | 0.017 | -0.087 | 0.097 | -0.046 |
| Female $\times$ age | 0.0016 | 0.0018 | 0.00092 | 0.00035 | 0.12** | -0.029 | 0.16 |
| Constant | 5.73** | 1.24** | 1.18** | 1.55** | 27.1** | 19.8** | 135.9** |

*Notes:* p-values: * $p < 0.05$, ** $p < 0.01$. Analyses are pooled across 2012 and 2013 MLSFH mature adult survey. Standard errors are adjusted for clustering within respondents.

**Appendix Table 10: Association of cognitive score with protein intake, earnings, savings, and work efforts: Alternative parametrizations of ICA categories**

| | Protein intake | Earnings (log) past year | Any labor earnings past year | Any Savings | Work efforts |
|---|---|---|---|---|---|
| Mean of dep. Var. | 2.90 | 9.75 | 0.89 | 0.40 | 19.0 |
| Std dev | (1.93) | (3.65) | (0.31) | (0.49) | (12.8) |
| *Regression on:* | OLS | OLS | Logit | Logit | OLS |
| Panel 1: Alt parameterization A (.5%, 3%, 25%, 75%) (ref: average ability) | | | | | |
| *High ability* | 0.41** | 0.24 | -0.044 | 0.58** | 0.52 |
| | (0.14) | (0.27) | (0.30) | (0.18) | (1.38) |
| *Low ability* | -0.15 | -0.29 | -0.23 | -0.19 | -0.67 |
| | (0.14) | (0.25) | (0.23) | (0.16) | (1.18) |
| *Mild imp.* | -0.44* | -0.92* | -0.42 | -0.63* | -4.40* |
| | (0.22) | (0.42) | (0.30) | (0.28) | (1.74) |
| *Mod. to sev. imp.* | -0.45* | -2.25** | -1.26** | -1.02* | -3.55 |
| | (0.23) | (0.60) | (0.33) | (0.43) | (2.25) |
| Panel 2: Alt parameterization B (1%, 5%, 15%, 85%) (ref: average ability) | | | | | |
| *High ability* | 0.29+ | -0.18 | -0.44 | 0.49* | 0.77 |
| | (0.16) | (0.32) | (0.32) | (0.21) | (1.55) |
| *Low ability* | -0.31* | -0.19 | -0.11 | -0.15 | -0.62 |
| | (0.14) | (0.27) | (0.24) | (0.17) | (1.24) |
| *Mild imp.* | -0.31+ | -0.99** | -1.12** | -0.64** | -5.50** |
| | (0.18) | (0.36) | (0.46) | (0.24) | (1.51) |
| *Mod. to sev. imp.* | -0.56** | -2.16** | -1.46* | -0.87* | -3.53+ |
| | (0.21) | (0.57) | (0.63) | (0.38) | (2.01) |
| Panel 3: Alt parameterization C (.5%, 3%, 15%, 85%) (ref: average ability) | | | | | |
| *High ability* | 0.29+ | -0.19 | -0.45 | 0.48* | 0.74 |
| | (0.16) | (0.32) | (0.32) | (0.21) | (1.55) |
| *Low ability* | -0.27* | -0.35 | -0.23 | -0.21 | -1.55 |
| | (0.13) | (0.26) | (0.22) | (0.16) | (1.18) |
| *Mild imp.* | -0.50* | -0.95* | -0.41 | -0.66* | -4.78** |
| | (0.21) | (0.41) | (0.29) | (0.28) | (1.69) |
| *Mod. to sev. imp.* | -0.51* | -2.28** | -1.25** | -1.03* | -4.00+ |
| | (0.22) | (0.60) | (0.32) | (0.42) | (2.20) |

*Notes:* Panel A shows the primary results from an alternative parameterization using the bottom .5% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom .5-3% as the threshold for mild impairment, the bottom 3-25% for low ability, and 75% or higher for high ability. Panel B shows the primary results from an alternative parameterization using the bottom 1% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom 5% as the threshold for mild impairment, the bottom 5-15% for low ability, and 85% or higher for high ability. Panel C A shows the primary results from an alternative parameterization using the bottom .5% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom .5-3% as the threshold for mild impairment, the bottom 3-15% for low ability, and 85% or higher for high ability.

**Appendix Table 11: Association of cognitive health with life satisfaction, depression (PHQ9), anxiety (GAD7), and SF-12 mental health score: Alternative parameterizations of ICA categories**

| | Life satisfaction | PHQ9 depression score | GAD7 anxiety score | SF-12 mental health score |
|---|---|---|---|---|
| Mean of dep. Var. | 3.53 | 2.98 | 2.59 | 52.9 |
| Std dev | (0.97) | (3.79) | (2.82) | (10.1) |
| *Regression on:* | OLS | OLS | OLS | OLS |
| Panel 1: Alt parameterization A (.5%, 3%, 25%, 75%) (ref: average ability) | | | | |
| *High ability* | 0.0021 | -0.16 | -0.22 | 1.53+ |
| | (0.078) | (0.31) | (0.23) | (0.89) |
| *Low ability* | -0.27** | 0.81** | 0.49* | -2.25** |
| | (0.067) | (0.28) | (0.19) | (0.71) |
| *Mild imp.* | -0.34** | 2.11** | 1.64** | -5.21** |
| | (0.098) | (0.52) | (0.39) | (1.27) |
| *Mod. to sev. imp.* | -0.71** | 2.69** | 1.85** | -5.43** |
| | (0.13) | (0.73) | (0.46) | (1.81) |
| Panel 2: Alt parameterization B (1%, 5%, 15%, 85%) (ref: average ability) | | | | |
| *High ability* | 0.11 | -0.16 | -0.22 | 1.56+ |
| | (0.087) | (0.31) | (0.23) | (0.94) |
| *Low ability* | -0.23** | 0.68* | 0.42* | -1.95* |
| | (0.072) | (0.31) | (0.20) | (0.77) |
| *Mild imp.* | -0.23** | 1.74** | 1.46** | -4.49** |
| | (0.084) | (0.41) | (0.30) | (1.07) |
| *Mod. to sev. imp.* | -0.61** | 2.50** | 1.75** | -4.82** |
| | (0.12) | (0.66) | (0.44) | (1.72) |
| Panel 3: Alt parameterization C (.5%, 3%, 15%, 85%) (ref: average ability) | | | | |
| *High ability* | 0.11 | -0.15 | -0.22 | 1.54 |
| | (0.087) | (0.31) | (0.23) | (0.94) |
| *Low ability* | -0.22** | 0.80** | 0.54** | -2.19** |
| | (0.067) | (0.29) | (0.19) | (0.75) |
| *Mild imp.* | -0.28** | 2.03** | 1.63** | -5.02** |
| | (0.095) | (0.51) | (0.39) | (1.25) |
| *Mod. to sev. imp.* | -0.65** | 2.61** | 1.85** | -5.21** |
| | (0.13) | (0.73) | (0.46) | (1.80) |

*Notes:* Panel A shows the primary results from an alternative parameterization using the bottom .5% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom .5-3% as the threshold for mild impairment, the bottom 3-25% for low ability, and 75% or higher for high ability. Panel B shows the primary results from an alternative parameterization using the bottom 1% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom 5% as the threshold for mild impairment, the bottom 5-15% for low ability, and 85% or higher for high ability. Panel C A shows the primary results from an alternative parameterization using the bottom .5% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom .5-3% as the threshold for mild impairment, the bottom 3-15% for low ability, and 85% or higher for high ability

**Appendix Table 12: Association of total ICA score with physical health, pain, grip strength, BMI, and BP: Supplement to Table 7 (Panel 1)**

| | Self-rated health | Accomp-lished less, due to physical health | Work limitation,c due to physical health | Pain interfered with work | Grip Strength | Body Mass Index | Blood pressure (systolic) |
|---|---|---|---|---|---|---|---|
| Mean of dep. Var. | 3.21 | 1.90 | 1.86 | 1.96 | 22.1 | 21.7 | 135.3 |
| Std dev | (0.96) | (1.10) | (1.07) | (1.18) | (6.31) | (3.90) | (25.6) |
| *Regression on:* | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Panel 1: Alt parameterization A (.5%, 3%, 25%, 75%) (ref: average ability) | | | | | | | |
| *High ability* | 0.18* | -0.028 | -0.031 | -0.058 | 1.36** | 0.094 | 0.47 |
| | (0.075) | (0.094) | (0.086) | (0.092) | (0.50) | (0.38) | (2.88) |
| *Low ability* | -0.25** | 0.22** | 0.20** | 0.18* | -1.07* | -0.87* | 1.47 |
| | (0.071) | (0.077) | (0.073) | (0.083) | (0.45) | (0.36) | (2.48) |
| *Mild imp.* | -0.43** | 0.58** | 0.55** | 0.60** | -2.61** | -0.68 | 3.33 |
| | (0.11) | (0.13) | (0.13) | (0.14) | (0.56) | (0.52) | (4.16) |
| *Mod. to sev. imp.* | -0.61** | 0.80** | 0.83** | 0.83** | -3.16** | -0.96 | -0.95 |
| | (0.14) | (0.19) | (0.18) | (0.20) | (0.74) | (0.61) | (5.89) |
| Panel 2: Alt parameterization B (1%, 5%, 15%, 85%) (ref: average ability) | | | | | | | |
| *High ability* | 0.25** | -0.0073 | 0.032 | -0.043 | 1.09+ | 0.23 | 0.60 |
| | (0.082) | (0.10) | (0.099) | (0.10) | (0.60) | (0.44) | (3.14) |
| *Low ability* | -0.21** | 0.18* | 0.15* | 0.13 | -1.42** | -0.66+ | 0.72 |
| | (0.074) | (0.083) | (0.077) | (0.084) | (0.45) | (0.37) | (2.70) |
| *Mild imp.* | -0.37** | 0.52** | 0.48** | 0.58** | -2.87** | -0.50 | 1.05 |
| | (0.090) | (0.11) | (0.10) | (0.12) | (0.45) | (0.46) | (3.33) |
| *Mod. to sev. imp.* | -0.55** | 0.77** | 0.74** | 0.73** | -3.52** | -0.83 | -3.02 |
| | (0.13) | (0.17) | (0.17) | (0.19) | (0.69) | (0.54) | (5.30) |
| Panel 3: Alt parameterization C (.5%, 3%, 15%, 85%) (ref: average ability) | | | | | | | |
| *High ability* | 0.24** | -0.0051 | 0.034 | -0.040 | 1.08+ | 0.23 | 0.59 |
| | (0.082) | (0.10) | (0.099) | (0.10) | (0.60) | (0.44) | (3.14) |
| *Low ability* | -0.23** | 0.23** | 0.19** | 0.19* | -1.69** | -0.66+ | 0.16 |
| | (0.071) | (0.081) | (0.074) | (0.082) | (0.42) | (0.36) | (2.52) |
| *Mild imp.* | -0.40** | 0.57** | 0.53** | 0.60** | -2.88** | -0.49 | 2.52 |
| | (0.10) | (0.12) | (0.13) | (0.14) | (0.53) | (0.50) | (4.09) |
| *Mod. to sev. imp.* | -0.58** | 0.79** | 0.81** | 0.82** | -3.44** | -0.75 | -1.86 |
| | (0.14) | (0.19) | (0.18) | (0.20) | (0.72) | (0.59) | (5.84) |

*Notes:* Panel A shows the primary results from an alternative parameterization using the bottom .5% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom .5-3% as the threshold for mild impairment, the bottom 3-25% for low ability, and 75% or higher for high ability. Panel B shows the primary results from an alternative parameterization using the bottom 1% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom 5% as the threshold for mild impairment, the bottom 5-15% for low ability, and 85% or higher for high ability. Panel C A shows the primary results from an alternative parameterization using the bottom .5% of the 45-54-year old distribution of ICA scores as the threshold for moderate to severe impairment, the bottom .5-3% as the threshold for mild impairment, the bottom 3-15% for low ability, and 85% or higher for high ability.

**Appendix Table 13: Survey outcomes for 2012 and 2013 MLSFH Mature Adult surveys**

| | **2012** | **2013** |
|---|---|---|
| Target Sample (*N*) | 1,402 | 1,376 |
| Completed surveys | 1,266 (90.3%) | 1,257 (91.4%) |
| Reasons for not completing survey | | |
| *Refused* | 0.5% | 0.7% |
| *Resp. was hospitalized* | 0.3% | 0.1% |
| *Resp. had died* | 3.1% | 2.0% |
| *Resp. was temporarily absent* | 1.8% | 1.8% |
| *Resp. moved* | 2.1% | 3.0% |
| *Other* | 2.0% | 1.1% |

**Appendix Table 14: First available MLSFH Round for MLSFH participants in 2010 and 2012**

| First available MLSFH Round | MLSFH 7 (2012) Respondents | | | 2012 Age | | |
|---|---|---|---|---|---|---|
| | *Females* | *Males* | *Total* | $25^{th}$ *%tile* | *Mean* | $75^{th}$ *%tile* |
| 1998 | 50.14% | 54.61% | 52.05% | 49 | 55.4 | 60 |
| 2001 | 11.60% | 10.89% | 11.30% | 48 | 55.0 | 59 |
| 2004 | 0.97% | 6.64% | 3.40% | 50 | 57.0 | 63 |
| 2006 | 2.49% | 3.87% | 3.08% | 48 | 58.1 | 66 |
| 2008 | 34.81% | 23.99% | 30.17% | 62 | 69.2 | 76 |
| 2010 | – | – | – | – | – | – |
| *N* | 724 | 542 | 1,266 | | | |

## Appendix Table 15: Selected measurements in the 2012–13 MLSFH mature adult surveys on mental health and well-being

| *Construct Definition* | *Measurement/Scales/Items Source* |
|---|---|
| ***Mental health and depression*** | SF12 mental health score; Primary Care Evaluation of Mental Disorders (PRIME-MD), including PHQ9 depression module and GAD7 anxiety module; subjective well-being. |
| ***Cognitive function*** | Spatial/temporal orientation and language; visual/constructional test; visual/verbal memory, attention/working memory, memory/delayed recall and executive functioning developed by the project team. |
| ***Physical health and performance*** | Subjective health assessments; hand grip strength (measured using hand-held dynamometer); measured height, weight and body mass index (BMI); blood pressure (2013 only; measured using upper-arm blood pressure monitors); activities of daily living (ADLs); biomarker-based HIV status (2012 only). |
| ***Alcohol and tobacco Consumption*** | Alcohol use based on the Alcohol Use Disorder Identification Test (AUDIT); tobacco use. |
| ***Subjective risk assessments and probabilistic expectations*** | Interactive probabilistic expectation elicitation method developed for Malawi and low literacy populations, including about mortality/survival, own HIV infection, local HIV prevalence and prevalence of local AIDS-related morbidity. |
| ***Social capital and resources networks*** | MLSFH modules on social capital & family transfer networks. |
| ***Social, demographic and economic background*** | Modules repeated from MLSFH questionnaire 2008 & 2010, including income, assets, economic shocks, financial and non-financial transfers, illness/mortality of family members, household composition, socioeconomic context, social and human capital. |
| ***Work efforts and productivity*** | Time devoted to different work activities and intensity of work; work efforts and work-related health limitations. |

HIV status is known for *all* MLSFH respondents (measured in 2012, 2008, 2006, 2004). All MLSFH households are geocoded, and can be linked to health infrastructure and other spatial data. Spouses are linked in the MLSFH, and children reported by respondents are longitudinally linked in the household rosters across waves.

**Appendix Table 16: Number of HIV+ respondents and HIV prevalence by age among the MLSFH mature adults in 2012**

| | Females | | Males | | Total | |
|---|---|---|---|---|---|---|
| Age | # of Cases | Prevalence (%) | # of Cases | Prevalence (%) | # of Cases | Prevalence (%) |
| 45–54 | 18 | 6.0% | 12 | 6.6% | 30 | 6.2% |
| 55–64 | 11 | 5.3% | 14 | 8.2% | 25 | 6.6% |
| 65–74 0 | 0 | 0.0% | 2 | 1.8% | 2 | 0.9% |
| 75+ | 2 | 2.6% | 0 | 0.0% | 2 | 1.4% |
| Total | 31 | 4.4% | 28 | 5.3% | 59 | 4.8% |

*Note:* HIV positive: any HIV test during 2004–12 is HIV positive

**Appendix Table 17: 2010 and 2012 MLSFH Survey outcome for all 2008 MLSFH respondents meeting mature-adult age-eligibility criteria ($Age_{2008} \geq 41$)**

| Mature adults surveyed in 2008 ($Age_{2008} \geq 41$): | | 2012 Outcome | | | |
|---|---|---|---|---|---|
| **2010 Outcome** | | Survey completed | Not surveyed/ not found | Dead | Not eligible/ not selected |
| Survey completed | 1,477 | 1,266 | 93 | 43 | 75 |
| Not surveyed/not found | 340 | 0 | 0 | 0 | 340 |
| Dead | 61 | 0 | 0 | 0 | 61 |
| Total | 1,878 | 1,266 | 93 | 43 | 476 |

**Appendix Table 18: Comparison of 2008 respondent characteristics for 2008 age-eligible respondents depending on whether they were surveyed in the 2012 mature adult survey or not**

| | Surveyed in 2012 mature adult survey | | | |
|---|---|---|---|---|
| 2008 Respondent Characteristics | Yes | No | Total | Signif. Diff. |
| Female | 0.572 | 0.536 | 0.560 | $^{-}$ |
| Age | 55.23 | 58.57 | 56.30 | * |
| | (11.92) | (14.96) | (13.06) | |
| Age Group | | | | |
| *< 45* | 0.194 | 0.170 | 0.186 | $^{-}$ |
| *45-54* | 0.343 | 0.243 | 0.311 | * |
| *55-64* | 0.246 | 0.248 | 0.247 | $^{-}$ |
| *65-74* | 0.138 | 0.185 | 0.153 | * |
| *75+* | 0.0795 | 0.154 | 0.103 | * |
| Schooling attainment | | | | |
| *No formal schooling* | 0.368 | 0.398 | 0.378 | $^{-,-}$ |
| *Primary schooling* | 0.575 | 0.540 | 0.564 | $^{-,-}$ |
| *Secondary or higher* | 0.0568 | 0.0615 | 0.0583 | $^{-,-}$ |
| Muslim | 0.274 | 0.282 | 0.276 | $^{-,-}$ |
| Currently married | 0.818 | 0.766 | 0.801 | $^{*,-}$ |
| Wealth indicator: House has metal/tiled roof | 0.231 | 0.217 | 0.226 | $^{-,-}$ |
| HIV status (based on all prior tests) | 0.0371 | 0.0615 | 0.0438 | $^{*,-}$ |
| Region of residence | | | | |
| *Central* | 0.302 | 0.359 | 0.321 | * |
| *South* | 0.366 | 0.408 | 0.380 | $^{-}$ |
| *North* | 0.333 | 0.232 | 0.300 | * |
| SF12 Mental Health Score | 52.89 | 52.88 | 52.89 | $^{-,-}$ |
| | (9.295) | (9.695) | (9.396) | |
| Subjective well-being | 3.881 | 3.764 | 3.851 | $^{*,-}$ |
| (1 = very unsatisfied, ..., 5 = very satisfied) | (0.956) | (1.020) | (0.974) | |
| Depression/anxiety Index (DAX) | 0.442 | 0.481 | 0.452 | $^{-,-}$ |
| | (0.708) | (0.725) | (0.712) | |
| SF12 Physical Health Score | 50.05 | 48.35 | 49.61 | $^{*,-}$ |
| | (8.303) | (9.940) | (8.781) | |
| # of observations | 1,266 | 612 | 1,878 | |

*Notes:* Table includes all 2008 MLSFH respondents that are age-eligible for 2012 mature adult survey (i.e., $\text{Age}_{2008} \geq 41$). The column "Signif. Diff." indicates whether the difference in 2008 respondent characteristics is significantly different between those surveyed and those *not* surveyed in 2012. * before the comma indicates that the difference is significant at 5% or higher, $^{-}$ indicates that the difference is not statistically significant. # after the comma indicates that the difference is significant at 5% or higher after controlling for region, age, age$^2$ and gender, $^{-}$ indicates that the difference is not statistically significant. This second test is not performed for region, age, and gender, and none of the differences in the other variables remain significant at 5% after controlling for region, age, age$^2$ and gender.

**Appendix Table 19: Age-eligible 2008 respondents: Predictors of *not* being surveyed in 2012 MLSFH mature adult survey (odds ratios)**

| | Outcome: not being surveyed in 2012 | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female | 0.84 | $0.77^{+}$ | 0.86 | 0.84 |
| | (0.10) | (0.11) | (0.13) | (0.13) |
| Age (in 2008) | $0.90^{**}$ | $0.87^{**}$ | $0.89^{**}$ | $0.88^{**}$ |
| | (0.023) | (0.028) | (0.026) | (0.029) |
| $(\text{Age}/10)^2$ | $1.11^{**}$ | $1.13^{**}$ | $1.12^{**}$ | $1.14^{**}$ |
| | (0.023) | (0.030) | (0.027) | (0.032) |
| Schooling attainment (Ref: no formal schooling) | | | | |
| *Primary schooling* | 1.06 | 1.09 | 1.24 | 1.26 |
| | (0.14) | (0.17) | (0.20) | (0.21) |
| *Secondary or higher* | 1.41 | 1.43 | 1.54 | 1.67 |
| | (0.36) | (0.43) | (0.50) | (0.56) |
| Muslim | 0.81 | 0.89 | 0.85 | 0.86 |
| | (0.14) | (0.19) | (0.19) | (0.20) |
| Currently married | 0.83 | $0.75^{+}$ | 0.77 | 0.74 |
| | (0.12) | (0.13) | (0.13) | (0.14) |
| Region of residence (Ref: Central) | | | | |
| *South* | 1.08 | 1.10 | 1.04 | 1.08 |
| | (0.18) | (0.22) | (0.22) | (0.24) |
| *North* | $0.58^{**}$ | $0.63^{**}$ | $0.62^{**}$ | $0.59^{**}$ |
| | (0.082) | (0.10) | (0.11) | (0.11) |
| HIV status (based on all prior tests) | | $1.82^{*}$ | | $1.74^{+}$ |
| | | (0.49) | | (0.54) |
| Wealth indicator: House has metal/tiled roof | | 0.93 | 0.93 | 0.92 |
| | | (0.14) | (0.15) | (0.15) |
| SF12 Mental Health Score | | | 1.01 | 1.00 |
| | | | (0.0073) | (0.0076) |
| Subjective well-being | | | 0.91 | |
| (1 = very unsatisfied, ..., 5 = very satisfied) | | | (0.062) | |
| SF12 Physical Health Score | | | | 0.99 |
| | | | | (0.0081) |
| Observations | 1,813 | 1,462 | 1,385 | 1,286 |
| Proportion of 2008 respondents *not* surveyed in 2012 | 0.32 | 0.27 | 0.26 | 0.25 |

*Notes:* Analyses include all 2008 MLSFH respondents that are age-eligible for 2012 mature adult survey (i.e., $\text{Age}_{2008} \geq 41$). Dependent variable is not being surveyed in 2012 (among age-eligible 2008 respondents). $p$-values: $^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$.

**Appendix Table 20: Attrition among MLSFH mature adults 2008–12: OLS analyses of the determinants of 2008 mental health, with interaction for respondents who subsequently attrited during 2008–12**

| | (1) | (2) | (3) |
|---|---|---|---|
| Outcome | Depression/ anxiety index (DAX) | SF12 mental health score | Subj. well-being |
| Not surveyed in 2012 | 0.16 | -3.64 | -0.89** |
| | (0.25) | (2.90) | (0.33) |
| Age | 0.0097** | -0.14** | -0.018** |
| | (0.0020) | (0.025) | (0.0025) |
| Age × Not surveyed in 2012 | -0.0028 | 0.067 | 0.011** |
| | (0.0038) | (0.043) | (0.0044) |
| Female | 0.25** | -4.18** | -0.18** |
| | (0.043) | (0.58) | (0.063) |
| Female=1 × Not surveyed in 2012 | 0.093 | -1.08 | 0.026 |
| | (0.087) | (1.18) | (0.13) |
| Schooling attainment (Ref: no formal schooling) | | | |
| *Primary schooling* | 0.0078 | 0.23 | 0.044 |
| | (0.052) | (0.66) | (0.073) |
| *Secondary or higher* | -0.065 | 1.22 | 0.084 |
| | (0.095) | (1.46) | (0.16) |
| *Primary schooling* × Not surveyed in 2012=1 | 0.010 | -0.30 | 0.25 |
| | (0.11) | (1.38) | (0.16) |
| *Secondary or higher* × Not surveyed in 2012=1 | 0.036 | -1.58 | 0.35 |
| | (0.19) | (2.95) | (0.30) |
| Region of residence (Ref: Central) | | | |
| *South* | 0.23** | -1.95** | -0.089 |
| | (0.052) | (0.66) | (0.072) |
| *North* | 0.25** | -3.05** | -0.068 |
| | (0.052) | (0.73) | (0.077) |
| *South* × Not surveyed in 2012 | -0.062 | 0.49 | 0.000078 |
| | (0.10) | (1.30) | (0.15) |
| *North* × Not surveyed in 2012 | -0.069 | 2.74$^{+}$ | -0.14 |
| | (0.11) | (1.53) | (0.17) |
| House has metal/tiled roof | -0.057 | 0.50 | 0.11 |
| | (0.050) | (0.68) | (0.071) |
| House has metal/tiled roof × Not surveyed in 2012 | 0.025 | -0.48 | 0.0046 |
| | (0.10) | (1.46) | (0.15) |
| Constant | -0.39** | 64.6** | 4.95** |
| | (0.13) | (1.66) | (0.17) |
| Observations | 1,394 | 1,385 | 1,396 |
| Proportion of age-eligible 2008 respondents *not* surveyed in 2012 | 0.25 | 0.26 | 0.26 |
| F-test (p-values) for $H_0$ that all interactions with *Not surveyed in 2012* are equal to zero | | | |
| including level effect (*Not surveyed in 2012*) | .93 | .53 | .28 |
| excluding level effect (*Not surveyed in 2012*) | .91 | .43 | .35 |

*Notes:* Analyses include all 2008 MLSFH respondents with non-missing observations that are age-eligible for 2012 mature adult survey (i.e., $\text{Age}_{2008} \geq 41$). $p$-values: $^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$.