# The Dynamic Response of Physical and Mental Health to Subjective Expectations of Mortality and Disease: the Case of Mature Adults in Rural Malawi[1]

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## Abstract

We investigate the dynamic response of physical and mental health to subjective expectations of mortality and disease, emphasizing behavioral adaptations to disease. We use data from the Malawi Longitudinal Study of Families and Health (MLSFH) and focus on rural individuals aged 45+. We estimate a Structural Equation Model (SEM), controlling for individual heterogeneity. Our results suggest that negative shocks of physical or mental health produce a significant increase in the subjective probability of death and disease for both sexes. The opposite effect is lagged by two years: an increasing subjective probability of death and disease has a negative effect on male physical health. We infer that this is an adaptive response of males who adjust their behaviors to a shorter time horizon of planning, and consequentially jeopardizing their health. The dynamic response of females aged 45-59 shows no significant effect, suggesting a different pathway of adaptation with more control of their lives.

# 1 Introduction and Background

One of the most substantial topics in social science research is the problem of health disparities. This research problem has been approached from two leading perspectives. The epidemiological approach analyzes the proximate factors of morbidity and mortality to explain why some individuals and societies are healthier than others. On the other hand, the social medicine

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approach, proposed by Link & Phelan (1995), emphasizes *social conditioning* as the fundamental cause of the disease. From this perspective, individuals demand social and economic resources to avoid disease. Thus, the most frequent association of a health gradient is between health disparities and socioeconomic status. According to Link, Lennon & Dohrenwend (1993), the health gradient can be hypothesized through the competing theories of *social selection* and *social causation*. The *social selection* theory approaches the problem of health disparities as a consequence of genetic predisposition and one's family background during childhood, resulting in lower socioeconomic status and poorer health status in adulthood. Conversely, the theory of *social causation* argues that individuals adapt their personality in response to stressful life events, producing different behavioral pathways in how individuals control and plan their lives (Link, Lennon & Dohrenwend, 1993). In this theory, lower rank and subordination might induce some level of frustration and psychological stress. When permanent, psychological stress affects the physical health. Thus, the most common approach is to assume that social disparities have a socioeconomic cause through psychological factors.

One argument to support the effect of psychological factors in health disparities is the neurobiological response activated by psychological stress. In this regard, Sapolsky (2004) theorizes that animals respond to life-threatening events by triggering a stress-response. This response implies a temporary disruption of the allostatic balance, for example, by increasing the production of hormones like adrenaline, noradrenaline and cortisol. However, a sustained stress-response increases the risk of stress-related diseases. Similarly, Cohen & Rodriguez (1995) discuss evidence of the effect of negative emotions on levels of blood pressure and peripheral blood vessels, leading to cardiovascular disease. Moreover, the elevated production of cortisol associated to chronic stress might result in immunological suppression, thus increasing the risk of infectious diseases (Sapolsky, 2004; Cohen & Rodriguez, 1995). However, the empirical evidence of the biological argument has not been conclusive. Lynch et al. (1996) show no significant effect of socioeconomic status on heart-related mortality after controlling for genetic predisposition and behavioral, psychological and social factors. Carroll et al. (1997) show evidence of individuals with higher rank and with higher blood pressure reactivity. Thus, the association of health disparities and socioeconomic status is operating in the opposite direction. Epel et al. (2004) investigate the effects of stress on cellular aging using a sample of females, and conclude that mothers of chronically ill children show at least one more decade of cellular aging compared with their counterparts. Dowd & Goldman (2006) provide evidence that basal cortisol levels are not associated with higher or lower socioeconomic levels in a sample of Taiwanese mature adults.

The second argument to explain the effect of psychosocial factors and negative emotions on physical health is the hypothesis of the relative deprivation. From this perspective, individuals do not respond to the absolute lack of material resources, but to the relative position compared with their equals.  In this context, Wilkinson (1994), Marmot & Wilkinson (2001), Wilkinson & Pickett (2007), and Subramanyam et al. (2009) argue that income inequalities, and relative differences in the levels of wealth play a major role on the stress-response of individuals, affecting the overall health of individuals with lower socioeconomic status. However, the main disadvantage of this mechanism of health disparities is the lack of empirical association between physical and mental health.

The third argument explaining health disparities emphasizes the behavioral response, and the reciprocal effects of physical and mental health. On the one hand, behaviors may attenuate or exacerbate negative emotions, life events, and physical disorders, by increasing or preventing the exposure to the risk factors of illness (Mayne, 1999). On the other hand, the comorbidity of physical and mental health implies that physical and mental health disorders depend on each other. For example, physical limitation is associated with some degree of symptoms of depression, and a depressive state may result in physical illness. Using a longitudinal survey of Kentuckians aged 55+, Meeks et al. (2000) analyze the reciprocal response of self-reported health and depressive symptoms. These authors conclude that negative perceptions of health predict a short-term increase in depressive symptoms, but depressive symptoms have only a minor effect on health. Although there is a clear association of physical and mental health, the explanation of the linking mechanism is still elusive (Salovey et al., 2000). In this regard, Cohen & Rodriguez (1995) argue that individuals have a behavioral response to physical and psychological disorders to the extent that the perception of illness might result in psychological stress. According to these authors, the perception of illness implies *behavioral disengagement* and *cognitive distortion*. On the one hand, the *behavioral disengagement* might be an adaptive response to the interference of the disease with social and labor activities, as well as the adoption of unhealthy behaviors that increase the problems associated with physical health, for example, alcoholism, smoking and the abuse of substances. On the other hand, *cognitive distortions* of individuals, such as pessimistic perceptions about their own health, affect behavioral choices and interpersonal transactions, leading to social detachment and negative emotions that would jeopardize their physical health (Cohen & Rodriguez, 1995). Interactions between perceptions, social behaviors, and physical and mental health are dynamic and their negative implications on health outcomes accumulate over the life course of individuals.

This paper focuses on the behavioral argument to assess the problem of health disparities. We stress the importance of a causal mechanism operating through the comorbidity of physical and psychological disorders. Furthermore, we identify this mechanism by estimating the negative effect of pessimistic mortality expectations on the prospective health status. Social science research has dedicated special attention to explain how individuals form subjective expectations about their own mortality and how these expectations affect their lives. As decision-makers, individuals face uncertainty about their future health status and use available information to infer future outcomes (Hurd, 2009). Behaviors and choices are modified in consequence. Since individuals form expectations based on private information and their own circumstances, experiences, and beliefs; then, health and mortality expectations are essentially subjective (Hurd & McGarry, 1995). In the context of the HIV epidemic, Auld (2003) proposes a theoretical model of expectations formation and the intertemporal choice of sexual partners to demonstrate that a pessimistic expectation about the likelihood of being infected increases risky behaviors. On the other hand, Delavande & Kohler (2012) show evidence suggesting that individuals, living in Rural Malawi, modified expectations about being infected after they were informed about their seropositive status and the seropositive status of their spouses. In the context of mortality expectations, health status, and retirement decisions in the US, Hurd & McGarry (2002) evaluate the effect of health shocks (a new diagnosis) and mortality shocks (the death of parent or spouse) on the self-reported health status and the mortality expectations. These authors conclude that health shocks have an effect on mortality expectations and self-reported health, but mortality shocks have only effects on mortality expectations. On the other hand, Bloom et al. (2006) assess the predictive power of subjective survival expectations on wealth and retirement decisions. Using instrumental variables (age and parents' age at death), these authors show that longer lifespans are associated with more accumulation of wealth, but no increase in retirement age.

The purpose of this paper is to investigate the dynamic response of physical and mental health to subjective expectations of mortality and disease, emphasizing the behavioral adaptation to disease. We argue that the perception of physical and mental illness implies a behavioral response producing a negative distortion on the subjective expectations of mortality and health. Given that some individuals may anticipate shorter lifespans, they might assume additional risks that jeopardize their health. We approach the problem from the direct association between physical and mental health, the direct association of symptoms of depression and pessimistic expectations, and the lagged effect of negative perceptions on the physical health.

In this paper, we analyze a longitudinal sample of men and women aged 45+ years living in Malawi that represents one of the poorest environments in sub-Saharan Africa. Most dynamic approaches on health and mortality use evidence from developed countries, where longitudinal data allowing to investigate these perspectives are available. In contrast, the evidence from low and middle income countries is limited, and hence our paper makes an important contribution to understand the link between physical and mental health and their dynamic response to subjective expectations of mortality and disease.

# 2 Data

The sample used for the present analysis comes from the *Malawi Longitudinal Study of Families and Health* (MLSFH; formerly, *Malawi Diffusion and Ideational Change Project*). This longitudinal cohort study began in 1998 with a random sample of 1,745 ever-married women aged 15-49, and 1,519 spouses, who were living in the rural area of three major districts: Mchinji, Balaka, and Rumphi. In 2001, participants were interviewed again, and 331 new spouses were added to the study. In 2004, the original sample was extended to include 1,531 adolescents, and 198 new spouses. For the first time in the study, participants interviewed in

2004 were voluntarily tested for HIV. Blood tests to detect HIV were also administrated in 2006, 2008 and 2012. In 2006, the sample was extended to include 529 new spouses. Ever since 2006, the SF12 questionnaire (*12-Item Short-Form Health Survey*) has been administered. In 2008, the sample was extended to include 826 parents of participants interviewed in previous rounds, and 350 new spouses. The follow-up of 2010 included 299 new spouses. Data collection of 2012 and 2013 follow a subsample of participants aged 45 and above.

Table 1: Cohort profile of mature adults in the MLSFH

| | *2006* | *2008* | *2010* | *2012* | *2013* |
|---|---|---|---|---|---|
| *Eligible Individuals* | 956 | 1,002 | 1,455 | 1,455 | 1,324 |
| *(-)* Temporary Absent / Refusal | 145 | 7 | 6 | 78 | 51 |
| *(-)* Dead | 0 | 0 | 0 | 39 | 23 |
| *(-)* Lost of Follow-Up | 0 | 0 | 0 | 92 | 0 |
| *(+)* New Additions | 46 | 453 | 0 | 0 | 0 |
| *Total Interviewed* | 857 | 1,448 | 1,449 | 1,246 | 1,234 |

The analysis is focused in four consecutive assessments with equal time intervals from 2006 to 2012. We selected a subsample of 1,455 mature adults, aged 45+ in 2012, who were interviewed in 2008 and 2010, as is shown in Table 1. Due to lack of follow-up, a total of 92 respondents were excluded from the analysis. Although these 92 individuals were interviewed in 2008 and 2010, no interview was made in 2012 or 2013, thus we classify them as attrition. On the other hand, individuals who were not interviewed in 2012, but in 2008, 2010 and 2013, were included in the analysis and their information in 2012 is assumed to be missed at random.

The analysis is conditional to survivors living in the areas of data collection. In consequence, we exclude 39 cases due to mortality of the participant, and 16 cases due to permanent migration, as they were documented in 2012 and 2013. Similarly, some cases were not included in the analysis due to incomplete information: 15 cases were excluded because GPS location of the respondent was unknown, 8 additional cases were excluded because the HIV status was unknown, and 11 additional cases were excluded because incomplete information. In sum, the sample analyzed in this paper consists of 542 males and 732 females; this is a total of 1,274 participants. Major concern would exist with the 366 respondents[5] added in 2008 who are included in the analysis and whose information in 2006 is assumed to be missed at random.

[5] According to Table 1, the total number of new additions in 2008 is equal to 453. However, 87 respondents were excluded because incomplete information, selection, or attrition.

Table 2: General descriptive statistics of the sample

| | Males | | Females | |
|---|---|---|---|---|
| | Included | Excluded | Included | Excluded |
| Age | 60.43 | 63.25 | 59.09 | 65.92 |
| | *0.46* | *1.42* | *0.42* | *1.28* |
| Widowed (at least once) | 0.05 | 0.05 | 0.31 | 0.56 |
| | *0.01* | *0.02* | *0.02* | *0.05* |
| Divorced (at least once) | 0.05 | 0.10 | 0.23 | 0.21 |
| | *0.01* | *0.03* | *0.02* | *0.04* |
| Years of schooling | 4.35 | 3.76 | 2.50 | 1.81 |
| | *0.14* | *0.39* | *0.10* | *0.21* |
| HIV prevalence | 0.06 | 0.20 | 0.05 | 0.11 |
| | *0.01* | *0.05* | *0.01* | *0.04* |
| Observations | 542 | 84 | 732 | 106 |

Mean/*standard error of the mean*

On average, respondents included in the analysis at the time of the last interview were 59.66 years old, reported 3.28 years of formal education, and had a prevalence of HIV equal to 5.47%. Other individual characteristics indicate that about 20.01% of the participants had reported to be widowed at least once, and the 15.38% had reported at least one divorce. Given the initial characteristics of the MLSFH as well as the addition of new participants in the study, the group of females is overrepresented in the sample.

As it can be deduced from Table 2, males excluded from the analysis have, on average, a higher prevalence of HIV (significant at 95% level of confidence) compared to males included in the analysis. Similarly, the group of females excluded from the analysis is, on average, significantly older and have reported a higher prevalence of widowhood and less years of formal education compared to the group of females included in the analysis. Table 2 also leads to infer that the group of males included in the analysis is significantly older compared to their female counterparts, report more years of formal education, and shows less prevalence of marital experiences ending in divorce or widowhood.

In this paper, the items used to measure the physical health of the respondents are directly related to the degree of physical limitation and the interference of pain to work and to perform typical activities. Similarly, the items used to measure the mental health are related to symptoms of depression, anxiety, lack of energy, lack of motivation, and the interference of emotions to work and to perform typical activities. Although these measurements do not replace the clinical diagnosis of depression or physical disability, they are convenient measurements for a general population as they encompass a variety of related symptoms. In this paper we approach to the problem of physical and mental health using independent items for each. In consequence, our analysis is concentrated on 10 items of the SF12 questionnaire that were used to compute six scales of the SF12 methodology: *Physical Functioning*, *Bodily Pain*, *Role Physical*, *Mental Health*, *Vitality* and *Role Emotional*. For the purposes of this paper, the scales of *General Health* and *Social Functioning* are not included in the analysis, as they can be equally related to physical and mental health issues. Scales have a range that goes from 0 to 100. A value equal to zero in one of the six dimensions is indicative of a severe compromise of the component, and is associated with a diminished health status.

Two additional variables were analyzed in this paper: *Mortality Expectations* and *Health Expectation*s. The variable of *Mortality Expectations* is a subjective value responding to a probability of dying within a period of five years. Values were collected using an experimental design, counting beans on a scale that goes from 0 to 10 (Kohler et al., 2014). A reported value equal to 10 indicates that the chance of dying within the next 5 years is above 95%. For the purpose of this paper, the variable of *Mortality Expectations* was adjusted to a scale of 0 to 100. Since the variable is reporting numbers on a defined scale, it can be understood as a probabilistic expectation. Compared to a life table, reported values usually overestimate the probabilities of dying (Delavande & Kohler, 2009). However, these subjective probabilities provide information on the uncertainty about the future. On the other hand, the variable of *Health Expectation*s indicates the anticipated deterioration (or improvement) of the health status within the next 12 months. The variable was collected on a scale from 1 to 5. A reported value equal to 1 indicates that health status would improve a lot, and a reported value equal to 5 indicates that the health status would worsen a lot. In the analysis, this variable was adjusted to a scale of 0 to 100. Contrary to the *Mortality Expectations*, the uncertainty about the future health status was not reported on a numerical scale.

Table 3 shows mean values and the standard errors of the means for each wave of data collection. Values are presented by gender. Compared to males, females report lower scores in the group of variables describing health, and higher scores in the case of the health and mortality expectations. Differences in mean values are significant at a level of 5%. There are four exceptions: the probability of dying in 2006 and 2008, the anticipation of a worse health in 2006, and the score of the role emotional in 2006. Since data summarized in Table 1 correspond to an unbalanced panel, changes on mean values from one wave to another might be affected by the composition of the sample. The most substantial change in the sample occurs from 2006 to 2008 with the addition of the new sample of parents.

Table 3: Descriptive statistics of the items used to measure physical and mental health, and mortality and health expectations

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | *2006* | *2008* | *2010* | *2012* | *2006* | *2008* | *2010* | *2012* |
| Physical Functioning (PF) | 91.43 | 90.46 | 80.50 | 85.40 | 87.12 | 82.49 | 71.64 | 74.01 |
| | *1.05* | *0.95* | *1.25* | *1.16* | *1.13* | *1.00* | *1.17* | *1.15* |
| Bodily Pain (BP) | 91.10 | 84.70 | 80.26 | 80.89 | 86.07 | 77.18 | 72.20 | 71.18 |
| | *1.06* | *1.12* | *1.16* | *1.21* | *1.11* | *1.00* | *1.11* | *1.17* |
| Role Physical (RP) | 88.20 | 84.00 | 72.50 | 84.81 | 79.06 | 74.64 | 59.05 | 71.57 |
| | *1.68* | *1.60* | *1.88* | *1.49* | *1.90* | *1.59* | *1.80* | *1.65* |
| Mental Health (MH) | 86.69 | 82.15 | 76.93 | 80.35 | 81.05 | 73.23 | 69.76 | 72.73 |
| | *0.98* | *0.93* | *0.92* | *0.92* | *1.04* | *0.85* | *0.85* | *0.89* |
| Vitality (VT) | 84.90 | 81.98 | 74.33 | 75.99 | 78.98 | 71.74 | 66.83 | 66.45 |
| | *1.14* | *1.01* | *1.12* | *1.09* | *1.12* | *0.95* | *1.00* | *0.99* |
| Role Emotional (RE) | 89.89 | 92.32 | 83.82 | 88.98 | 86.77 | 83.52 | 73.83 | 81.33 |
| | *1.55* | *1.14* | *1.54* | *1.30* | *1.61* | *1.36* | *1.58* | *1.39* |
| Anticipation of a worse health | 34.46 | 27.47 | 32.65 | 39.91 | 35.67 | 34.28 | 37.38 | 44.85 |
| (within the next 12 months) | *1.02* | *1.07* | *0.96* | *1.02* | *1.00* | *0.93* | *0.82* | *0.87* |
| Probability of dying at the | 40.66 | 41.42 | 45.74 | 53.14 | 43.91 | 43.56 | 50.34 | 60.04 |
| time interval $[t, t+5)$ | *1.27* | *1.14* | *1.11* | *1.16* | *1.15* | *1.02* | *0.96* | *0.94* |
| Probability of dying at the | 43.16 | 39.48 | 44.88 | 57.15 | 44.47 | 41.26 | 50.91 | 63.94 |
| time interval $[t+5, t+10)$ | *1.68* | *1.48* | *1.43* | *1.53* | *1.51* | *1.37* | *1.31* | *1.30* |
| Observations | 356 | 541 | 541 | 531 | 429 | 729 | 731 | 707 |

Mean/*standard error of the mean*

Table 4 shows that mean values are also strongly influenced by the age composition of the sample. Regardless of gender and compared to the group of respondents aged 45-59, participants aged 60+ reported lower scores of the different scales used to measure physical and mental health, higher expectations of worst health, and higher probabilities of dying within the next 5 years. However, in the case of the data collected in 2006 and due to fewer observations, comparisons by groups of age are not always significant at convenient levels. Table 4 shows, on the other hand, that regardless of the age group females report lower scores on the health components and higher expectations of mortality and disease, when they are compared to males of similar ages. Yet older individuals report lower values of the health scales and expectations, the age composition is not the leading cause to explain gender differences.

Table 4: Descriptive statistics of the items used to measure physical and mental health, and mortality and health expectations, by age group

| | Males aged 45-59 | | | | Males aged 60+ | | | | Females aged 45-59 | | | | Females aged 60+ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *2006* | *2008* | *2010* | *2012* | *2006* | *2008* | *2010* | *2012* | *2006* | *2008* | *2010* | *2012* | *2006* | *2008* | *2010* | *2012* |
| Physical Functioning (PF) | 94.36 | 94.16 | 88.21 | 92.48 | 86.35 | 86.20 | 71.60 | 77.75 | 87.89 | 89.00 | 79.36 | 83.63 | 83.65 | 72.37 | 59.95 | 59.93 |
| | *1.07* | *0.97* | *1.32* | *1.20* | *2.12* | *1.66* | *2.07* | *1.93* | *1.26* | *1.00* | *1.32* | *1.16* | *2.57* | *1.84* | *1.98* | *2.02* |
| Bodily Pain (BP) | 92.04 | 88.42 | 85.09 | 85.87 | 89.45 | 80.42 | 74.69 | 75.49 | 87.25 | 82.42 | 77.56 | 77.20 | 80.77 | 69.03 | 64.08 | 62.37 |
| | *1.23* | *1.29* | *1.29* | *1.45* | *1.97* | *1.85* | *1.94* | *1.92* | *1.19* | *1.11* | *1.29* | *1.40* | *2.88* | *1.77* | *1.87* | *1.90* |
| Role Physical (RP) | 89.16 | 88.68 | 81.00 | 91.12 | 86.54 | 78.57 | 62.66 | 77.95 | 80.80 | 83.20 | 69.34 | 80.83 | 71.05 | 61.34 | 43.64 | 58.01 |
| | *2.01* | *1.85* | *2.24* | *1.63* | *2.98* | *2.67* | *3.01* | *2.48* | *2.04* | *1.70* | *2.17* | *1.86* | *4.89* | *2.89* | *2.88* | *2.83* |
| Mental Health (MH) | 87.39 | 82.79 | 79.70 | 83.51 | 85.48 | 81.43 | 73.70 | 76.92 | 81.77 | 76.40 | 73.10 | 77.51 | 77.76 | 68.32 | 64.74 | 65.77 |
| | *1.13* | *1.26* | *1.22* | *1.07* | *1.86* | *1.38* | *1.38* | *1.49* | *1.16* | *1.02* | *1.07* | *1.03* | *2.35* | *1.44* | *1.35* | *1.50* |
| Vitality (VT) | 86.50 | 85.25 | 79.03 | 80.89 | 82.12 | 78.20 | 68.93 | 70.69 | 80.00 | 76.56 | 72.09 | 73.27 | 74.35 | 64.14 | 58.83 | 56.53 |
| | *1.30* | *1.24* | *1.35* | *1.31* | *2.14* | *1.60* | *1.76* | *1.72* | *1.24* | *1.11* | *1.22* | *1.13* | *2.53* | *1.60* | *1.58* | *1.64* |
| Role Emotional (RE) | 90.27 | 96.11 | 87.05 | 93.12 | 89.23 | 87.97 | 80.04 | 84.51 | 87.39 | 89.06 | 78.76 | 87.98 | 83.97 | 74.90 | 66.37 | 71.60 |
| | *1.93* | *1.12* | *1.92* | *1.46* | *2.62* | *2.04* | *2.45* | *2.17* | *1.76* | *1.44* | *1.89* | *1.48* | *4.03* | *2.56* | *2.69* | *2.56* |
| Anticipation of a worse health (within the next 12 months) | 32.72 | 25.00 | 28.83 | 35.00 | 37.61 | 30.67 | 37.06 | 45.50 | 35.16 | 32.07 | 33.23 | 40.12 | 37.89 | 38.04 | 44.18 | 51.98 |
| | *1.27* | *1.43* | *1.27* | *1.23* | *1.67* | *1.59* | *1.40* | *1.61* | *1.09* | *1.12* | *0.93* | *0.98* | *2.43* | *1.60* | *1.45* | *1.49* |
| Probability of dying at the time interval $[t, t+5)$ | 36.53 | 40.11 | 42.26 | 50.69 | 48.00 | 43.68 | 49.75 | 55.86 | 42.63 | 42.78 | 46.24 | 59.06 | 49.73 | 46.29 | 56.72 | 61.48 |
| | *1.51* | *1.45* | *1.42* | *1.56* | *2.16* | *1.83* | *1.69* | *1.72* | *1.22* | *1.15* | *1.16* | *1.22* | *3.07* | *2.23* | *1.60* | *1.45* |
| Probability of dying at the time interval $[t+5, t+10)$ | 38.47 | 39.00 | 40.03 | 53.28 | 51.50 | 40.31 | 50.47 | 61.43 | 43.23 | 41.10 | 46.34 | 61.58 | 50.13 | 41.82 | 58.04 | 67.40 |
| | *1.93* | *1.85* | *1.83* | *2.12* | *3.04* | *2.46* | *2.19* | *2.19* | *1.65* | *1.54* | *1.64* | *1.70* | *3.77* | *3.01* | *2.12* | *1.99* |
| Observations | 226 | 285 | 285 | 276 | 130 | 256 | 256 | 255 | 351 | 435 | 438 | 420 | 78 | 294 | 293 | 287 |

Mean/*standard error of the mean*

# 3 Methods

## Measurement of physical health, mental health, and expectations

In this paper, physical health is measured using the scales of *Physical Functioning* (PF), *Bodily Pain* (BP), and *Role Physical* (RP). Particularly, for each period of data collection we define a latent variable of physical health $p$, that is not observed directly but through its effect on the scales of PF, BP, and RP, as shown by equations 1.1, 1.2, and 1.3. From this perspective, the variable of physical health is related to the degree of physical limitation while performing moderate and strenuous physical activities in a typical day of activity, the degree of physical limitation and difficulty while performing work-related activities, and the interference of pain in work-related activities and household duties. If these symptoms were entirely absent, the scales of PF, BP, and RP would be equal to 100, and the score of the physical health would be the highest.

(1.1) $\mathrm{PF}_{i,t} = \alpha_{\mathrm{PF},t} + \beta_{\mathrm{PF}} \cdot p_{i,t} + e_{\mathrm{PF},i,t};$ $\quad e_{\mathrm{PF,i},t} \sim N\left(0, \sigma^2_{\mathrm{PF},t}\right);$ $\quad \beta_{\mathrm{PF}} = 1;$

(1.2) $\mathrm{BP}_{i,t} = \alpha_{\mathrm{BP},t} + \beta_{\mathrm{BP}} \cdot p_{i,t} + e_{\mathrm{BP},i,t};$ $\quad e_{\mathrm{BP},i,t} \sim N\left(0, \sigma^2_{\mathrm{BP},t}\right);$

(1.3) $\mathrm{RP}_{i,t} = \alpha_{\mathrm{RP},t} + \beta_{\mathrm{RP}} \cdot p_{i,t} + e_{\mathrm{RP},t};$ $\quad e_{\mathrm{RP},t} \sim N\left(0, \sigma^2_{\mathrm{RP},t}\right).$

Similarly, we measure the mental health using the scales *Mental Health* (MH), *Vitality* (VT), and *Role Emotional* (RE). As is shown by equations 2.1, 2.2, and 2.3, for each assessment included in the analysis, we define a latent variable of mental health $m$, that is observable as it affects the scales of MH, VT, and RE. In this paper, the variable of mental health is indicative of difficulties finding moments of calm and peace, the lack of energy to perform daily activities, feelings of discouragement and depression, and the degree of emotional limitation to perform work-related activities and duties during a typical day of activity.

(2.1) $\mathrm{MH}_{i,t} = \alpha_{\mathrm{MH},t} + \beta_{\mathrm{MH}} \cdot m_{i,t} + e_{\mathrm{MH},i,t};$ $\quad e_{\mathrm{MH},i,t} \sim N\left(0, \sigma^2_{\mathrm{MH},t}\right);$ $\quad \beta_{\mathrm{MH}} = 1;$

(2.2) $\mathrm{VT}_{i,t} = \alpha_{\mathrm{VT},t} + \beta_{\mathrm{VT}} \cdot m_{i,t} + e_{\mathrm{VT},i,t};$ $\quad e_{\mathrm{VT},i,t} \sim N\left(0, \sigma^2_{\mathrm{VT},t}\right);$

(2.3) $\mathrm{RE}_{i,t} = \alpha_{\mathrm{RE},t} + \beta_{\mathrm{RE}} \cdot m_{i,t} + e_{\mathrm{RE},i,t};$ $\quad e_{\mathrm{RE},i,t} \sim N\left(0, \sigma^2_{\mathrm{RE},t}\right).$

Alternatively, the analysis might use the Physical Composite Score (PCS12), and the Mental Composite Score (MCS12), which are calculated as latent variables using a combination of the eight scales comprising the methodology SF12. However, the methodology SF12 estimates PCS12 and MCS12 through analytic rotation, which generally imposes a covariance structure between physical health and mental health. From this perspective, the covariance of physical and mental health would be equal to zero in the case of orthogonal algorithms, or a maximum covariance in the case of oblique algorithms. On the other hand, from the perspective applied in this paper, in which three independent scales are used to measure physical health and three different scales are used to measure mental health, there is no imposition, a priori, of any correlation between the two variables of interest.

In the case of expectations, we define a factor of health and mortality expectations $q$, as a continuous latent variable affecting the subjective probabilities of dying at two independent time intervals of five years of length, and the anticipation of a worse health status within the next year. Respondents of the MLSFH reported cumulative probabilities of dying at three time intervals starting from the date of the interview: one year, five years, and ten years. Two measurements were computed using this information: *i*) the subjective probability of dying within the next 5 years (as reported); and *ii*) the probability of dying within the following 5 years conditional to survive to the next five years. This is the time period $[t+5, t+10)$. An individual who reports a total of 1 bean out of 10 when asked about the probability of dying within the next five years receives a score of 10.00 out of 100.00 points on the scale of *Mortality Expectation* ($\mathrm{ME}^{\mathrm{I}}$). If the same respondent adds 3 more beans to the probability of dying within the next 10 years, we compute a conditional probability of $(4-1)/(10-1)=3/9$, and the respondent receives a score of 33.33 out of 100 points on the scale of *Mortality Expectation* ($\mathrm{ME}^{\mathrm{II}}$). On the other hand, the expectation of a health status that gets worse a lot during the next 12 months would receive a score of 100 on the scale of HE. The higher the scores of health and mortality expectations the greater is the value of the latent variable measuring expectations $q$.

(3.1) $$\mathrm{ME}^{\mathrm{I}}_{i,t} = \alpha_{\mathrm{ME}^{\mathrm{I}},t} + \beta_{\mathrm{ME}^{\mathrm{I}}} \cdot q_{i,t} + e_{\mathrm{ME}^{\mathrm{I}},i,t}; \qquad e_{\mathrm{ME},i,t} \sim N\left(0, \sigma^2_{\mathrm{ME}^{\mathrm{I}},t}\right);\ \beta_{\mathrm{ME}^{\mathrm{I}}} = 1;$$

(3.2) $$\mathrm{ME}^{\mathrm{II}}_{i,t} = \alpha_{\mathrm{ME}^{\mathrm{II}},t} + \beta_{\mathrm{ME}^{\mathrm{II}}} \cdot q_{i,t} + e_{\mathrm{ME}^{\mathrm{II}},i,t}; \qquad e_{\mathrm{ME}^{\mathrm{II}},i,t} \sim N\left(0, \sigma^2_{\mathrm{ME}^{\mathrm{II}},t}\right);$$

(3.3) $$\mathrm{HE}_{i,t} = \alpha_{\mathrm{HE},t} + \beta_{\mathrm{HE}} \cdot q_{i,t} + e_{\mathrm{HE},i,t}; \qquad e_{\mathrm{HE},i,t} \sim N\left(0, \sigma^2_{\mathrm{HE},t}\right).$$

Although intercepts $\alpha$ and the variance of the measurement errors $\sigma^2$ vary over time, factor loadings $\beta$ are constrained to be the same values from 2006 to 2012. This condition implies that $p$, $m$, and $q$ are standardized on each period of data collection, and their expected values are always equal to zero. The specification of the model also assumes that measurement errors $e_{\mathrm{h},i,t}$ are uncorrelated from each other, thus the $Cov\left[e_{h,i,t}, e_{k,j,s}\right] = 0\ \forall\ i \neq j, t \neq s, h \neq k$.

# 4 Identification and Estimation

The system of equations presented in Section 3 describes the measurement component of the model. In Section 4, we discuss some structural restrictions and estimation strategies used to identify the dynamic response of physical and mental health. The equations of the measurement component and the structural component are estimated simultaneously through Maximum Likelihood, using the statistical package Mplus7.11. In particular, the scales of Physical

Functioning (PF), Bodily Pain (BP), Role Physical (RP), Mental Health (MH), Vitality (VT), and Role Emotional (RE), Mortality Expectations ($ME^{I}$ and $ME^{II}$), and Health Expectation (HE), were assumed as continuous variables. Although some of them have a broad number of categories that would not make it possible to estimate the model as one of multiple categorical variables, the dispersion of the data shows important discontinuities. In this case, some sacrifice of efficiency is expected to happen on the estimation. The Maximum Likelihood estimation of a Structural Equation Model (SEM) has some advantages. The first advantage is the estimation of factor loadings given that some reported variables may have some degree of measurement error. The second advantage is that we can estimate the model without sacrificing the observations that have missing values in the endogenous variables. This means that no imputation is necessary and the model simply maximizes over the conditional expectation of the endogenous variables. Both advantages are discussed in the literature of SEM.

In this paper, we investigate the dynamic of physical and mental health and the effect of subjective expectations of mortality and disease. In this regard, we propose a variety of models and identification strategies emphasizing the behavioral adaptation to disease. Our first approach then, is to estimate a model of cross-lagged effects between physical and mental health. As shown in equations 4.1.1 and 4.1.2, and given a longitudinal data, we are able to represent an autoregressive model assuming the current status of physical and mental health depend on early assessments of the same variables. From this perspective, we do not impose any theoretical framework to specify the model. However, we constrain the effect of lagged information to be always the same at any point of time.

(4.1.1) $m_{i,t} = \delta_{11} \cdot m_{i,t-2} + \delta_{12} \cdot p_{i,t-2} + \epsilon_{m,i,t}; \quad \epsilon_{m,i,t} \sim N(0, \sigma_m^2);$

(4.1.2) $p_{i,t} = \delta_{21} \cdot m_{i,t-2} + \delta_{22} \cdot p_{i,t-2} + \epsilon_{p,i,t}; \quad \epsilon_{p,i,t} \sim N\left(0, \sigma_p^2\right).$

Under the assumption of no theoretical constraints involved, the coefficient $\delta_{11}$ measures the effect of early assessments of mental health on the current status controlling for the previous status of physical health, $\delta_{12}$. Similarly, the coefficient $\delta_{22}$ captures the effect of previous information of physical health controlling for the potential effect of the early assessment of mental health. The identification strategy that we impose is to constrain the lagged effect of mental health to be zero in the equation of physical health ($\delta_{21} = 0$), and to estimate correlated errors to model the endogenous relation between physical and mental health. Hence, the $Cov\left[\epsilon_{m,i,t}, \epsilon_{p,j,s}\right] \neq 0 \;\forall\; i = j, t = s$. The system of equations 4.1.1 and 4.1.2 has a path diagram representation shown in Figure 1.

Figure 1: Longitudinal design of cross-lagged effects between four assessments of physical health $p$, mental health $m$

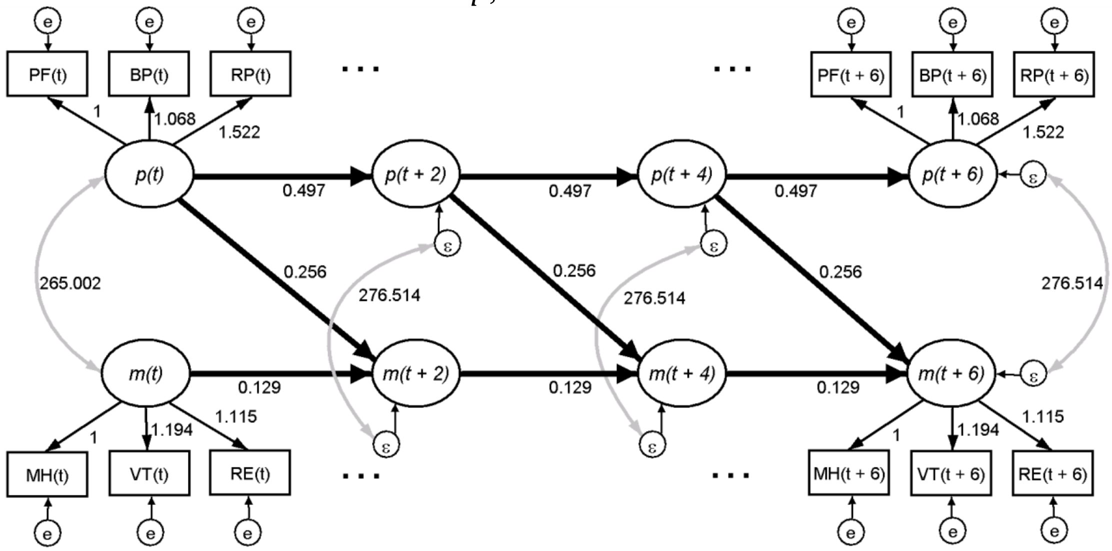



Table 5 shows the estimated coefficients of the model described in equations 4.1.1 and 4.1.2. In summary, early assessments of physical health have a moderated effect on the current status of the same variable, and also a smaller effect on the current status of mental health. The model of cross-lagged effects allows two types of testing: in the first place, we are allowed to test a reciprocal effect between physical and mental health by evaluating the significance of the coefficient $\delta_{12}$, which is reduced, but also positive and significant. In a second place, we are allowed to test the significance of the covariance of the errors.

Table 5: A model of cross-lagged effects between physical and mental health

| | Physical Health *(t+2)* | Mental Health *(t+2)* |
|---|---|---|
| *Lagged Effects* | | |
| Physical Health *(t)* | 0.497 | 0.256 |
| | *0.021* | *0.054* |
| Mental Health *(t)* | 0.000 | 0.129 |
| | - | *0.064* |
| *Variances and Covariances of the Errors* | | |
| Physical Health | 338.936 | 276.514 |
| | *21.314* | *9.544* |
| Mental Health | 276.514 | 262.723 |
| | *9.544* | *17.426* |
| *Measurement Component* | | |
| Physical Functioning (PF) | 1.000 | |
| | *0.000* | |
| Bodily Pain (BP) | 1.068 | |
| | *0.019* | |
| Role Physical (RP) | 1.522 | |
| | *0.030* | |
| Mental Health (MH) | | 1.000 |
| | | *0.000* |
| Vitality (VT) | | 1.194 |
| | | *0.022* |
| Role Emotional (RE) | | 1.115 |
| | | *0.030* |

Coefficient/*standard error*

Although the strong correlation ($> .9$) might support the appraisal of the endogenous specification of physical and mental health even controlling for early assessments of the same variables, that linear dependency of the error term can be indicative of specification problems such as omitted variables equally affecting the physical and the mental health status. The Markovian model proposed in equations 4.1.1 and 4.1.2 can be extended to control for individual heterogeneity. The addition of fixed or random effects, in both equations, produces estimates of the coefficient $\delta_{hk}$ that are unrelated (orthogonal) to a vector of unobserved fixed characteristics $v$.

We argue that the dynamic of physical and mental illness implies a behavioral response. The intuition is as follow: On the one hand, health shocks affecting the physical health $\epsilon_p$ also have an instantaneous effect on the mental health status that is attenuated or intensified by a proportion $\gamma_1$. If significant, this effect is supported by the emotional response of physical distress and the comorbidity of physical and mental illness. On the other hand, health shocks affecting the mental health $\epsilon_m$ would take some time to produce an effect on the physical status that is attenuated or intensified by a proportion $\gamma_2$. If significant, this effect is supported by the adaptive response of individuals and the health behaviors adopted to endure physical and mental illness. In this regard, we propose a second identification strategy assuming physical health has a direct effect on mental health, but the effect of early assessments of mental health has only a lagged effect on physical health, as shown in equations 4.2.1 and 4.2.2.

(4.2.1) $m_{i,t} = \gamma_1 \cdot p_{i,t} + v_i + \epsilon_{m,i,t}; \qquad \epsilon_{m,i,t} \sim N(0, \sigma_m^2);$

(4.2.2) $p_{i,t} = \gamma_2 \cdot m_{i,t-2} + v_i + \epsilon_{p,i,t}; \qquad \epsilon_{p,i,t} \sim N\left(0, \sigma_p^2\right);$

$$E[v_i] = 0; \qquad Var[v_i] = \sigma_v^2;$$

$$Cov\left[\epsilon_{m,i,t}, \epsilon_{p,j,s}\right] = 0 \ \forall \ i \neq j, t \neq s.$$

The system of equations 4.2.1 and 4.2.2 has a path diagram representation shown in Figure 2 and implies the following interpretation: controlling for individual heterogeneity, individuals with diminished physical health, manifested in physical disability and bodily pain, would also experience some level of frustration and emotional discomfort in their lives expressed in higher levels of symptoms related to feelings depression and discouragement. This association, measured by the coefficient $\gamma_1$, is mainly explained by the comorbidity effect and the pass-through of physical limitations to emotional perceptions about their own health. On the other hand, our identification strategy implies that any change in the mental health status might have a lagged response on the physical health, as a consequence of an adaptive behavior responding to health and disease. This effect is measured by the coefficient $\gamma_2$.

Figure 2: Longitudinal design of four assessments of physical health $p$, mental health $m$, assuming physical health has a contemporaneous effect on mental health, but mental health has a lagged effect on physical health

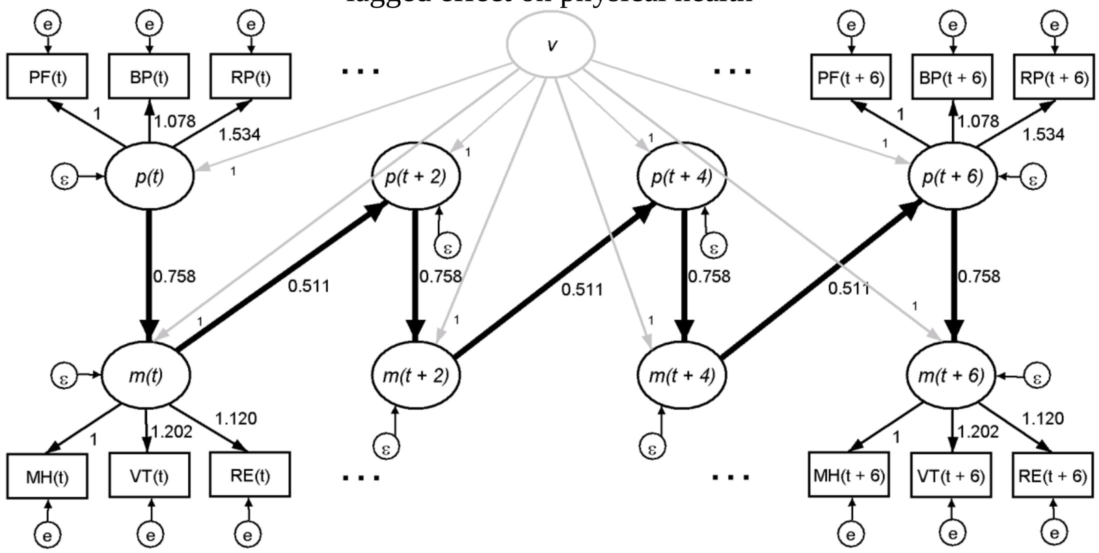



Table 6 shows the estimated coefficients of the model described in equations 4.2.1 and 4.2.2. The analysis also includes coefficients by gender, and by gender and age groups. However, we constrain the factor loadings to take the same values of the measurement component for all individuals in sample. In general, the effect of physical health on mental health is strong and significant. For the population in sample, a health shock of physical health equal to one unit also has a slightly attenuated impact of 0.758 units on the mental health status. This effect exhibits some degree of age variation but not by gender. Conversely, the effect of mental health on physical health is moderated and exhibits substantial variations by age in the case of the females. The range of estimated values goes from 0.182 units for females aged 45-59, to 0.852 units in the case of females aged 60+. For the mature adults of rural Malawi, this result provides some evidence of a general pattern of comorbidity between physical and mental health and an idiosyncratic response to health shocks that is related to the age of the respondents.

Table 6: The dynamic response of physical and mental health

| *Structural Component* | All | Males | Females | Males 45-59 | Males 60+ | Females 45-59 | Females 60+ |
|---|---|---|---|---|---|---|---|
| $\gamma_1$ | 0.758 | 0.776 | 0.749 | 0.869 | 0.703 | 0.782 | 0.716 |
| | *0.018* | *0.027* | *0.020* | *0.040* | *0.032* | *0.026* | *0.026* |
| $\gamma_2$ | 0.511 | 0.552 | 0.482 | 0.523 | 0.502 | 0.182 | 0.852 |
| | *0.032* | *0.050* | *0.040* | *0.065* | *0.071* | *0.046* | *0.064* |
| *Variances of the Errors* | | | | | | | |
| $\sigma_v^2$ | 3.869 | 4.141 | 3.772 | 1.022 | 7.679 | 5.495 | 1.669 |
| | *1.730* | *2.590* | *2.397* | *2.376* | *4.666* | *2.709* | *4.628* |
| $\sigma_p^2$ | 356.957 | 278.892 | 415.362 | 177.232 | 403.401 | 292.163 | 566.536 |
| | *14.257* | *15.895* | *19.642* | *14.248* | *30.041* | *16.998* | *40.249* |
| $\sigma_m^2$ | 37.356 | 26.836 | 45.125 | 16.025 | 41.294 | 43.805 | 48.667 |
| | *3.897* | *5.070* | *5.263* | *6.343* | *7.917* | *6.318* | *8.859* |
| *Measurement Component* | | | | | | | |
| Physical Health | | | | | | | |
| $\beta_{\text{PF}}$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| $\beta_{\text{BP}}$ | 1.078 | 1.076 | 1.076 | 1.066 | 1.066 | 1.066 | 1.066 |
| | *0.020* | *0.020* | *0.020* | *0.019* | *0.019* | *0.019* | *0.019* |
| $\beta_{\text{RP}}$ | 1.534 | 1.535 | 1.535 | 1.517 | 1.517 | 1.517 | 1.517 |
| | *0.030* | *0.030* | *0.030* | *0.030* | *0.030* | *0.030* | *0.030* |
| Mental Health | | | | | | | |
| $\beta_{\text{MH}}$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| $\beta_{\text{VT}}$ | 1.202 | 1.197 | 1.197 | 1.197 | 1.197 | 1.197 | 1.197 |
| | *0.022* | *0.022* | *0.022* | *0.022* | *0.022* | *0.022* | *0.022* |
| $\beta_{\text{RE}}$ | 1.120 | 1.124 | 1.124 | 1.122 | 1.122 | 1.122 | 1.122 |
| | *0.030* | *0.030* | *0.030* | *0.031* | *0.031* | *0.031* | *0.031* |

Coefficient/*standard error*

We argue that the behavioral response affecting the dynamic of physical and mental health operates through the formation of expectations related to mortality and the prospective health status. The theoretical argument behind the third identification strategy establishes that individuals adapt their personality in response to stressful life events. Thus, individuals embrace specific conducts in how they control and plan their lives (Link, Lennon & Dohrenwend, 1993). Pessimistic perceptions of the prospective health status affect behavioral choices of individuals (Cohen & Rodriguez, 1995). In consequence, when a shorter lifespan is expected due to health related issues, individuals might respond in different ways: *i*) by adopting a sort of preventive actions to reduce or neutralize the negative shocks affecting the health status; or *ii*) by assuming unhealthy behaviors that increase the problems associated with physical health.

$$(4.3.1)\quad m_{i,t} = \alpha_1 \cdot p_{i,t} + v_i + \epsilon_{m,i,t}; \qquad \epsilon_{m,i,t} \sim N(0, \sigma_m^2);$$

$$(4.3.2)\quad q_{i,t} = \alpha_2 \cdot m_{i,t} + v_i + \epsilon_{q,i,t}; \qquad \epsilon_{q,i,t} \sim N\left(0, \sigma_q^2\right);$$

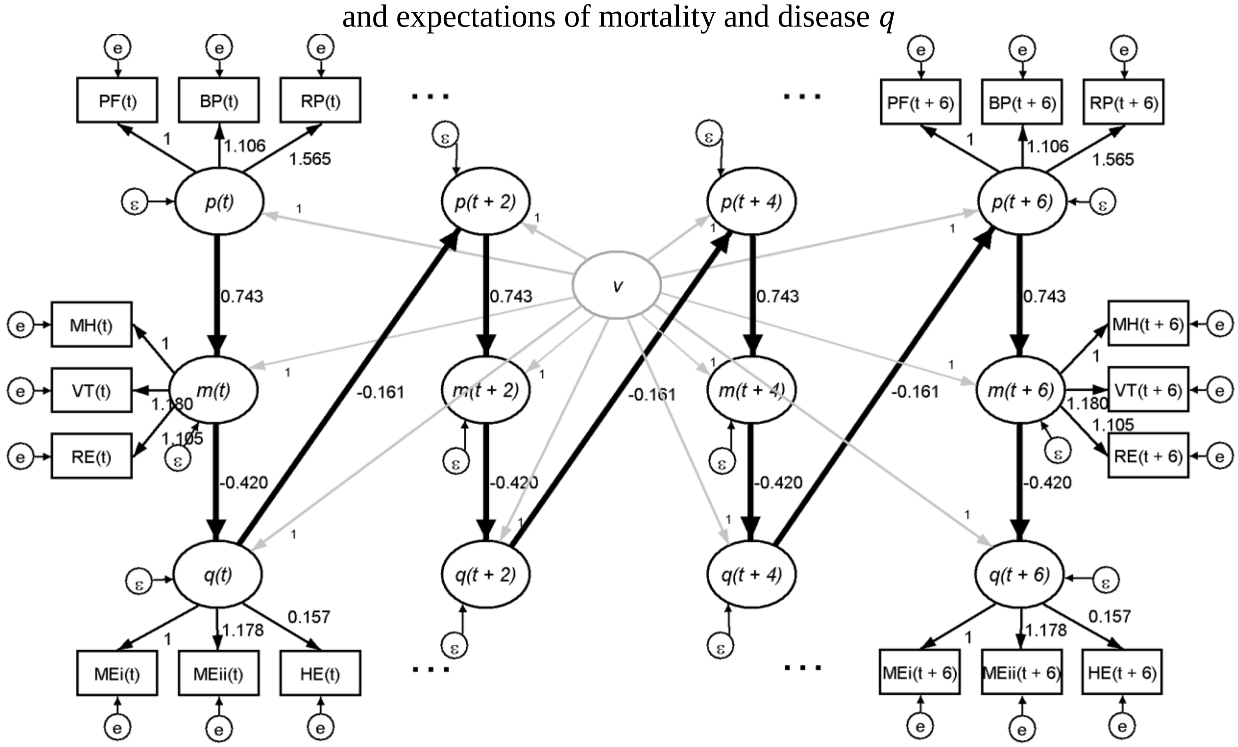
$$(4.3.3)\quad p_{i,t} = \alpha_3 \cdot q_{i,t-2} + v_i + \epsilon_{p,i,t}; \qquad \epsilon_{p,i,t} \sim N\left(0, \sigma_p^2\right);$$

$$E[v_i] = 0; \qquad Var[v_i] = \sigma_v^2;$$

$$Cov\left[\epsilon_{h,i,t}, \epsilon_{k,j,s}\right] = 0 \; \forall \; h \neq k, i \neq j, t \neq s.$$

The third identification strategy implies a contemporaneous effect of physical health on mental health, and a dynamic response of the physical component to changes in mental health through the formation of mortality and health expectations. In summary, we assume that, controlling for individual heterogeneity $v$, the symptoms of physical limitation $p$, have a direct effect $\alpha_1$, on mental health $m$. Additionally, symptoms of depression and anxiety have a direct effect $\alpha_2$, on the formation of expectations. However, the effect of health and mortality expectations on physical health $\alpha_3$, operates with a lag of one period length, as shown in equations 4.3.1, 4.3.2, and 4.3.3. The path diagram of the third identification strategy is described in Figure 3.

Figure 3: Longitudinal design of four assessments between physical health $p$, mental health $m$, and expectations of mortality and disease $q$




The argument behind this approach emphasizes the adaptive response of an individual to changes in his/her health status. There exists a direct link between the deterioration of physical health and the emotional component $(\alpha_1 > 0)$. However, the deterioration of mental health related symptoms of depression and anxiety only has an effect on the status of physical health if individuals change their behavior. A deterioration in the emotional component leads to an adaptive response to the extent that individuals have less control, direction and planning of their lives, which could be manifested by a more pessimistic perception of their life expectancies $(\alpha_2 < 0)$. In consequence, a shorter planning horizon affects physical health through two types of adaptation: *i*) individuals could adopt healthier habits that allow them to compensate the decline in physical and mental health $(H_o\colon \alpha_3 \geq 0)$ ; or *ii*) individuals could adjust their behavior to a reduced life expectancy, and therefore assume additional risks and unhealthy behaviors that would amplify the deterioration of their physical and mental health $(H_a\colon \alpha_3 < 0)$.

Table 7: The dynamic response of physical and mental health to expectations of mortality and disease

| *Structural Component* | All | Males | Females | Males 45-59 | Males 60+ | Females 45-59 | Females 60+ |
|---|---|---|---|---|---|---|---|
| $\alpha_1$ | 0.743 | 0.742 | 0.740 | 0.815 | 0.690 | 0.791 | 0.687 |
| | *0.017* | *0.026* | *0.019* | *0.040* | *0.031* | *0.026* | *0.023* |
| $\alpha_2$ | -0.420 | -0.525 | -0.359 | -0.599 | -0.417 | -0.312 | -0.456 |
| | *0.027* | *0.045* | *0.033* | *0.065* | *0.061* | *0.042* | *0.050* |
| $\alpha_3$ | -0.161 | -0.195 | -0.142 | -0.177 | -0.175 | -0.006 | -0.394 |
| | *0.023* | *0.031* | *0.032* | *0.035* | *0.052* | *0.031* | *0.061* |
| *Variances of the Errors* | | | | | | | |
| $\sigma_v^2$ | 14.227 | 16.442 | 13.914 | 12.259 | 17.713 | 7.346 | 24.583 |
| | *2.113* | *3.375* | *2.818* | *3.512* | *5.322* | *2.439* | *6.406* |
| $\sigma_p^2$ | 382.648 | 294.620 | 444.193 | 185.072 | 424.674 | 290.516 | 692.335 |
| | *16.316* | *17.884* | *21.846* | *15.920* | *32.378* | *17.202* | *50.084* |
| $\sigma_m^2$ | 39.137 | 30.727 | 46.049 | 19.418 | 44.389 | 46.483 | 43.878 |
| | *3.919* | *5.164* | *5.244* | *6.458* | *8.061* | *6.375* | *8.249* |
| $\sigma_q^2$ | 439.276 | 446.319 | 430.378 | 401.718 | 484.604 | 399.258 | 479.366 |
| | *22.672* | *27.639* | *23.753* | *29.370* | *35.994* | *23.439* | *36.832* |
| *Measurement Component* | | | | | | | |
| Physical Health | | | | | | | |
| $\beta_{\mathrm{PF}}$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| $\beta_{\mathrm{BP}}$ | 1.106 | 1.106 | 1.106 | 1.090 | 1.090 | 1.090 | 1.090 |
| | *0.021* | *0.021* | *0.021* | *0.020* | *0.020* | *0.020* | *0.020* |
| $\beta_{\mathrm{RP}}$ | 1.565 | 1.569 | 1.569 | 1.545 | 1.545 | 1.545 | 1.545 |
| | *0.032* | *0.032* | *0.032* | *0.031* | *0.031* | *0.031* | *0.031* |
| Mental Health | | | | | | | |
| $\beta_{\mathrm{MH}}$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| $\beta_{\mathrm{VT}}$ | 1.180 | 1.176 | 1.176 | 1.178 | 1.178 | 1.178 | 1.178 |
| | *0.220* | *0.021* | *0.021* | *0.022* | *0.022* | *0.022* | *0.022* |
| $\beta_{\mathrm{RE}}$ | 1.105 | 1.108 | 1.108 | 1.109 | 1.109 | 1.109 | 1.109 |
| | *0.030* | *0.030* | *0.030* | *0.030* | *0.030* | *0.030* | *0.030* |
| Mortality and Health Expectations | | | | | | | |
| $\beta_{\mathrm{ME^{I}}}$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| $\beta_{\mathrm{ME^{II}}}$ | 1.178 | 1.181 | 1.181 | 1.196 | 1.196 | 1.196 | 1.196 |
| | *0.050* | *0.050* | *0.050* | *0.047* | *0.047* | *0.047* | *0.047* |
| $\beta_{\mathrm{HE}}$ | 0.157 | 0.157 | 0.157 | 0.161 | 0.161 | 0.161 | 0.161 |
| | *0.018* | *0.018* | *0.018* | *0.018* | *0.018* | *0.018* | *0.018* |

Coefficient/*standard error*

Estimated coefficients of the model described in equations 4.3.1, 4.3.2, and 4.3.3 are shown in Table 7. As a general characteristic, a negative shock affecting the physical health will also have a negative impact on mental health. For the sample of mature adults, this effect is estimated to be 0.743. The result suggests that symptoms of depression are more likely to be reported by individuals affected by some degree of physical pain and disability. The effect is marginally higher in the case of individuals aged 45-49 compared to individuals aged 60+ regardless of their gender.

Health shocks affecting the mental health will also have some moderated effect on the expectations of mortality and disease. Other things constant, individuals reporting symptoms of depression are more likely to expect shorter lifespans and are more likely to anticipate some degree of health deterioration. Thus, a reduced mental health status is related with more pessimistic views about future health and survival. Controlling for individual heterogeneity, a negative shock reducing the mental health status in one unit would also increase the expectations of mortality and disease in 0.420 units. However, the parameter $\alpha_2$ exhibits substantial differences by gender, and by gender and age. On the one hand, the response of males is significantly higher but decreases with age. On the other hand, the response of females increases with age.

Pessimistic views about health and mortality have a negative impact on the prospective status of physical health. The effect of mortality expectations on the prospective status of physical health is estimated to be -0.161. The parameter $\alpha_3$ is smaller but significant. In general, this result implies that the adaptive response of mature adults living in Rural Malawi is to adjust their behaviors to a shorter horizon of planning, something that would amplify the deterioration of their physical and mental health. Although this parameter exhibits small variations by gender, age differences are prominent in the case of females, thus suggesting different pathways of adaptation. Compared to the group of females aged 60+, the adaptive response of females aged 45-59 shows no significant effect of mortality expectations on physical health suggesting that females aged 45-59 compensate a negative shock of health by adopting healthy behaviors.

# 5 Discussion

In this paper we investigate health disparities of a sample of mature adults living in rural Malawi. We approach the problem from the perspective of a dynamic response of physical and mental health, thus prospective status of physical and mental health would depend on earlier assessments of the same variables. We argue that this dynamic response implies a behavioral adaptation to negative health shocks. We identify this mechanism imposing structural constraints in our model: *i*) health shocks affecting mental health would take more time to produce a response in physical health; *ii*) to produce a response in physical health, mental health shocks might operate through the expectations of mortality and disease.

We argue that subjective expectations of mortality and disease are related to health behaviors as these expectations are indicative of the planning horizon of the individuals, and how they modify their choices. On the one hand, to live a longer life would demand the right choices of health-related behaviors. On the other hand, a pessimistic view of the probability of dying certainly affects intertemporal choices, thus individuals diminish the potential gains of adopting healthier behaviors. The main contribution of this paper is to provide some evidence supporting this argument in one of the poorest environments in sub-Saharan Africa.

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