Can time heal all wounds?
An empirical assessment of adaptation to functional limitations

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ABSTRACT

Self-reported satisfaction with life and health are key variables in economic evaluations of health policies. Individuals with a similar objective health may differ in their subjective assessment because of time-invariant traits, but ratings will also differ *within* one individual over time if one adapts to disabilities. However, to date there is little empirical evidence to which extent these variables are influenced by adaptation to enduring bad health. This paper studies adaptation to chronic disability in 5000 respondents of the Survey of Health, Ageing and Retirement in Europe (SHARE) who develop disabilities during the span of the 6 waves of data collection. In order to examine the effect of time since the onset of disability on self-perceived health and life satisfaction, a fixed effects ordered logit model is used. We found evidence supporting adaptation in life satisfaction, but not in self-perceived health. This difference may be explained by the contextualization of the response variables, where the question on self-perceived health is more focused on health limitations and the question on life satisfaction on general well-being.

KEY WORDS: adaptation, disability, self-perceived health, life satisfaction, fixed effects ordered logit

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1. Introduction

Attributing effects to interventions requires randomized controlled studies, but often large scale observational data is used to infer causal relationships. An issue in those studies is the natural course of disease and the way that is manifested in the primary outcome of interest. Chronic diseases and functional limitations may have serious and persistent consequences for one's life satisfaction or quality of life (QoL). Over time, however, the negative impact of chronic conditions and functional limitations on QoL may diminish, a process we will describe as 'adaptation'. This paper quantifies the size and timing of the effect of adaptation in patients with disabilities to help the interpretation of uncontrolled prospective or retrospective studies. This paper investigates the occurrence of adaptation in patients with disabilities and aims to identify if individuals return to or possibly exceed previously reported levels of life satisfaction and self-reported health.

Within health care, QoL of patients is an important outcome measure to assess quality of care and effectiveness of interventions. While adaptation may be seen as a remarkable display of human resilience, it is often considered a 'problem' from a measurement perspective. Measurement of QoL may be biased in observational studies due to adaptation, potentially causing misleading conclusions. In the context of cost-utility analysis - a key method for priority setting in health care resource allocation - adaptation to self-reported QoL has been the source of continuous debate regarding the normative discussion whose values are the appropriate maximand in economic evaluations (for recent contributions see Versteegh and Brouwer (2016) and Brazier et al. (2017)). There is, however, relatively little known about adaptation. For instance, how long after the onset of a disease does it take before the adaptation starts? And are self-reported measures of life satisfaction and health affected equally? Sufficient longitudinal data, including information on the relevant outcome variables, has only become available relatively recently to allow studying this question.

Adaptation may result in individuals' reconceptualization of QoL, changing values, or changing internal standards, a process referred to as response shift (Peeters & Stiggelbout, 2013; Sprangers & Schwartz, 1999). The first two elements of response shift correspond to a true change in subjective QoL. They require one to rethink the dimensions that comprise QoL (including non-health-related dimensions) or to revalue these dimensions (putting more weight on non-health-related dimensions). Alternatively, a change in internal standards refers to a change in the interpretation of the scale on which QoL is measured over time, also deemed scale recalibration (Ubel, Peeters, & Smith, 2010). Some have argued that scale recalibration should be seen as measurement error and not as part of the effect of adaptation. Particularly in the context of health economic decision making, scale recalibration may not be desirable, since only a true change in subjective QoL is of interest. While we acknowledge the meaningful distinction between these three drivers of response shift, we here refer to 'adaptation' as the umbrella term for the cause of reporting higher levels of life satisfaction and self-reported health as we do not have the data to distinguish between the three.

Prior studies do not provide unambiguous support for the occurrence or level of adaptation to ill-health. Lucas (2007) does not find any adaptation of life satisfaction to disability in two large panel data sets while Oswald and Powdthavee (2008) find a considerable level of adaptation using one of these data sets but a different econometric specification. Following the specification of Oswald and Powdthavee (2008), McNamee and Mendolia (2014) observe some adaptation to chronic pain for women, but none for men. Cubí-Mollà, Jofre-Bonet, and Serra-Sastre (2016) provide evidence for adaptation after a relatively long duration of 20 years in self-assessed health, making use of a fixed effects probit model. The differences in results from the abovementioned studies might be caused by i) differences in the target population (e.g. adaptation could differ per health condition or per age group), ii) the methods or iii) the difference in response variable (life satisfaction or self-assessed health).

This paper contributes to and extends the existing adaptation literature by, first of all, analyzing adaptation in both self-perceived health and life satisfaction. Thus, we shed light on whether these two response variables are equally sensitive to adaptation, which potentially explains part of the ambiguity surrounding adaptation results from prior studies. Secondly, this paper is the first to use a long-standing disability scale as an indicator of ill-health: the Instrumental Activities of Daily Living (IADL) measure within a population experiencing chronic illness. The main advantage of using IADL compared to the (medically) diagnosed chronic illness (used by Cubí-Mollà et al. (2016)) is that one is more likely to adapt to the functional limitations caused by chronic illness than to "the feeling of being chronically ill". The main advantage of using the IADL scale instead of more simple questions about disability (Lucas, 2007; Oswald & Powdthavee, 2008) is that the IADL scale is less prone to justification bias. Finally, the IADL scale used here ranges from 0 (not disabled) to 7 (most disabled), so that like the measure in Lucas (2007) but unlike those in Oswald and Powdthavee (2008), McNamee and Mendolia (2014) and Cubí-Mollà et al. (2016), the latent health of those in ill-health is not assumed to stay constant. In sum, this paper sheds light on adaptation by empirically assessing the trajectory of self-reported health and life satisfaction levels after the onset of functional limitations.

2. Methods

2.1. Data

We use data from the Survey of Health, Ageing and Retirement in Europe (SHARE). We use data from all 18 European countries and Israel and all 5 regular waves between 2004 and 2015 (i.e. excluding wave 3, which was about the respondent's life history). Individuals of 50 years and over at the time of sampling were asked to participate, whereas their spouse was asked to participate regardless of his or her age.

The total number of observations in these five waves is 260,244. Of these, we select individuals who i) had no IADL limitations when they were first interviewed, ii) subsequently developed one or more IADL limitations, iii) remained disabled and iv) reported having at least one chronic illness from a list of 14 common chronic diseases at any point during and (if applicable) before the onset of the limitations. This leaves us with 15,826 (6.1%) observations for the main analysis of life satisfaction and self-perceived health.

2.2. Variables

The life satisfaction measure is obtained by the question: "*On a scale from 0 to 10 where 0 means completely dissatisfied and 10 means completely satisfied, how satisfied are you with your life?*" which was asked in waves 2, 4, 5 and 6. The question on self-perceived health is posed as "how would you describe your health in general?", with five answer categories: Poor, Fair, Good, Very good and Excellent. Wave 3 did not contain this and is excluded.

We measure disability through the validated IADL scale (Graf, 2007). The IADL limitations are a good objective health measure because they measure a wide range of limitations that occur frequently among the elderly and that are essential for living independently. The three main independent variables are an indicator of having at least one IADL limitation, the number of IADL limitations and the duration: the time since the onset of these limitations. The activities included in IADL are: using a map to figure out how to get around in a strange place, preparing a hot meal, shopping for groceries, making telephone calls, taking medications, doing work around the house or garden, managing money, such as paying bills and keeping track of expenses, leaving the house independently and accessing transportation services and doing personal laundry.

We measure duration as follows. If an individual reports to have a disability in a particular wave, but not in the preceding wave, the duration is approximated by the time in years between these two waves divided by two. If the individual has already reported chronic limitations for more than one wave, the full length in years between the current and preceding wave is added to the previously recorded duration. Subsequently, duration is split up in four dummy variables, since the effect of duration may be nonlinear. The dummy categories represent whether there is no disability, whether the onset of the disability is reported within the past 2 years (1 wave), between 2.1 and 5.5 years (2 waves) or more than 5.5 years ago (more than 2 waves). This division is chosen because it corresponds to the number of waves spend with disability. For example, the category for the onset of a chronic disability within the past 2 years includes all the individuals that indicate to have chronic limitations for the first time and excludes those that have had a disability for more than 1 wave or that have no disability at all.

The fixed effects in our specification absorb the impact of characteristics and circumstances that do not change in the short run for an elderly population, including personality traits, level of education and the country in which the respondent lives. Additionally, we control for *time-variant* socioeconomic characteristics that may be correlated with and affect an individual's life satisfaction. Following Clark, D'Ambrosio, and Ghislandi (2016) and Cubí-Mollà et al. (2016), we control for marital status , employment status, the number of children and household income . We do not control for variables on healthcare use, which may be "bad controls" as they may (in part) be affected by the functional limitations.

2.3 **Descriptive statistics**

Figures 1 and 2 depict the concentration of life satisfaction and self-reported health for four subgroups of respondents ranked by duration of IADL limitations. These two figures highlight that i) there are relatively few people in the lowest categories of life satisfaction and in the highest categories of self-perceived health for all subgroups, ii) those with IADL limitations score lower than those who have no IADL limitations yet, but iii) those with enduring IADL limitations appear to return to pre-onset levels for life satisfaction but not for self-reported health.

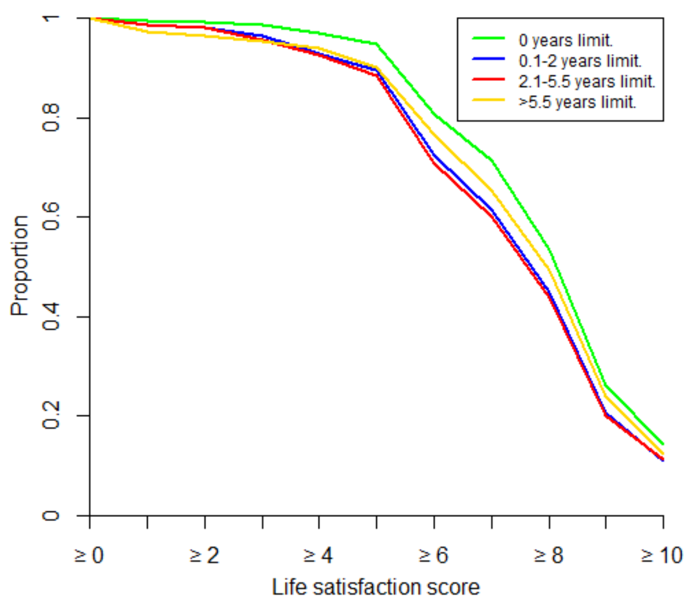

Figure 1: Life satisfaction scores displayed for different disability durations

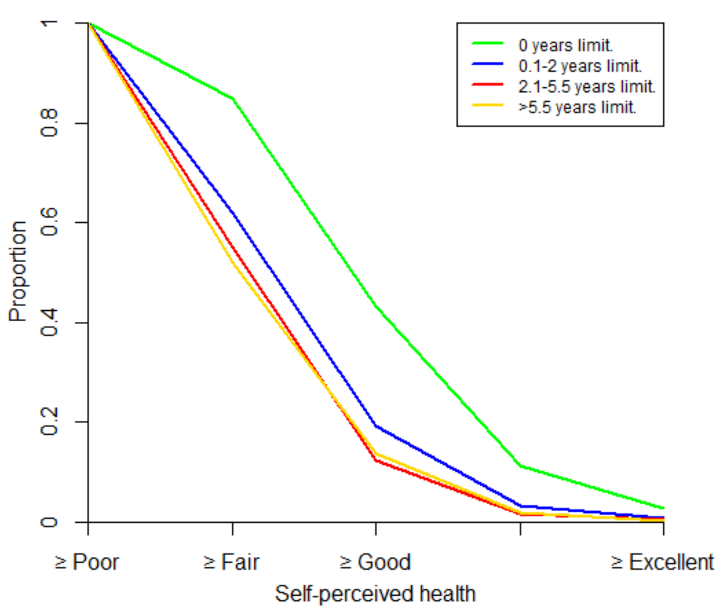

Figure 2: Self-perceived health displayed for different disability durations

Half of the selected observations are individuals with disabilities and 83% has a chronic illness (table 1). The average *number* of limitations with IADL is 2.4 and the average duration of having IADL limitations is 2 years. Furthermore, approximately 41% is male, 62% is married and 70% is retired (mean age is 72 years).

Table 1[1]: Descriptive statistics

Variable	Definition	Mean	Standard deviation
Incidence of IADL limitations		0.451	
Incidence of chronic illness		0.832	
Number of IADL limitations		2.436	2.022
Duration of chronic disability		2.000	1.653
Marital status	0 = Married/registered partnership (reference category)	0.617	
	1 = Not married	0.383	
Employment	1 = Retired (reference category)	0.699	
	2 = Employed	0.086	
	3 = Unemployed	0.022	
	4 = Inactive	0.193	
Log household income	Logarithm of household income	9.566	1.490
Number of children		2.275	1.529
Number of subjects	5341		
Number of observations	15826		

[1]The descriptive statistics in this table are based on the first of five multiple imputations for each wave obtained from the SHARE imputation database.

2.3. Statistical analyses

We estimate the effect of duration on life satisfaction and self-perceived health using a fixed effects ordered logit specification which models a latent response variable according to the "blow-up and cluster" (BUC) estimator (Baetschmann, Staub, & Winkelmann, 2015). The ordered logit specification assumes the existence of a latent response variable according to:

$$Y_{it}^{*} = C_{it}'\theta + D_{it}'\delta + IADL_{it}\gamma + \alpha_i + \varepsilon_{it}, \qquad i = 1, \ldots, N, \qquad t = 1, \ldots, T_i. \tag{1}$$

Y_{it}^{*} is respondent *i*'s latent self-perceived health or life satisfaction at time t, $IADL_{it}$ the number of IADL limitations, D_{it} a vector with dummy variables capturing the time since the onset of the disability and

C_{it} a vector with covariates. Lastly, α_i is the individual specific fixed effect and ε_{it} the error term, which follows a logistic distribution:

$$F(\varepsilon_{it}|C_{it}, D_{it}, IADL_{it}, \alpha_i) = \frac{\exp(\varepsilon_{it})}{1+\exp(\varepsilon_{it})} \equiv \Lambda(\varepsilon_{it}). \quad (2)$$

The observed self-perceived health or life satisfaction, denoted by Y_{it}, is constructed from Y_{it}^* as follows:

$$Y_{it} = k \quad \text{if} \quad \tau_{ik-1} < Y_{it}^* \leq \tau_{ik}, \quad k = 1, \dots, K. \quad (3)$$

The thresholds between categories $k-1$ and k can be individual specific, with $\tau_{i0} = -\infty$ and $\tau_{iK} = \infty$, and $\tau_{ik-1} \leq \tau_{ik}$ for all k.

The probability for individual i at time t of reporting outcome k is given by

$$P(Y_{it} = k|C_{it}, D_{it}, IADL_{it}, \alpha_i) = \Lambda(\tau_{ik} - C_{it}'\theta - D_{it}'\delta - IADL_{it}\gamma\beta - \alpha_i) - \Lambda(\tau_{ik-1} - C_{it}'\theta - D_{it}'\delta - IADL_{it}\gamma\beta - \alpha_i) \quad (4)$$

For the remainder of this discussion, we shorten the notation by grouping the regressors in the vector $X_{it} = (C_{it}', D_{it}', IADL_{it})'$ and the parameters by $\beta = (\theta', \delta', \gamma)'$. Clearly, $P(Y_{it} = k)$ does not only depend on X_{it} and β, but also on α_i, τ_{ik-1} and τ_{ik}. Hence, we are faced with two problems. Firstly, there is an identification problem, since only $\tau_{ik} - \alpha_i$ is identified and not τ_{ik} and α_i separately. Secondly, with a fixed number of time periods, the incidental parameters problem persists (Neyman & Scott, 1948). These two concerns are addressed by means of conditional maximum likelihood estimation on a binary variable constructed from the original multinomial variable Y_{it}. The binary variable, d_{it}^k, is constructed by dichotomizing the response variable at a cut-off point k: $d_{it}^k = \mathbb{1}(Y_{it} \geq k)$. Here, the cut-off point can lie anywhere between 2 and K. The joint probability of observing $d_i^k = \left(d_{i1}^k, \dots, d_{iT}^k\right)' = (j_{i1}, \dots, j_{iT})' = j_i$, where $j_{it} \in \{0,1\}$, is given by

$$P_i^k(\beta) = P\left(d_i^k = j_i \middle| \sum_{t=1}^{T_i} d_{it}^k = g_i\right) = \frac{\exp(j_i' X_i \beta)}{\sum_{j \in B_i} \exp(j' X_i \beta)}. \quad (5)$$

Here, the sum of all the outcomes over time, $\sum_{t=1}^{T_i} d_{it}^k = g_i = \sum_{t=1}^{T_i} j_{it}$, is a sufficient statistic for $\alpha_i$since the probability in (5) is independent of α_i and the thresholds. In the denominator of (5), j is a vector of length T_i that has as many elements equal to one as the observed vector j_i of individual i. All possible combinations of this vector comprise the set B_i:

$$B_i = \left\{ j \in \{0,1\}_i^T | \sum_{t=1}^{T_i} j_t = g_i \right\}.$$

Moreover, X_i is a $T_i \times M$ matrix, where M equals the number of regressors and row t equal to X_{it}.

The resulting conditional log likelihood is given by

$$LL^k(b) = \sum_{i=1}^{N} \log\left(P_i^k(b)\right). \tag{6}$$

The maximization of this likelihood function for a dichotomized dependent variable at any cut-off point k has been shown to be consistent by Chamberlain (1980) and will therefore be referred to as the Chamberlain estimator denoted by $\hat{\beta}^k$.

The BUC estimator proposed by Baetschmann et al. (2015) is based on the maximization of the sum of all possible $K-1$ Chamberlain likelihood functions:

$$LL^{BUC}(b) = \sum_{k=2}^{K} LL^k(b), \tag{7}$$

where $LL^k(b)$ is defined in (6). By exploiting the information provided by the different configurations of individuals for different cut-off points, the BUC estimator is more efficient than the Chamberlain estimator. The BUC estimator, $\hat{\beta}^{BUC}$, maximizes the likelihood in (7) under the restriction that $\hat{\beta}^2 = \cdots = \hat{\beta}^K$. The consistency of the BUC estimator follows from the consistency of the individual Chamberlain estimator. A discussion on the calculation of the standard errors and marginal effects can be found in appendix A.

2.5. Robustness checks

In addition to the main analysis, we perform four sets of additional analyses in order to assess the robustness of our results with respect to model features and attrition issues that have raised concern in previous studies. First, analyses are performed for a linear model specification and a continuous duration variable. Second, to ensure that the results are not driven by respondents who have only been living with IADL limitations for a relatively short period of time, one analysis is executed for a smaller sample of individuals who have had IADL limitations for three or more consecutive waves. Third, in order to assess adaptation through different disability measures, we perform two additional regressions with ADL and mobility as the disability measure. Fourth, to make sure that the imputations are not affecting the conclusions, we perform analyses with IADL, ADL and mobility as disability measure on the subset of the data that has complete observations on the response variables for all observed waves.

3. Results

3.1. Main results

The regression results reveal that respondents who became disabled less than two years ago (reference category) experience a lower life satisfaction than those living without disability (table 2). Furthermore, the estimated coefficient on the number of IADL limitations is significant and negative: a higher number of limitations is related to a lower life satisfaction. However, individuals who have lived with disability longer have higher levels of life satisfaction than the reference group (which has had limitations for 0.1 to 2 years): the coefficients for having limitations for 2.1 to 5.5 years and for more than 5.5 years of IADL limitations are significant and positive. The latter finding supports the adaptation hypothesis.[1]

[1] However, note that the magnitudes cannot directly be compared because of the non-linear regression specification.

In the regression with life satisfaction, the married are significantly more satisfied with their lives than the not married respondents and the employed respondents are more satisfied with their lives than the retired. Unemployment is related to significantly lower life satisfaction compared to retirement. The log of household income has a positive effect on life satisfaction and so does the number of children.

Having IADL limitations and the number of IADL limitations also have a significant negative effect on self-perceived health. There is no sign of adaptation for this measure, however, as the coefficients for the dummies indicating that the respondent has had IADL limitations for 2.1 to 5.5 years or more than 5.5 years are not significant . Furthermore, employed respondents have a significantly higher self-reported health than retired respondents, probably in part because being in good health enables someone to continue to work.

Table 2: FE ordered logit regression for life satisfaction and self-perceived health

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) IADL limitations	0.249***	1.143***
	(0.025)	(0.029)
0.1-2 years IADL limitations (reference category)		
2.1-5.5 years IADL limitations	0.131**	-0.044
	(0.044)	(0.036)
> 5.5 years IADL limitations	0.444***	-0.017
	(0.094)	(0.065)
Number of IADL limitations		
Number of IADL limitations	-0.082***	-0.194***
	(0.010)	(0.010)
Marital status		
(Reference category Married)		
Not married	-0.219**	-0.066
	(0.080)	(0.077)
Employment status		
(Reference category: Retired)		
Employed	0.467***	0.732***
	(0.065)	(0.067)
Unemployed	-0.340***	0.080
	(0.099)	(0.102)
Inactive	-0.040	-0.081
	(0.046)	(0.044)
Household income		
Log household income	0.030*	0.010
	(0.013)	(0.009)
Number of children		
Number of children	0.050*	-0.009
	(0.024)	(0.028)
Number of subjects	5341	
Number of observations	15826	

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
Standard errors are reported underneath the regression estimates within parentheses.
Standard errors are obtained by means of cluster robust variance estimation.

To better understand the magnitude of the adaptation to disability, we calculate average marginal effects (see appendix A for details and appendix tables B.1 and B.2 for the full results, including Krinsky-Robb standard errors). The average marginal effects for the duration of IADL limitations on the probability of reporting a higher life satisfaction category than category *k* are displayed in figure 3 for categories 0 to 9. Figure 3 shows for instance that the probability of reporting a life satisfaction score higher than 7 (on the 0 to 10 scale, where higher is better) is about 6 percentage point higher for those not experiencing any IADL limitations than for the reference category consisting of respondents who became disabled in the past 2 years. Respondents who have had IADL limitations for 2.1-5.5 years are 4 percent more likely than the reference category to report a life satisfaction score larger than 7. Surprisingly, respondents who have had IADL limitations for at least 5.5 years (i.e. three waves) have the highest probability of all four subgroups of reporting a score of higher than 7 – about 11 percentage points higher than the reference category. All effects are positive, meaning that for all the displayed duration categories and across the entire distribution, the probability of reporting a higher life satisfaction category is larger than that for the first observed period with a disability.

The average marginal effects for duration in the regression with self-perceived health show a large effect of having no IADL limitations on the probability of being in the three highest categories (25 percentage point) and the four highest categories (22 percentage point) of the self-reported health measure compared to having IADL limitations for 0.1-2 years (figure 4). Here, the effects for all self-perceived health categories are negative for 2.1-5.5 years and more than 5.5 years of IADL limitations. This means that, on average, respondents who have experienced IADL limitations for a longer period have a lower likelihood of reporting higher self-perceived health compared to respondents who experience living with a disability for the first time.

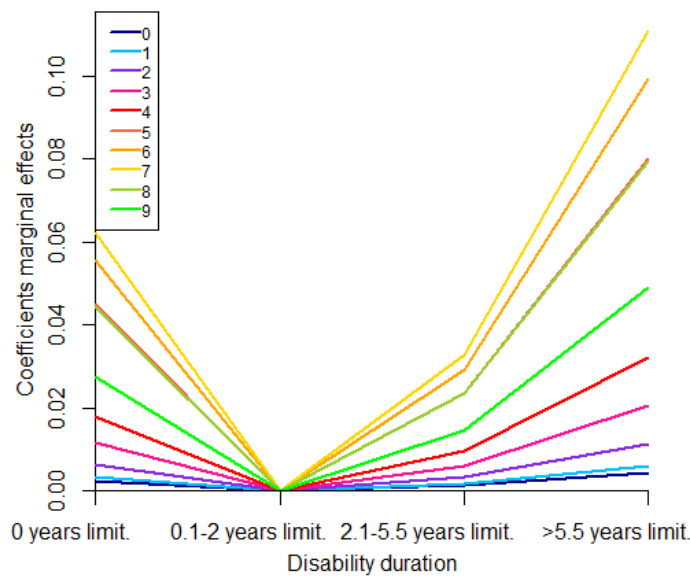

Figure 3: Average marginal effects for disability duration on the probability of reporting $Y > k$ for life satisfaction

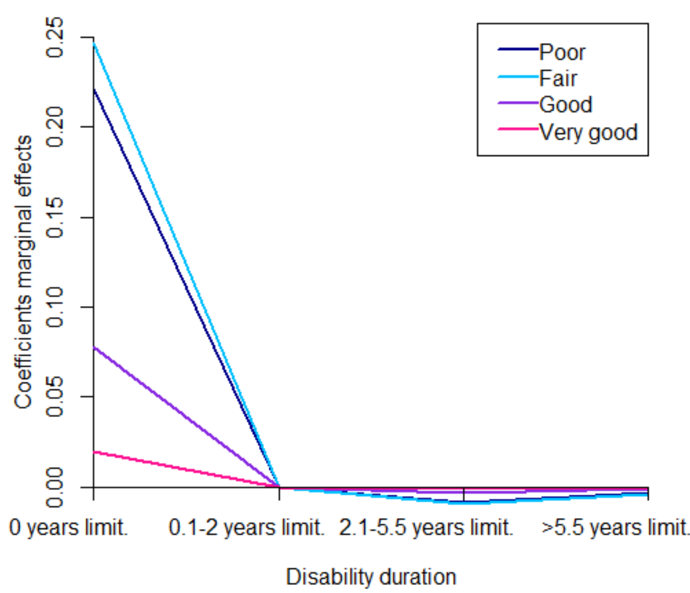

Figure 4: Average marginal effects for disability duration on the probability of reporting $Y > k$ for self-reported health

3.2. Robustness checks

The results are robust to a change from a nonlinear FE ordered logit specification to a linear FE specification (appendix table B.3). Moreover, we performed an analysis with a continuous duration variable as opposed to the dummy specification outlined above (appendix table B.4). Again, in both cases, we found a positive effect of duration on life satisfaction, but not on self-perceived health.

The additional analysis with regards to respondents living with IADL limitations for three or more consecutive waves shows the same pattern of results for both life satisfaction and self-perceived health (appendix table B.5). This shows that the results are not driven by disabled respondents who exit the panel after being included in the sample for a very short period.

Two additional analyses with activities of daily living (ADL) and mobility as the disability measure were also used to assess the effect of duration since the onset of disability on self-reported life satisfaction and health (appendix table B.6 and appendix table B.7). The ADL scale, which measures more severe (and more rare) limitations than the IADL scale, includes the following activities: dressing, walking across a room, bathing or showering, eating, getting in or out of bed and using the toilet, including getting up or down. The mobility scale is the sum of 10 mobility items measured in SHARE. In both cases, the results agree with those from the analysis with IADL as disability measure. We find adaptation for life satisfaction as response variable, but not for self-perceived health.

Finally, in order to assess the effect of the imputations on the results, additional analyses were performed for all of the abovementioned disability measures. Only individuals that had complete observations for the response variable in all observed periods were analyzed. The imputations do not affect the conclusions for all of the abovementioned disability measures (appendix tables B.8-B.10). However, evidence for adaptation in the regression on life satisfaction becomes weaker for the analysis with ADL. The reason for this could be the drastic reduction in sample size, which is less than half of the original sample.

4. Discussion

Subjective assessment of the same objective health may change within one individual over time if one is able to adapt to disabilities. However, there is little empirical evidence for the extent of adaptation in self-reported measures like life satisfaction and self-perceived health. This paper analyzed adaptation to disability assessed through the effect of time since the onset of disability on both life satisfaction and self-perceived health. Prior studies made hardly any distinction between the two, even though self-perceived health is generally considered part of the much broader defined construct of life satisfaction, which might affect the adaptation process. We used the SHARE data for the analyses; the study population consisted of individuals aged 50 and over with an average age of 72. In general, it seems that individuals may regain satisfaction with their life despite their understanding that they are in impaired health. We find evidence supporting the adaptation hypothesis for IADL disabilities in the life satisfaction data, but not for self-perceived health. Life satisfaction is a more holistic measure of well-being than self-reported health, which is affected by more than one's health. Hence, adaptation of life satisfaction to disability might occur faster, since nonmedical factors like social support, make it easier to change one's definition of general well-being, thereby facilitating the adaptation process.

Our maximum duration of experiencing chronic limitations is approximately 9.5 years. Cubí-Mollà et al. (2016) only found a significant effect of duration after 20 years on subjective health. Therefore, the observed period in the SHARE data might not be long enough to measure adaptation in self-perceived health and we cannot exclude the possibility of adaptation occurring after a longer period of time. Nevertheless, this does not affect our main finding that adaptation in life satisfaction occurs much faster than that in self-perceived health.

Furthermore, the average age of our respondents is 72. It is possible that the adaptation process is different for different age groups, since their day-to-day activities will be different and therefore their means to adapt. Alternatively, the chronic conditions prevalent in a different age group might be different to those reported by our sample and the adaptation process for these subsets of diseases could differ. SHARE does not contain respondents who are aged below 50, which makes subgroup analyses for younger age groups infeasible.

A complicating factor in the study of adaptation is that one cannot verify what mechanisms comprise the effect of adaptation. We are generally interested in a change in well-being or subjective health that is a result of a reconceptualization of QoL or a change in values rather than a change in one's internal standards (i.e. scale recalibration). Scale recalibration leads to a different interpretation of the subjective response scale, but not to a true change in life satisfaction or self-perceived health itself. Future research could separate the effects of scale recalibration and the other effects of adaptation using anchoring vignettes (Salomon, Tandon, Murray, & World Health Survey Pilot Study Collaboration Group, 2004). A change in values could be identified with a time trade-off or discrete choice experiment at different points in time. Lastly, reconceptualization of QoL can be studied with ranking methods to identify important dimensions of QoL.

The main implication of our results for adaptation theory is that the adaptation process differs for life satisfaction and self-perceived health, with full adaptation for life satisfaction while there is no evidence for adaptation of self-perceived health in the first years. In future theoretical discussions, this distinction ought to be made. In practice, the findings are relevant to epidemiologists and health practitioners, since they provide insight into the trajectory of a patient's subjective health and well-being over the course of the disability. The natural course of life satisfaction seems to be one of self-restoring after physical limitations have occurred and this implies that caution is needed in the interpretation of uncontrolled studies that attribute improvements in life satisfaction to interventions. In the context of cost-utility analysis, the results presented here suggest that there is a meaningful distinction to be made with regard to QoL measurements that focus on 'adaptation sensitive domains' (i.e. life satisfaction or well-being) and more objective measures such as IADL and ADL. In short, after the onset of chronic disabilities, individuals do not return to previously reported levels of self-reported health, but exceed previously reported life satisfaction, illustrating the remarkable human ability to adapt and learn from hardship.

CONFLICT OF INTEREST
The authors have no conflict of interest.

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APPENDIX A: Estimation details

This appendix is about the estimation of the standard errors and marginal effects of the BUC estimator. We need to cluster the standard errors of the BUC estimator at the individual level, due to the constructed dependency between the observations. A cluster robust variance estimator is used based on the following asymptotic variance (the limiting variance of $\sqrt{n}(\hat{\beta}^{BUC} - \beta)$):

$$Avar(\hat{\beta}^{BUC}) = \left\{\sum_{k=2}^{K} E(H_i^k(\beta))\right\}^{-1} \left[\sum_{k=2}^{K}\sum_{l=2}^{K} E(s_i^k(\beta)s_i^{l'}(\beta)')\right]\left\{\sum_{k=2}^{K} E\left(H_i^k(\beta)\right)\right\}^{-1}. \tag{A.1}$$

Here, $s_i^k(\beta)$ denote the first-order derivatives of the Chamberlain log likelihood function (6) with respect to β:

$$s_i^k = \delta \log \frac{P_i^k(b)}{\delta b} = x_i' \left\{ d_i^k - \sum_{j \in B_i} j \frac{exp(j' x_i b)}{\exp(l' x_i b)} \right\}, \tag{A.2}$$

And $H_i^k(\beta)$ denote the individual Hessians:

$$H_i^k(b) = \frac{\delta^2 \log\left(P_i^k(b)\right)}{\delta b \delta b'} = -\sum_{j \in B_i} \frac{\exp(j' x_i b)}{\sum_{l \in B_i} \exp(l' x_i b)} \times \left(x_i' j - \sum_{m \in B_i} \frac{\exp(m' x_i b)}{\sum_{l \in B_i} \exp(l' x_i b)} m' x_i\right)\left(x_i' j - \sum_{m \in B_i} \frac{\exp(m' x_i b)}{\sum_{l \in B_i} \exp(l' x_i b)} m' x_i\right)'. \tag{A.3}$$

In the analysis, the expectations are replaced by their sample analogs and the parameters by their estimated values.

Finally, from the β estimates we can derive the statistical significance of the effect of the regressors on the probability of reporting better self-perceived health or life satisfaction. They cannot, however, be interpreted in terms of the size of this effect. For this type of interpretation the marginal effects are required. In the subsequent analyses, we use the marginal effect on $P(Y_{it} > k) = 1 - \Lambda(\tau_{ik} - X_{it}'\beta - \alpha_i)$, since the sign of the regression estimate here always concurs with that of the corresponding marginal effects and the interpretation is straightforward. The general formula for the marginal effect of the lth regressor on the probability that a respondent reports an outcome higher than category k is:

$$\frac{\partial P(Y_{it} > k | X_{it}, \alpha_i)}{\partial X_{itl}} = \Lambda_{ik}(1 - \Lambda_{ik})\beta_l \qquad \text{A.4)}$$

with $\Lambda_{ik} = \Lambda(\tau_{ik} - X_{it}'\beta - \alpha_i)$. Usually, the average of the effects is calculated to aid the interpretation. Unfortunately, average marginal effects for $P(Y_{it} > k)$ cannot be calculated directly, since τ_{ik} and α_i are not estimated by the BUC estimator. However, we will approximate the required probabilities with the sample probabilities:

$$\widetilde{\Lambda}_{ik} = \tilde{P}(Y_{it} \leq k) = \frac{\sum_{i=1}^{N} \sum_{t=1}^{T_i} \mathbb{1}[Y_{it} \leq k]}{\sum_{i=1}^{N} T_i} \tag{A.5}$$

These are computed by summing the number of observations in the categories smaller than k and dividing this by the total number of observations. The standard errors of the marginal effects are approximated by means of the Krinsky and Robb (1986, 1990) method.

APPENDIX B: additional results

Table B.1: Marginal effects on the probability of reporting $Y > k$ for life satisfaction

	Life satisfaction										
	Score 1 Completely dissatisfied	Score 2	Score 3	Score 4	Score 5	Score 6	Score 7	Score 8	Score 9	Score 10	Score 11 Completely satisfied
Duration											
0 years (NO) IADL limit.	0.002***	0.003***	0.006***	0.012***	0.018***	0.045***	0.056***	0.062***	0.045***	0.028***	-
	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.005)	(0.006)	(0.006)	(0.005)	(0.003)	-
0.1-2 years IADL limit. (reference category)											
2.1-5.5 years IADL limit.	0.001**	0.002***	0.003**	0.006***	0.009**	0.024***	0.029**	0.033**	0.023**	0.014**	-
	(0.000)	(0.001)	(0.001)	(0.002)	(0.003)	(0.008)	(0.010)	(0.011)	(0.008)	(0.005)	-
> 5.5 years IADL limit.	0.004***	0.006***	0.011***	0.021***	0.032***	0.080***	0.099***	0.111***	0.079***	0.049***	-
	(0.001)	(0.001)	(0.002)	(0.004)	(0.007)	(0.017)	(0.021)	(0.023)	(0.017)	(0.010)	-
Number of IADL limitations											
Number of IADL limit.	-0.001***	-0.001***	-0.002***	-0.004***	-0.006***	-0.015***	-0.018***	-0.021***	-0.015***	-0.009***	-
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.001)	-
Marital status											
(Ref. Married)											
Not married	-0.002**	-0.003**	-0.006**	-0.010**	-0.016**	-0.040**	-0.049**	-0.055**	-0.039**	-0.024**	-
	(0.001)	(0.001)	(0.002)	(0.004)	(0.006)	(0.015)	(0.018)	(0.020)	(0.014)	(0.009)	-
Employment status											
(Ref. Retired)											
Employed	0.004***	0.006***	0.012***	0.022***	0.034***	0.084***	0.104***	0.117***	0.083***	0.052***	-
	(0.001)	(0.001)	(0.002)	(0.003)	(0.004)	(0.012)	(0.015)	(0.016)	(0.012)	(0.007)	-
Unemployed	-0.003***	-0.005***	-0.009***	-0.016***	-0.025***	-0.061***	-0.076***	-0.085***	-0.061***	-0.038***	-
	(0.001)	(0.001)	(0.003)	(0.005)	(0.007)	(0.018)	(0.022)	(0.025)	(0.018)	(0.011)	-
Inactive	0.000	-0.001	-0.001	-0.002	-0.003	-0.007	-0.009	-0.010	-0.007	-0.004	-
	(0.000)	(0.001)	(0.001)	(0.002)	(0.003)	(0.008)	(0.010)	(0.011)	(0.008)	(0.005)	-
Household income											
Log household income	0.000*	0.000*	0.001*	0.001*	0.002*	0.005*	0.007*	0.008*	0.005*	0.003*	-
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	-
Number of children											
Number of children	0.000*	0.001*	0.001*	0.002*	0.004*	0.009*	0.011*	0.013*	0.009*	0.006*	-
	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.005)	(0.006)	(0.006)	(0.004)	(0.003)	-

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of the Krinsky and Robb method.

Table B.2: Marginal effects on the probability of reporting $Y > k$ for self-perceived health

	Self-perceived health				
	Poor	Fair	Good	Very good	Excellent
Duration					
0 years (NO) IADL limitations	0.221***	0.247***	0.078***	0.019***	-
	(0.006)	(0.006)	(0.002)	(0.001)	-
0.1-2 years IADL limitations (reference category)					
2.1-5.5 years IADL limitations	-0.008**	-0.009**	-0.003**	-0.001**	-
	(0.007)	(0.008)	(0.002)	(0.001)	-
> 5.5 years IADL limitations	-0.003	-0.004	-0.001	-0.000	-
	(0.013)	(0.014)	(0.004)	(0.001)	-
Number of IADL limitation					
Number of IADL limit.	-0.038***	-0.042***	-0.013***	-0.003***	-
	(0.002)	(0.002)	(0.001)	(0.000)	-
Marital status					
(Ref. Married)					
Not married	-0.013	-0.014	-0.005	-0.001	-
	(0.015)	(0.017)	(0.005)	(0.001)	-
Employment status					
(Ref. Retired)					
Employed	0.142***	0.158***	0.050***	0.012***	-
	(0.013)	(0.015)	(0.005)	(0.001)	-
Unemployed	0.015	0.017	0.005	0.001	-
	(0.020)	(0.022)	(0.007)	(0.002)	-
Inactive	-0.016	-0.018	-0.006	-0.001	-
	(0.009)	(0.010)	(0.003)	(0.001)	-
Household income					
Log household income	0.002	0.002	0.001	0.000	-
	(0.002)	(0.002)	(0.001)	(0.000)	-
Number of children					
Number of children	-0.002	-0.002	-0.001	-0.000	-
	(0.005)	(0.006)	(0.002)	(0.001)	-

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of the Krinsky and Robb method.

Table B.3: FE linear regression for life satisfaction and self-perceived health

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) IADL limitations	0.157***	0.320***
	(0.044)	(0.017)
0.1-2 years IADL limitations (reference category)		
2.1-5.5 years IADL limitations	0.111	0.021
	(0.062)	(0.023)
> 5.5 years IADL limitations	0.384**	0.053
	(0.122)	(0.043)
Number of IADL limitations		
Number of IADL limitations	-0.090***	-0.081***
	(0.015)	(0.006)
Marital status		
(Ref. Married)		
Not married	-0.270*	-0.029
	(0.122)	(0.043)
Employment status		
(Ref. Retired)		
Employed	0.328**	0.287***
	(0.103)	(0.039)
Unemployed	-0.278	0.020
	(0.162)	(0.062)
Inactive	-0.045	-0.044
	(0.074)	(0.027)
Household income		
Log household income	0.026	0.001
	(0.017)	(0.006)
Number of children		
Number of children	0.033	0.013
	(0.040)	(0.015)
Number of subjects	5341	
Number of observations	15826	

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses.

Table B.4: FE ordered logit regression for life satisfaction and self-perceived health with continuous duration

	Life satisfaction	Self-perceived health
Duration		
Duration of chronic disability	0.034**	-0.208***
	(0.010)	(0.013)
Number of IADL limitations		
Number of IADL limitations	-0.132***	-0.389***
	(0.009)	(0.011)
Marital status		
(Ref. Married)		
Not married	-0.258**	-0.177*
	(0.079)	(0.076)
Employment status		
(Ref. Retired)		
Employed	0.569***	0.954***
	(0.065)	(0.066)
Unemployed	-0.229*	0.308**
	(0.100)	(0.094)
Inactive	-0.018	0.010
	(0.045)	(0.045)
Household income		
Log household income	0.031*	0.012
	(0.013)	(0.009)
Number of children		
Number of children	0.050*	-0.006
	(0.024)	(0.027)
Number of subjects	5341	
Number of observations	15826	

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.

Table B.5: FE ordered logit regression for life satisfaction and self-perceived health with respondents that are living with functional limitations for 3 or more waves

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) IADL limitations	-0.017	1.272***
	(0.095)	(0.091)
0.1-2 years IADL limitations (reference category)		
2.1-5.5 years IADL limitations	-0.014	-0.357***
	(0.083)	(0.075)
> 5.5 years IADL limitations	0.494***	-0.209*
	(0.129)	(0.082)
Number of IADL limitations		
Number of IADL limitations	-0.142***	-0.149***
	(0.023)	(0.026)
Marital status		
(Ref. Married)		
Not married	0.051	-0.084
	(0.252)	(0.181)
Employment status		
(Ref. Retired)		
Employed	1.115***	0.348
	(0.249)	(0.218)
Unemployed	1.219***	2.443***
	(0.320)	(0.448)
Inactive	0.247	0.279*
	(0.140)	(0.123)
Household income		
Log household income	0.025	0.112**
	(0.042)	(0.039)
Number of children		
Number of children	0.211	-0.022
	(0.109)	(0.063)
Number of subjects	324	
Number of observations	1487	

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.

Table B.6: FE ordered logit regression for life satisfaction and self-perceived health with ADL as disability measure

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) ADL limit.	0.109**	0.993***
	(0.038)	(0.035)
0.1-2 years ADL limitations (reference category)		
2.1-5.5 years ADL limitations	0.189***	0.031
	(0.052)	(0.042)
> 5.5 years ADL limitations	0.259**	-0.088
	(0.085)	(0.076)
Number of ADL limitations		
Number of ADL limitations	-0.100***	-0.323***
	(0.015)	(0.014)
Marital status (Ref. Married)		
Not married	-0.348***	-0.093
	(0.084)	(0.086)
Employment status (Ref. Retired)		
Employed	0.613***	0.852***
	(0.077)	(0.080)
Unemployed	-0.353**	0.123
	(0.130)	(0.133)
Inactive	-0.082	-0.122*
	(0.048)	(0.050)
Household income		
Log household income	0.030	0.039***
	(0.016)	(0.011)
Number of children		
Number of children	0.023	0.058
	(0.029)	(0.032)
Number of subjects	4143	
Number of observations	12302	

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.

Table B.7: FE ordered logit regression for life satisfaction and self-perceived health with mobility as disability measure

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) mobility limitations	-0.006	0.898***
	(0.030)	(0.030)
0.1-2 years mobility limitations (reference category)		
2.1-5.5 years mobility limitations	0.206***	-0.205***
	(0.033)	(0.034)
> 5.5 years mobility limitations	0.235***	-0.213***
	(0.064)	(0.058)
Number of mobility limitations		
Number of mobility limitations	-0.127***	-0.309***
	(0.012)	(0.010)
Marital status		
(Reference category Married)		
Not married	-0.523***	-0.188*
	(0.106)	(0.091)
Employment status		
(Reference category: Retired)		
Employed	0.171**	0.409***
	(0.058)	(0.056)
Unemployed	-0.618***	0.034
	(0.088)	(0.084)
Inactive	-0.079	-0.152**
	(0.065)	(0.054)
Household income		
Log household income	0.032*	0.030**
	(0.013)	(0.010)
Number of children		
Number of children	-0.007	-0.012
	(0.032)	(0.026)
Number of subjects	5130	
Number of observations	14708	

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.0erceived$ Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.

Table B.8: FE ordered logit regression for life satisfaction and self-perceived health with IADL as disability measure and complete observations for the response variable

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) IADL limit.	0.065*	1.143***
	(0.032)	(0.029)
0.1-2 years IADL limitations (reference category)		
2.1-5.5 years IADL limitations	0.245***	-0.051
	(0.043)	(0.036)
> 5.5 years IADL limitations	0.516***	-0.021
	(0.122)	(0.065)
Number of IADL limitations		
Number of IADL limitations	-0.183***	-0.193***
	(0.013)	(0.01)
Marital status		
(Ref. Married)		
Not married	-0.298**	-0.067
	(0.092)	(0.077)
Employment status		
(Ref. Retired)		
Employed	0.468***	0.736***
	(0.075)	(0.067)
Unemployed	-0.388***	0.082
	(0.115)	(0.102)
Inactive	-0.203***	-0.076
	(0.054)	(0.044)
Household income		
Log household income	0.035**	0.011
	(0.012)	(0.009)
Number of children		
Number of children	0.064*	-0.009
	(0.03)	(0.028)
Number of subjects	3226	5332
Number of observations	8647	15802

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.

Table B.9: FE ordered logit regression for life satisfaction and self-perceived health with ADL as disability measure and complete observations for the response variable

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) ADL limit.	-0.044	0.988***
	(0.04)	(0.035)
0.1-2 years ADL limitations (reference category)		
2.1-5.5 years ADL limitations	0.156**	0.034
	(0.052)	(0.042)
> 5.5 years ADL limitations	-0.244	-0.095
	(0.139)	(0.076)
Number of ADL limitations		
Number of ADL limitations	-0.191***	-0.324***
	(0.018)	(0.014)
Marital status		
(Ref. Married)		
Not married	-0.615***	-0.095
	(0.105)	(0.083)
Employment status		
(Ref. Retired)		
Employed	0.747***	0.852***
	(0.089)	(0.08)
Unemployed	-0.181	0.127
	(0.141)	(0.133)
Inactive	-0.138*	-0.110*
	(0.063)	(0.05)
Household income		
Log household income	0.047**	0.039***
	(0.017)	(0.011)
Number of children		
Number of children	0.032	0.055
	(0.035)	(0.03)
Number of subjects	2362	4132
Number of observations	6328	12273

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.

Table B.10: FE ordered logit regression for life satisfaction and self-perceived health with mobility as disability measure and complete observations for the response variable

	Life satisfaction	Self-perceived health
Duration		
0 years (NO) mobility limitations	-0.015	0.887***
	(0.031)	(0.03)
0.1-2 years mobility limitations (reference category)		
2.1-5.5 years mobility limitations	0.305***	-0.215***
	(0.037)	(0.034)
> 5.5 years mobility limitations	0.233*	-0.218***
	(0.092)	(0.058)
Number of mobility limitations		
Number of mobility limitations	-0.136***	-0.314***
	(0.01)	(0.01)
Marital status		
(Reference category Married)		
Not married	-0.781***	-0.188*
	(0.132)	(0.089)
Employment status		
(Reference category: Retired)		
Employed	0.111*	0.416***
	(0.054)	(0.055)
Unemployed	-0.668***	0.037
	(0.088)	(0.084)
Inactive	-0.207***	-0.149**
	0.061)	(0.055)
Household income		
Log household income	0.046***	0.031**
	(0.011)	(0.01)
Number of children		
Number of children	-0.054	-0.013
	(0.032)	(0.026)
Number of subjects	3505	5121
Number of observations	9182	14680

Note. Ref. stands for reference category. *** indicates $p < 0.001$, ** $p < 0.01$, * $p < 0.0erceived$ Standard errors are reported underneath the regression estimates within parentheses. Standard errors are obtained by means of cluster robust variance estimation.