ARTICLE

Subjective well-being and chronic illnesses: A combined survey and register study

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Abstract: Populations are ageing, and higher proportions live with chronic illnesses. Understanding the association between health and well-being and being able to predict who may experience the largest detriment in well-being is essential if societies are to maintain high levels of social welfare. Our study places itself in the limited literature examining the association between chronic illness and subjective well-being (SWB). We offer a unique contribution to the literature by studying different domains of SWB and by investigating variation in SWB. A cross-sectional survey of a representative group of Danish citizens aged 50-80 is linked with national register data containing comprehensive information on health and social issues. We identify six common chronic illnesses. In addition to general life satisfaction, we also measure SWB in seven domains of life, including health, using the Personal Wellbeing Index. Health state is measured by EQ-5D-5L. We use OLS and adjust for socio-demographics, lifestyle, personal skills, preferences, and personality traits. In a range of heterogeneity analyses we explore the role of 22 personal characteristics as predictive factors of SWB when being chronically ill. We also examine two possible sources of variation in SWB. We find robust evidence of negative associations between chronic illness and older individuals' SWB beyond the health domain. When ascertaining the influence of personal characteristics, we find that some factors predict vulnerability. Interestingly, heterogeneity in SWB across personal characteristics stem from differential health state and in some cases from differences in the association between SWB and health.

Keywords: Chronic illness; subjective well-being; ageing; personal characteristics; Denmark

1. Introduction

As disease patterns shift and longevity increases, more people live many years with chronic illness. Therefore, it is increasingly important to improve our understanding of how these individuals deal with their condition including an exploration of the association between health-related quality of life (HRQoL) and subjective well-being (SWB). It is well-known that chronic illness is associated with increased healthcare consumption and negative consequences on the welfare of the individual, their family and society at large (van Houtum et al., 2015; Wikman et al., 2011). As a consequence, studies emphasise the need to use measures of SWB alongside HRQoL to assess the full impact of chronic illnesses on individuals' lives. Having a better understanding of how healthcare interventions impact not only on HRQoL, but also on the broader welfare of individuals, may be helpful in providing a more comprehensive depiction of outcomes when assessing the cost-effectiveness and equitability of healthcare interventions (Böckerman et al., 2011; de Albornoz & Chen, 2021).

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Well-being is a broad, multifaceted construct but it is generally agreed that measures of SWB, such as happiness and life satisfaction scales, reflect individuals' evaluation of their feelings and lives and provide a valid measure of individuals' latent level of well-being (Diener, 1984; Frijters et al., 2020; Linton et al., 2016). There is a large body of literature linking SWB to socio-demographic characteristics such as gender, age, ethnicity, marital status, social networks, and socio-economic position. However, these factors have been found to play a smaller role in the variance of SWB. In contrast, personality traits such as extraversion and neuroticism have been shown to be the best predictors of well-being, whereas little is known about the association between SWB and personal skills and preferences such as health literacy, locus of control, planning horizon, and risk aversion. For a detailed review of factors that may explain SWB, see Diener and Ryan (2009).

It is also noteworthy that there are not many studies that specifically focus on SWB amongst individuals who are ill, or individuals with chronic illness, which is the focus of this study. Research into SWB and health at older ages, and amongst individuals who are ill, is at an early stage but growing (Steptoe et al., 2015; van Campen & van Santvoort, 2013). Within the literature it has been shown that personality traits, such as the Big Five personality traits, influence the way an individual reacts to adverse life events such as ill health (Diener, 1984; Headey & Wearing, 1989). Individuals with high internal locus of control may be better protected against ill health because such individuals are more likely to actively look for solutions to adverse events instead of relying on emotional support (Buddelmeyer & Powdthavee, 2016; Stillman & Velamuri, 2016). Little is still known about the influence of personal skills and traits such as health literacy, planning horizon, and risk aversion on the association between health and SWB. Moderating impacts of socio-demographic factors have also been investigated. Studies generally do not find an influence of gender, but they do find an impact of age in terms of the phenomenon 'the well-being paradox'. What has been observed is that despite poorer health and more impairments there is a positive relationship between age and SWB (Uppal, 2006). There is little evidence of a moderating role of ethnicity among ill individuals (Hampton, 2004), although some find an accentuating impact (Uppal, 2006). Social interactions and marriage may soften adverse events (Salokangas et al., 2001; van Campen & van Santvoort, 2013; Ville et al., 2001), while poor financial security increases vulnerability (Kageyama et al., 2019; Lim, 2020; Smith et al., 2005). Level of education and labour market participation does not seem to explain inequality in SWB (van Campen & van Santvoort, 2013). There is some evidence that healthy lifestyle behaviours are associated with better life satisfaction (Kuroki, 2016; Phulkerd et al., 2021; Shi et al., 2019). As observed with health shocks (Baji & Bíró, 2018), individuals may adjust their expectation downwards when diagnosed with chronic illness. Some studies have found gradual adaptation to health conditions, such as disabilities, using SWB measures (Oswald & Powdthavee, 2008; Pagán-Rodríguez, 2010).

If personal characteristics moderate the course of ill health or the ability to cope with ill health, identifying the predictive factors of lower well-being due to chronic illness could be beneficial for the individual, health professionals, and policy makers. Such predictions could improve patient-centred care and enable more equitable health resource allocations. The field is, however, to a large extent still uncharted. A majority of studies focus on specific diseases making it difficult to generalise beyond the scope of the study. Further, many studies focus only on general measures of well-being, rendering it difficult to verify in which dimensions of life individuals are affected. Moreover, little is known about the sources of heterogeneity in well-being among the chronically ill. Our study therefore fills several gaps in the literature.

2. Aims

On the basis of a unique and rich data set, in which we link high quality register data with survey data, this paper seeks to answer three key research questions:

- What is the association between chronic illness and domains of SWB?
- Is there heterogeneity in the association between chronic illness and SWB across personal characteristics?
- Can heterogeneity in SWB across personal characteristics among chronically ill individuals be explained by differences in health state and/or a differential association between health and SWB?

3. Data

We utilise a comprehensive collection of individual level Danish administrative register data in conjunction with a cross-sectional survey based on a representative group of Danish citizens aged 50-80 years. The unique individual personal identification number assigned to all individuals with permanent residence in Denmark provides an exceptional opportunity to link survey data and the national registers, allowing us to combine the accuracy from the registers with the versatility of the survey. We extract information on socio-demographics and health from the registers, while information on well-being, personal skills, preferences, and personality traits are taken from the survey.

Survey data was collected in spring 2019 through a web-based questionnaire administered by Statistics Denmark using the digital mailbox for official governmental communication[1]. 15,072 individuals were invited to participate, and 6,807 individuals (45%) returned a fully completed questionnaire. Of these, 80 individuals had lived abroad for extended periods of time during 2014-2018 and are therefore excluded. Another 24 are excluded due to non-response on the well-being questions ('do not know' and 'refuse to answer'), and 460 are excluded due to non-response on key variables. The control group consists of individuals with none of the selected chronic illnesses. The analyses are thus based on 1,495 individuals with a chronic illness, and 4,748 controls, leading to a total sample size of 6,243 individuals[2].

3.1 Measures from the survey

General SWB is measured using the life satisfaction question 'How satisfied are you with your life as a whole?' on a 11-point end-defined response scale, with numerical ratings ranging from 0 (extremely dissatisfied) to 10 (extremely satisfied). In addition, we also obtain information on seven domain specific SWB items (with similar phrasing) measured by the Personal Wellbeing Index (PWI)[3]. The seven items correspond to different quality of life domains: standard of living, health, achieving in life, relationships, safety, community connectedness, and future security. Items for each of the seven domains can be evaluated individually[4] (International Wellbeing Group, 2013). All SWB scores are converted into a 0-100 point scale.

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[1] Digital Post is letters from public authorities. It may be pension statements, letters from the hospital about examinations, or notification of a place at a daycare facility etc. For further detail, see lifeindenmark.borger.dk.

[2] See Table A1 (Supplementary Appendix) for sample sizes for each of the analyses conducted.

[3] The Danish version of the PWI utilised in this study was translated specifically for the survey. A previous Danish translation of the PWI can be downloaded from the web: www.acqol.com.au/uploads/pwi-a/pwi-a-danish.pdf.

[4] The seven items of the PWI can also be summed to form one SWB score. The PWI (the average score) implicitly assumes that all domains are equally important (i.e., equal weighting of the seven items), which may be criticized. As preference weights has not been established for the domains, we refrain from this approach and only measure general

Other self-reported information includes the following personal characteristics. Health state is assessed as HRQoL using EQ-5D-5L with Danish weights (EuroQol Research Foundation; Jensen et al., 2021). Body mass index (BMI) is calculated using weight and height. Smoking is measured using the question: 'Do you smoke?', where 'yes' and 'no, I quit' have been combined to a dummy variable indicating whether one has ever been a smoker vs. never a smoker. Alcohol is evaluated with: 'How many units of alcohol do you drink per week?' with six answers ranging from 'none', '1-7' to '31 or more'. Diet is assessed with the item: 'How do you rate your diet overall?' on a 5-point Likert scale ranging from 'very healthy' to 'very unhealthy'. Weekly exercise level is based on the question: 'On a typical week, how many days do you exercise at least 30 minutes of moderate to vigorous intensity?' with four response categories ranging from 'none' to '5-7 days'. This variable is reverse scored so that it has the same direction as the other lifestyle measures, i.e., a higher score indicates less exercise per week. The lifestyle measures are inspired by the questions in The Danish National Health Survey (Christensen et al., 2022). Planning horizon is assessed based on the question: 'As far as possible, I plan everything in advance' on a 6-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. This question is inspired by a question in the EASI-III Temperament Survey (Buss & Plomin, 1975). The propensity to take risk is measured with the item: 'How do you evaluate your willingness to take a risk in general?' on a 0 (no willingness to take risks) to 10 (high willingness to take risks) response scale, which is inspired by a question in the German SOEP (SOEP-IS Group, 2018). Health literacy assessment is based on the first four Likert scale questions from HLS-EU-Q16 (Pelikan et al., 2014). These four questions focus on ability to access and understand information relevant to health. The health literacy score is calculated by coding responses 'very easy' and 'easy' as 1, 'difficult' and 'very difficult' as 0, and subsequently summing them, which results in a score between 0 and 4. Internal health locus of control is assessed based on the six questions from the multidimensional health locus of control scale (Wallston et al., 1978) reflecting the internality dimension of health locus of control beliefs. Items are scored on a 6-point Likert scale ranging from 'strongly disagree' (1) to 'strongly agree' (6) and summed to a score between 6 and 36. The Big Five personality traits (extraversion, agreeableness, conscientiousness, emotional stability[5], and openness to experiences) are measured using the ten item personality measure (TIPI) (Gosling et al., 2003). When scoring the TIPI, we first recode the reverse scored items and then take the average of the two items that make up each scale. We also define a variable for survey completion time in minutes.

3.2 Measures from the registers

From the Danish registers we extract all the information needed to construct our chronic illness variable. We define chronic illness as having one of the following diagnoses: asthma, chronic obstructive pulmonary disease (COPD), rheumatoid arthritis, osteoporosis, type 1 diabetes, or type 2 diabetes. These six chronic illnesses are chosen as they are among the most common chronic illnesses (one in five adult Danes is diagnosed with at least one of them (Sundhedsdatastyrelsen, 2020))[6]. Importantly, these selected chronic diseases can be identified in the registers using an algorithm from The Danish Health Data Authority (Sundhedsdata-

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well-being using the one-item SWB question. We have included analyses for the PWI in the appendix and find similar results as with general SWB, although stronger in magnitude in many cases.

[5] Emotional stability is also known as neuroticism. Individuals who score high in emotional stability, score low in neuroticism.

[6] We do not include cancer in our list of chronic illnesses as not all cancers can be considered chronic (Bernell & Howard, 2016; www.cancer.org).

styrelsen, 2019). The algorithm identifies individuals with the selected chronic illnesses based on administrative data on hospital contacts (Danish National Patient Register) and purchases of prescription medication (Danish National Prescription Registry). Chronic illness status is evaluated on 1 March 2019. Date of diagnosis is established as the first date of contact in the National Patient Register with a relevant diagnosis, or as the first date of redemption for prescription in the National Prescription Registry for a relevant prescription[7]. We define a variable for number of years living with a chronic illness.

Apart from chronic illnesses, we also extract information from the registers on the individual's gender, age (rescaled by dividing with 5), ethnicity (ethnic Danish vs non-ethnic Danish), living situation (not living alone vs living alone), number of children, municipality of residence, education, labour market attachment, and wealth. The demographic variables are assessed on 1 January 2019. The individual's highest achieved education is reported in number of years, and individual wealth is measured as net worth in DKK 100,000; assets excluding private pensions minus debts. These variables are measured on 1 October 2018 and 31 December 2018, respectively. Labour market attachment is defined as a dummy variable equal to one if the individual is not working and is under the age of 65 years (the age of eligibility for old age pension) and equal to zero if the individual is working and is under 65 years or if the individual is 65 years or older. This variable is assessed on 31 December 2018.

3.3 Institutional setting

The Danish social system ensures universal social rights, offering free access to healthcare, free education, and a safety net for, e.g., ill citizens (Ministry of Social Affairs and Integration, 2011). Public health insurance covers most costs related to illness. However, individual co-payments are required for prescription drugs, although some medicine is reimbursable and there is a yearly out-of-pocket maximum for prescription drugs (Ministry of Health, 2017). The general practitioner holds the responsibility of monitoring and treating most individuals with chronic illnesses, including individuals with COPD and type 2 diabetes. Only individuals with severe complexities are managed by hospitals. Individuals with type 1 diabetes are however still primarily monitored at outpatient clinics at the hospital. In Denmark, income-related inequity in access to healthcare has been shown to be minimal (Gundgaard, 2006; Simonsen et al., 2020; Sortsø et al., 2017). Active labour market policies also contribute with support for people with reduced ability to work, e.g., by providing personal assistance, wage subsidies, or preferential access to the labour market (Danish Agency of Labour Market and Recruitment, 2018), or in more severe cases, by providing social disability pension. In a Danish setting, heterogeneity in SWB and HRQoL is therefore less likely to be driven by financial hardship and more likely to be driven by other personal circumstances and personality traits.

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[7] We here provide an example of the algorithm in the case of osteoporosis. Inclusion criteria: Individuals with an osteoporosis diagnosis in the Danish National Patient Register (ICD-10 codes M80, M81, and M82); individuals with minimum one purchase of osteoporosis medication in the National Prescription Registry (ATC codes M05BA01, M05BA04, M05BA06 (only 150 mg tablets), M05BA07, M05BB01, M05BB03, M05BX03, G03XC01, H05AA02, H05AA03 (only with the name Preotact)). Exclusion criteria: Individuals with only one date of redemption for osteoporosis medication; individuals who have not had a hospital contact related to osteoporosis or purchased osteoporosis medication within the last ten years from the date of evaluation. Age of diagnosis is assessed as the first hospital contact for osteoporosis or first redemption day with a prescription for osteoporosis medicine. For the other chronic illnesses, see Sundhedsdatastyrelsen (2019) (only available in Danish).

4. Methods

4.1 Empirical framework

To motivate our empirical strategy, we use a conceptual framework by Galinha and Pais-Ribeiro (2012) based on the major strands of theories stating that SWB can be predicted by contextual factors and intrapersonal (cognitive and affective) characteristics. Consequently, we align with the tradition in the literature and encompass both contextual and intrapersonal factors as covariates in our analyses.

In our empirical analyses we apply a significance level of 5% and verify whether the results remain statistically significant after Bonferroni correction. We do this to address the potential issue of multiplicity (inflation of the type I error rate). Both results are presented in the acknowledgement that the Bonferroni correction is a conservative approach to verifying statistical significance, and that there is a risk of rejecting true findings.

4.2 What is the association between chronic illness and domains of SWB?

For the estimation of chronic illness on well-being we use ordinary least squares for the seven SWB domains and general SWB for each of the six chronic illnesses and a combined variable for having at least one chronic illness (a total of 56 regressions):

$$SWB_{i,j} = \alpha_0 + \alpha_{1,k}C_{i,k} + \alpha_2 X_i + \varepsilon_i, j = 1, \dots 8; k = 1, \dots, 7 \tag{1}$$

where $SWB_{i,j}$ is individual i's j'th domain of well-being. $C_{i,k}$ is set of dummy variables representing the six chronic illnesses and the combined variable for having a least one chronic illness. X_i is a vector of covariates and includes socio-demographics, lifestyle, personal skills, preferences, personality traits, and municipality (described in sections 3.1. and 3.2.). ε_i is the error term. Our control group is non-chronically ill individuals. We apply robust standard errors. $\alpha_{1,k}$ is the coefficient of interest, estimating the association between chronic illness and well-being.

We include a wide range of covariates to present a plausible case for chronic illness being a predictor of SWB over and beyond personal characteristics. We do not presume to have estimated the true magnitude of the link between chronic illness and SWB, but identify an indicative range for the magnitude of this association by presenting results for the full set of covariates as well as a more limited set of covariates.

We choose to include our covariates in a stepwise manner (see Fig. A1, Supplementary Appendix), where we first include the more observable personal characteristics (demographics) and subsequently introduce the less observable contextual factors (socio-economics and lifestyle). In the next step we introduce unobservable personal traits by first including the Big Five personality traits, which are anticipated to impact SWB, then we include other personal skills and traits, for which there is little evidence on the association with SWB.

4.3 Is there heterogeneity in the association between chronic illness and SWB across personal characteristics?

To understand the underlying heterogeneity in SWB amongst individuals with chronic illness, we explore 22 personal characteristics and their propensity to predict variation in these individuals' well-being compared to the control. For the estimation of these heterogenous effects, we analyse the impact of having a chronic illness (irrespective of type of illness) and we focus only on general SWB. For each personal characteristic of interest, we estimate the following model (a total of 22 regressions):

$$SWB_i = \beta_0 + \beta_{1,p}Z_{i,p} + \beta_2 C_i + \beta_{3,p}Z_{i,p}C_i + \beta_{4,p-1}W_{i,p-1} + \nu_i, p = 1, \dots, 16 \tag{2}$$

where SWB_i is individual i's general well-being, and C_i is a dummy variable for having at least one chronic illness. Vector $Z_{i,p}$ is a subset of X_i from Eq. (1) that is interacted with chronic illness to estimate the added impact on SWB of being chronically ill and having a specific personal characteristic[8]. $W_{i,p-1}$ constitute the remaining variables from X_i, i.e., $W_{i,p-1} = X_i - Z_{i,p}$. v_i is our error term, and our control group consists of non-chronically ill individuals. We apply robust standard errors. $\beta_{3,p}$ is the parameter of interest and constitutes the additional impact of the personal characteristic on SWB due to chronic illness.

4.4 Can heterogeneity in SWB across personal characteristics among chronically ill individuals be explained by differences in health state and/or a differential association between health and SWB?

To better understand the variation in well-being when being chronically ill, we explore two possible sources of the heterogeneity in SWB across different personal characteristics: 1) differences in health state, and 2) differences in the association between health and SWB. For this purpose, we narrow our focus to the chronically ill individuals and first report difference in HRQoL for each personal characteristic, and second, estimate potential variation in the association between HRQoL and SWB for each personal characteristic. The latter is estimated by expanding Eq. (2) by including HRQoL as a covariate in the regression and including an interaction between the personal characteristic and HRQoL (a total of 23 regressions):

$$SWB_i = \gamma_0 + \gamma_{1,n}S_{i,n} + \gamma_2 H_i + \gamma_{3,n}S_{i,n}H_i + \gamma_{4,n-1}Q_{i,n-1} + \eta_i, \forall C_i = 1; n = 1, \dots, 17 \qquad (3)$$

where SWB_i and C_i are the same as in Eq. (2). $S_{i,n}$ includes the same personal characteristics as $Z_{i,p}$ in Eq. (2) as well as an additional variable for duration of chronic illness. $Q_{i,n-1}$ constitute the remaining covariates including duration of chronic illness. H_i is HRQoL. η_i is our error term, and we apply robust standard errors. $\gamma_{3,n}$ is the coefficient of interest as it comprises any differential association between HRQoL and SWB that is specific to a personal characteristic.

4.5 Robustness checks

To deal with potential specification issues, we perform numerous robustness analyses, which are included in the Supplementary Appendix.

In one robustness check, we define our continuous and ordinal covariates based on the median value instead of using them as continuous variables[9]. This allows for easier interpretation and reduces the influence of outliers. In another, we add a dummy variable for having multiple chronic illnesses to allow us to control for more severe cases of chronic illnesses as severity has been shown to matter (Uppal, 2006). In a third robustness check, we restrict our control group to only include individuals with a Charlson Comorbidity Index of zero, thereby getting a healthier control group. We drop 541 individuals with this specification of the control group. In a fourth robustness check, we weigh our regressions by survey weights provided by Statistics Denmark to recreate representativeness after dropouts[10]. Lastly, in a fifth robustness check, we add completion time of the survey as a covariate to ensure that our results are not driven by thoughtless answers by respondents rushing through the survey.

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[8] The only variable from X_i that is not interacted with chronic illness, i.e., not included in $Z_{i,p}$, is municipality.

[9] See Tables A2-A3 (Supplementary Appendix) for an overview of the median values of the personal characteristics.

[10] The survey weights calculated by Statistics Denmark are based on gender, age, family composition, education, socio-economic status, family income, type of immigrant, and labour market affiliation.

5. Results

5.1 Sample characteristics

Detailed summary statistics of characteristics of control and treatment groups can be found in Tables A4-A5 (Supplementary Appendix). Approximately one fourth of the sample have been diagnosed with a common chronic illness, 12.0% have more than one chronic illness, and the mean duration of living with their chronic illness is 11.6 years. Asthma (31.8%) and type 2 diabetes (30.4%) make up the largest shares of the chronically ill. COPD and osteoporosis constitute 22.9% and 20.5%, respectively, while rheumatoid arthritis (5.3%) and especially type 1 diabetes (1.9%) are less frequent.

We observe that general SWB is 3.5 points lower for those with a chronic illness (79.0, sd = 19.2) compared to those with no chronic illness (82.5, sd = 16.5). General SWB is lowest among individuals with COPD (76.2, sd = 20.5). We also see that SWB differs across the different domains, e.g., mean score on personal health is 62.5 (sd = 25.5), and mean score on community connectedness is 81.0 (sd = 19.4) for those with a chronic illness. The control group consistently score higher on the SWB domains. Finally, we observe that individuals with chronic illness differ from the control group on a range of personal characteristics.

5.2 What is the association between chronic illness and domains of SWB?

Fig. 1 displays the estimated associations for all eight SWB scores across the six chronic illnesses and the combined dichotomous variable for having at least one chronic illness. When controlling for the full set of covariates, the difference in general SWB is 2.0 points, constituting a reduction of 2.5% in average general SWB for those with chronic illness compared to the control group. That the impact of chronic illness remains significant despite controlling for a very large set of covariates demonstrates that having a chronic illness is an independent predictor of SWB. This also holds when we introduce Bonferroni correction.

As expected, chronic illness is associated with greater reductions in SWB scores in the personal health domain (8.3 points, constituting 11.6% of average personal health SWB). However, it is noteworthy that we observe a statistically significant link between SWB and scores for all domains. The association between chronic illness and lower scores on standard of living, personal health, community connectedness, and future security remain significant with the Bonferroni correction. It is also noteworthy that we find a statistically significant reduction in general SWB as well as the individual domains for most of our chronic illnesses, with the exception of asthma and rheumatoid arthritis. We find indications of variation in the degree to which chronic illness is associated with lower SWB across types of chronic illnesses, although the differences are not statistically significant in most cases. It is especially type 1 diabetes that appears to be associated with lower well-being (albeit the confidence intervals are large due to few respondents being diagnosed with type 1 diabetes). Looking at the larger groups of chronically ill, it is osteoporosis and COPD that appear to be more strongly associated with lower scores[11].

In Fig. A1 (Supplementary Appendix) we show results when we introduce our covariates in a stepwise manner. The role of chronic illness as predictor of SWB differs by inclusion of covariates, with chronic illness explaining between 4.3 points and 2.6 points. It is worth noting that these estimates are not statistically significantly different from each other, nor are they significantly different when compared to our base case analysis. This implies that the association

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[11] Table A6 (Supplementary Appendix) displays the results across the domains of SWB, PWI, and general SWB.

between chronic illness and SWB is not sensitive to the choice of covariates[12]. While there is some correlation between the covariates (see Fig. A2, Supplementary Appendix), there is no problem with multicollinearity when testing for this (results available upon request).

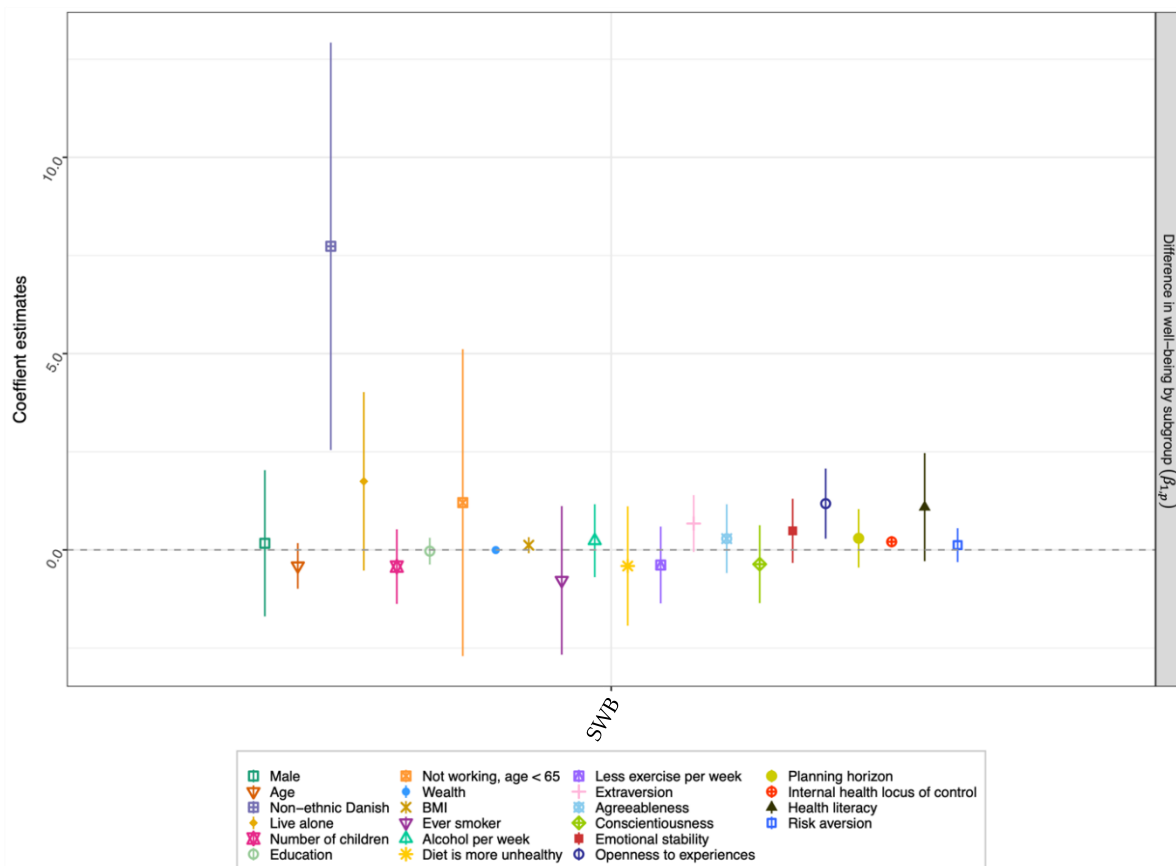**Fig. 1 Results from Eq. (1). Association between chronic illness and domains of SWB**
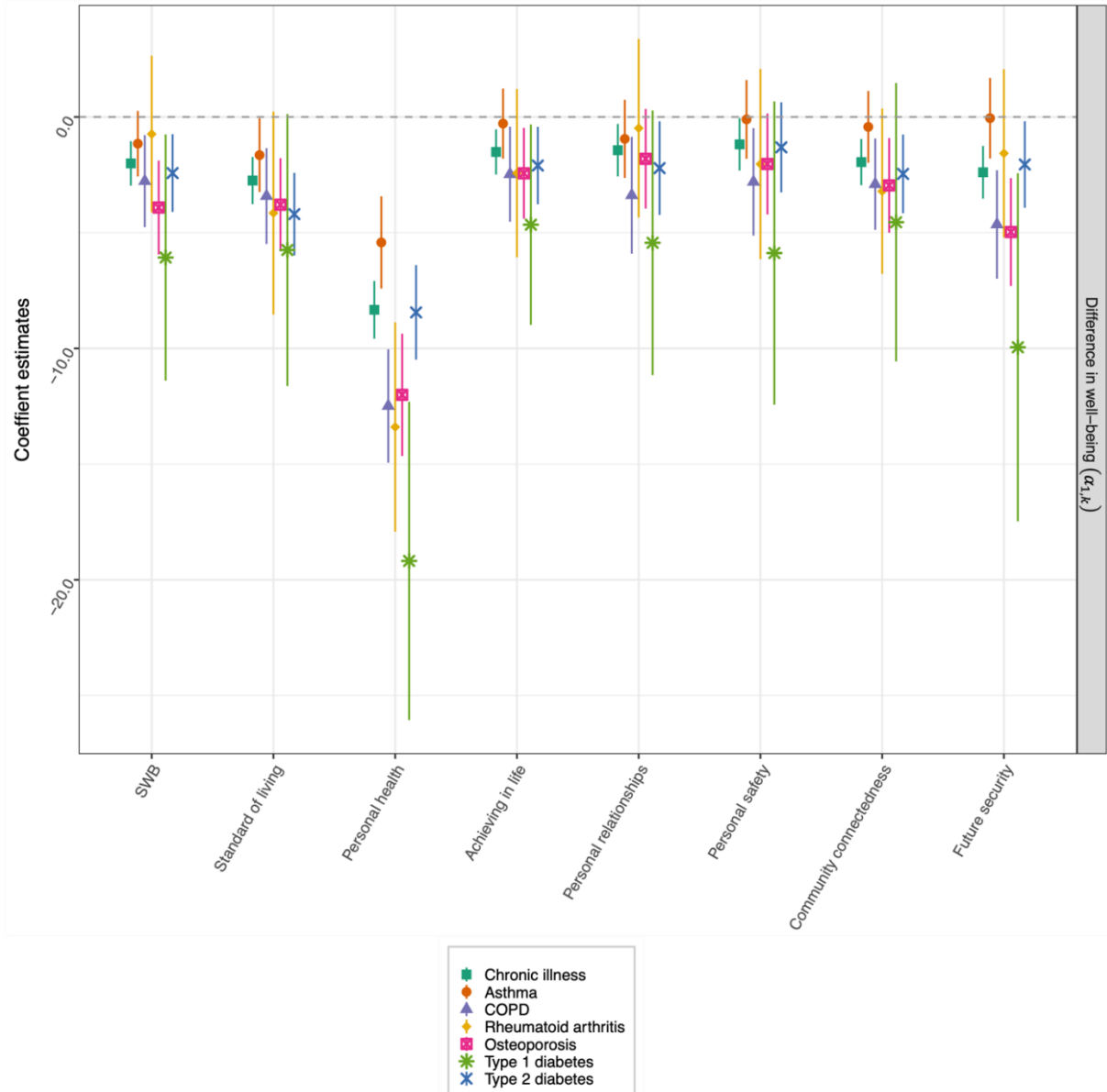
Note: The figure displays regression coefficients and their 95% confidence intervals (robust standard errors). We regress chronic illness on the seven domains of SWB and general SWB for each chronic illness and a combined variable for having at least one chronic illness. Specifications include the covariates: gender, age, non-ethnic Danish, living alone, number of children, municipality, years of education, labour market attachment, wealth in DKK 100,000, BMI, ever smoker, alcohol consumption, diet, exercise, extraversion, agreeableness, conscientiousness, emotional stability, openness to experiences, planning horizon, internal health locus of control, health literacy, and risk aversion.

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[12] AIC and BIC for the models in the stepwise inclusion support the model with all covariates (results available upon request).

5.3 Is there heterogeneity in the association between chronic illness and SWB across personal characteristics?

Fig. 2 presents the estimated heterogeneity in the association between having chronic illness and general SWB for each personal characteristic. Individuals with a non-ethnic Danish background experience a smaller detriment in their SWB score (i.e., a positive coefficient) compared to individuals with an ethnic Danish background (large confidence intervals are observed due to few individuals not being ethnic Danes). Likewise, individuals with higher degree of openness to experiences and individuals with higher internal health locus of control have higher scores on SWB. These results are all statistically significant at the 5% level, but none of the results remain significant when introducing the Bonferroni correction[13].

Fig. 2 Results from Eq. (2). Heterogeneity in the association between chronic illness and SWB across personal characteristics

Note: The figure displays the regression coefficients on the interaction between chronic illness and the personal characteristic of interest and their 95% confidence intervals (robust standard errors). We regress chronic illness on SWB for a combined variable for having at least one chronic illness. Regressions include the full set of covariates (see Section 4.3 and the note to Fig. 1) as well as interaction between chronic illness and the personal characteristic of interest. The regression for the interaction with labour market attachment is for the subgroup of individuals aged below 65 years.

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[13] Table A12 (Supplementary Appendix) shows the heterogeneity factors across the different domains of SWB. Some differences occur across SWB domains, e.g.,. less exercise per week implies lower scores on the personal health and future security domains, while living alone and being older reduce the scores for personal health.

5.4 Can heterogeneity in SWB across personal characteristics among chronically ill individuals be explained by differences in health state and/or a differential association between health and SWB?

To identify potential explanations for the heterogeneity in SWB observed in Fig. 2, we take the analyses one step further and focus on variation in well-being when being chronically ill. In Fig. 3, we explore whether the heterogeneity is driven by differences in health state or differences in the association between health and SWB. The upper panel presents the differences in HRQoL for each personal characteristic. The lower panel displays the differences in the association between health on SWB for the different personal characteristics.

In the upper panel of Fig. 3, it can be observed that HRQoL amongst chronically ill men is significantly better than that of chronically ill women. Age and having children have no impact on HRQoL, nor does an individual's planning horizon or duration of chronic illness, or whether an individual is conscientious or agreeable. However, we see significantly lower health for individuals living alone, individuals who are not working under the age of 65, individuals with a higher BMI, individual who report an unhealthier diet, as well as individuals who exercise less per week. Contrarily, individuals who consume more alcohol, have higher education, wealth, extraversion, emotional stability, openness to experiences, internal health locus of control, health literacy, and are more risk willing have higher HRQoL. All these results remain statistically significant when we introduce the Bonferroni correction. We also find that individuals who are non-ethnic Danes and individuals who are or have been smokers have lower health, but that statistical significance is only present without the Bonferroni correction.

When looking at the heterogeneity in the association between SWB and HRQoL across personal characteristics in the lower panel of Fig. 3, we see the association between health and SWB is lower (i.e., there is a negative interaction effect) for individuals with higher openness to experiences, implying that for these individuals, poorer health will be associated with smaller detriments to SWB. Interestingly, we find that the association between health and SWB is higher for individuals with higher wealth, suggesting that individuals with greater wealth are more affected by poorer health. These results remain statistically significant after Bonferroni correction. Moreover, we see that the link between health and SWB is higher among individuals who are current or past smokers, signifying that poorer health is associated with larger declines in SWB. For BMI, poorer health is associated with smaller decreases in SWB. These latter results are, however, not statistically significant with the Bonferroni correction.

The results in Fig. 3 provide an explanation for the results we observe in Fig. 2. For example, the higher SWB scores observed in Fig. 2 for individuals who are more open to experiences is likely explained by a combination of lower detriments in health state and weaker association between health and SWB. In contrast, the higher SWB score observed for chronically ill individuals with higher internal health locus of control seems to be explained only by better health state. While Fig. 3 provides some explanation for the results we observe in Fig. 2, the variation in SWB across personal characteristics may also stem from differences in SWB amongst the subgroups, which are unrelated to health. For example, chronically ill with a non-ethnic Danish background exhibit higher SWB than ethnic Danes (Fig. 2) despite them experiencing a lower health state (Fig. 3, upper panel). As the association between HRQoL and SWB (Fig. 3, lower panel) is the same across the two subgroups, our results suggests that the difference in SWB is driven by factors not attributable to health (or any of the observable characteristic we have controlled for)[14].

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[14] Table A13 (Supplementary Appendix) displays associations between HRQoL and SWB across the different SWB domains. Some differences occur across SWB domain, e.g., there is a stronger association between HRQoL and the

Fig. 3 Difference in health state (upper panel) and differential association between health and SWB (lower panel; results from Eq. (3)) among chronically ill individuals across personal characteristics
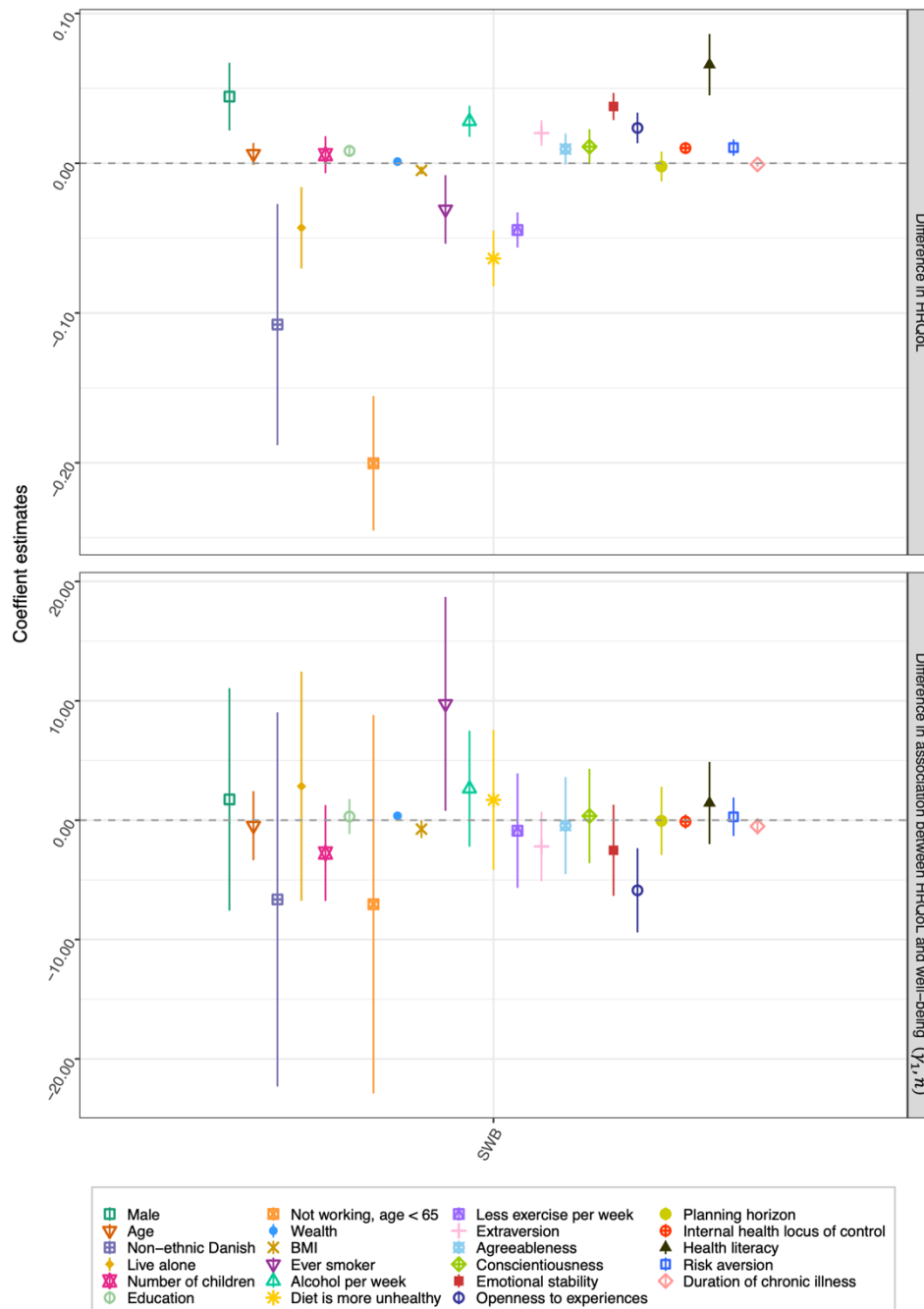
Note: The figure displays regression coefficients and their 95% confidence intervals (robust standard errors). We regress a combined variable for having at least one chronic illness on SWB. Regressions include the full set of covariates (see Section 4.4 and the note to Fig. 1) as well as HRQoL and interactions between HRQoL and the personal characteristic of interest. The sample only includes chronically ill individuals. Difference in HRQoL due to chronic illness across the personal characteristic of interest (upper panel) and the interaction between HRQoL and

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standard of living domain when living alone and a weaker association when having more children; having higher education strengthen the association between HRQoL and the achieving in life domain, and having a non-Danish ethnicity, high BMI, unhealthy diet and exercising less reduce the association between HRQoL and personal health SWB, while drinking more alcohol, being more extraverted, agreeable, conscientious, emotional stable, health literate, and risk willing heighten the association between HRQoL and the personal health domain.

the personal characteristic of interest (lower panel). The regression for the interaction with labour market attachment is for the subgroup of individuals aged below 65 years.

5.5 Robustness checks

We run several robustness checks to test our empirical strategy. Results for Eq. (1) are presented in Tables A7-A11 (Supplementary Appendix), while results for Eq. (2) and Eq. (3) are available upon request. Reassuringly, we still see the same negative associations between chronic illness and SWB and the same trends across domains of SWB and type of illness. Moreover, the observed heterogeneity in SWB amongst those who are chronically ill (Eq. (2)) is generally confirmed, as are the underlying variations in health and the estimates of the interaction between SWB and health (Eq. (3)). More specifically, when introducing a healthier control group in Eq. (2), we observe that extraversion, health literacy and health locus of control become statistically significant predictors (albeit only health locus of control remains significant after Bonferroni correction).

6. Discussion

Our study places itself in the limited literature examining the association between chronic illness and SWB among older individuals. We contribute to the literature by investigating different domains of SWB, by identifying personal characteristics that moderate the association between SWB and chronic illness, and by exploring two possible sources of variation in SWB.

A major strength of this study is the combination of data sources that allows us to overcome some of the shortcomings of previous research relying solely on self-reported measures. The Danish registers enable us to take account of an extensive set of covariates which is often a limitation in studies using survey data. At the same time, the survey data allows us to include covariates that go beyond the usually applied socio-demographic variables. We demonstrate, by controlling for a long list of covariates, that chronic illness is an independent predictor of SWB.

In our heterogeneity analyses we focus on how personal characteristics may moderate the association between chronic illness and SWB as well as the association between HRQoL and SWB among the chronically ill. We find no moderating impact of age which may be explained by the fact that our sample only encompasses 50-80 year olds. Interestingly, we observe that being chronically ill and having a non-ethnic Danish background entails higher SWB despite poorer health. This is not explained by a weaker association between SWB and health state. Thus, it appears that individuals with a non-ethnic Danish background have a higher level of SWB independent of health. Possible reasons for this result may be found in, e.g., religious beliefs, larger family networks, or other unobservable characteristics not associated with health. Chronically ill individuals with higher levels of education as well as individuals with labour market attachment (below 65 years of age) have better health, but this does not encompass higher SWB. Higher wealth is also associated with better health, and we see a positive statistically significant impact on the association between SWB and HRQoL, suggesting that wealthy individuals experience greater loss in SWB as their health deteriorates, perhaps due to higher expectations. Although we observe differences in health across socio-economic characteristics, we do not see the expected differences in SWB. A possible reason for this result may be the beneficial social security system and a relatively low income inequality in Denmark. We cannot exclude the possibility that sample selection may explain the lack of impact if non-responders are individuals with lower educational attainment and lower wealth who are more adversely affected by their chronic illness. However, when we weight our regressions by survey weights, we see a similar pattern (results available upon request), which suggests that selection may not

be a key driver. That socio-economic characteristics do not moderate the association between chronic illness and SWB may also be explained by the fact that we control for personality traits. Yet, when we drop these covariates, our results remain unchanged (results available upon request).

We find some indication that healthy lifestyle moderates the association between SWB and health, as also seen previously in the literature (Kuroki, 2016; Phulkerd et al., 2021; Shi et al., 2019). Being a current or past smoker strengthens the association between HRQoL and SWB, suggesting that smokers in poorer health are more exposed. In addition, they also have lower health compared to non-smokers. We also find that individuals with higher BMI have lower health, but that more overweight individuals are less affected by poor health on their SWB. Interestingly, we find that personal skills and traits predict vulnerability. Our results indicate that openness to experiences and internal health locus of control moderate the association between SWB and chronic illness. This is in line with previous literature that have found that personality traits have a substantial effect on the well-being levels of individuals (Diener & Ryan, 2009). We observe that lower SWB is explained by a poorer health state, and also through a weaker association between SWB and HRQoL among individuals who are more open to experiences.

Early literature claimed that SWB is relatively stable across time and that individuals' adaptive behaviour allow them to adjust to life events and bring them back to their setpoint of well-being over time (Diener & Suh, 1998; Suh et al., 1996). However, more recent studies indicate a more nuanced picture of adaption; that the amount of adaptation varies by life event, whether events repeat, and also on the chosen measure of SWB (Diener & Ryan, 2009; Kettlewell et al., 2020). In our study, we proxy adaptation using duration of chronic illness. Our results are not significant, but chronically ill individuals with a longer duration tend to fare better, which is in line with the theory of hedonic adaptation (Diener et al., 2006), and in line with previous results relating to disabilities (Oswald & Powdthavee, 2008; Pagán-Rodríguez, 2010).

The association between chronic illness and individuals' well-being is likely to have the same qualitative impact for other chronic illnesses and across countries. However, the magnitude of the association and which factors that predict SWB is likely to vary by type of illness (as seen by our results) and country due to, e.g., differences in severity and disease management, and different cultures and institutional settings (Biswas-Diener et al., 2010; Diener et al., 2003). van Campen and van Santvoort (2013) provide evidence that the gap in SWB between individuals with chronic disabilities and non-disabled is greater in Eastern European countries than in the Northern countries. Because the basic principles of the Danish welfare system is that all citizens have equal rights to social security, free and equal access to healthcare, and free education at large at all levels (Ministry of Health, 2017), the link between chronic illness and SWB is likely to be weaker compared to other countries with less favourable institutional settings. More specifically, for the chronically ill we observe limited heterogeneity in SWB across socio-economic characteristics, which is likely a product of a well-functioning social security system and few individuals suffering from financial hardship.

Some shortcomings of the study should be considered when interpreting our findings. Firstly, an obvious methodological problem is that the association between illness and well-being may be subject to confounding. We seek to overcome this by including a comprehensive amount of covariates. Despite potential overcontrolling, we see a negative association between chronic illness and SWB, implying chronic illness is an independent predictor of SWB.

Secondly, potential reverse causality renders it difficult to identify a causal direction, which is also why we refrain from interpreting our results as causal. Others have found indications that

there may be a reversed causality mechanism present. Diener (2013) finds that increased well-being has beneficial effects on health and longevity, social relationships, and productivity. It should be noted that we observe a negative impact on SWB for individuals diagnosed with type 1 diabetes (an illness which due to its strong genetic component is random and not life-style related), suggesting that the association we observe between chronic illness and SWB is likely to be explained by chronic illness impacting on SWB, and not vice versa. Further, personal characteristics may change as a result of health state and chronic illness. This endogeneity problem is particularly difficult to overcome because our covariates are measured after diagnoses. Factors such as living situation, labour market attachment, wealth, and lifestyle are likely time variant and dependent on health. While traditional theory builds on the assumption that personality traits, skills and preferences are stable over time, not all empirical evidence agrees. The Big Five personality traits are most likely stable over time (Cobb-Clark & Schurer, 2012), but time preferences, locus of control, health literacy and risk aversion might at least to some degree be time-variant and are likely influenced by health state (Baker et al., 2000; Becker & Mulligan, 1997; Cobb-Clark & Schurer, 2013; Decker & Schmitz, 2016).

Thirdly, the relatively small sample makes it difficult to fully investigate the predictive role of the personal characteristics and whether lower SWB is a result of poor health or lower ability to cope with health. We encourage researchers with larger samples to further study the underlying mechanisms of SWB.

That longitudinal large scale studies are warranted is supported by our findings which imply that individuals who live with chronic illnesses are indeed impacted on many dimensions of life, e.g., standard of living and future security. Well-being is thus more than health, and policymakers and healthcare personnel may have a better basis for providing cost efficient and equitable healthcare if they increasingly focus on individuals' multidimensional well-being and not only on their HRQoL. This is particularly relevant in the case of micro-prioritisation, where the optimal healthcare solution is to be found for the individual chronically ill individual. Nevertheless, it should be acknowledged that the heterogeneity that we have observed in the association between SWB and HRQoL raises some dilemmas, as the choice of objective (to maximise SWB or to maximise HRQoL) may point to different prioritisations across patient groups with different personal characteristics. For instance, is it fair to prioritise individuals whose well-being all else equal is more affected by their chronic illness than individuals in the same health state who are better at adapting to the situation? This ultimately raises the issue of whether SWB varies across individuals with similar levels of health for legitimate or illegitimate reasons (Baker et al., 2000; Becker & Mulligan, 1997; Cobb-Clark & Schurer, 2013; Decker & Schmitz, 2016). Examples of the latter could be low expectations in life, or an increased ability to adapt to poor circumstances due to adverse childhood circumstances. Examples of the former could perhaps be other priorities in life due to religious beliefs, other family constellations, or preferences linked to personal characteristics that are not formed by social structures. The distinction is clearly difficult to make, but also essential as underlying sources of the SWB-HRQoL relationship may justify different policy strategies. One may choose to channel *more* healthcare resources towards individuals with low capacity to generate SWB from HRQoL in order to reduce inequity in SWB. Alternatively, one may choose to devote *less* healthcare resources to these individuals in order to improve cost-effectiveness. The COVID-19 pandemic has demonstrated that societal welfare is more than maximisation of health, and thus the concept of SWB as a welfare goal is likely to be debated in the years to come.

7. Conclusion

We find robust evidence of negative associations between chronic illness and older individuals' well-being on general SWB as well as on all seven domains of SWB. This is an important and policy relevant finding as it stresses the importance of ensuring that chronically ill individuals fare well in all domains of life, and that having a chronic illness not only impacts on health state. Further, we find indications of heterogeneity in SWB across some personal characteristics suggesting that specific attention may be given to individuals at high risk of experiencing greater losses in SWB when they are chronically ill. We also demonstrate that heterogeneity in SWB across personal characteristics may be explained by both variations in health state and variations in the association between health state and SWB, suggesting that the ability to stay healthy and the ability to cope with detriments in health when being chronically ill varies systematically across groups in society. Identifying such sources of reduced SWB is a valuable guide when designing patient-centred interventions targeting chronically ill populations if the aim is to ensure a reasonable level of SWB for all.

Appendix A. Supplementary data
Supplementary data to this article can be found online at
https://internationaljournalofwellbeing.org/index.php/ijow/article/view/2443

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Conflict of interest
The authors declare no conflicts of interest.

Data availability statement
Due to Danish Data Protection Legislation, only Danish research environments can be granted authorisation to Danish administrative registers.

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