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Measuring subjective wellbeing in patients with heart disease: relationship and comparison between health-related quality of life instruments

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Abstract

Purposes This study aimed to validate the use of subjective wellbeing (SWB) in patients with heart disease, to explore the complementary vs substitute relationship between SWB and health status utility (HSU), and to reveal which life domains matter for patients with heart disease compared to healthy persons.

Methods Data were obtained from a large multi-national, multi-instrument comparison survey. Subjective wellbeing instruments (ONS4, PWI, SWLS), health status utility instruments (15D, AQoL-8D, EQ-5D-5L, HUI3 and SF-6D) and a disease-specific quality of life instrument (MacNew) were administered among patients with heart disease ($N = 943$). Validity and sensitivity of SWBs were studied. Exploratory factor analysis (EFA) was performed to examine the difference in descriptive systems between the SWB, HSU and MacNew. The importance of life domain satisfaction in explaining overall life satisfaction was investigated using regression analysis.

Results The known-group analysis showed that both SWB and HSU scores differed according to changes in the severity of heart disease. EFA showed that SWB and HSU were generally complementary instruments. The life domains that were significantly important to patients with heart disease were standard of living, followed by achieving in life, personal relationships, personal health, and future security. Compared to the healthy public, personal health and future security were significantly more important life domains.

Conclusions Assessing SWB provides complementary information on understanding heart patients' subjective outcome over the use of quality of life instruments alone. Given the adverse psychological impact of heart disease, addressing the important domain revealed by SWB assessment in management planning should be considered.

Keywords Subjective wellbeing · Health status utility · MacNew · Health-related quality of life · Heart disease

Introduction

Heart disease, including coronary heart disease, cardiomyopathy, heart failure, cardiac dysrhythmia and valve heart disease, is the most common cause of death worldwide [1, 2]. Most categories of heart disease are lifelong conditions despite advances in treatment over recent decades. Heart disease is a major cause of death and disability—approximately one-third of all deaths in people older than 35 years in developed economies occur from coronary heart disease alone [3–5]. With the aim of improving survival and preventing recurrent cardiovascular events, the ongoing care of patients with heart disease involves comprehensive management of risk factors through lifestyle modification (e.g. smoking cessation, weight control or physical activity) and evidence-based medical therapies. Given most heart diseases are not

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curable, it has been acknowledged that improving the quality of life (QoL) of those patients is as important as the survival benefits provided by pharmacological treatment [6–8].

Heart disease is commonly associated with disability. Patients who live with heart failure or survive an acute coronary event may live for an extended period of time but often may be incapacitated [9]. In calculating quality-adjusted life years (QALY), a health state utility (HSU), which lies on a 0–1 death-full health QALY scale, indicating that the strength of people's preference for different health states is applied to account for the negative impact of their health condition on survival (i.e. living with disability); such QALYs can then be used in cost utility analyses. Subjective well-being (SWB) refers to a broad category of phenomena that includes emotional responses, domain satisfactions, and global judgements of life satisfaction. It has been recently proposed that, in quantifying people's wellbeing, SWB should be considered in health-care resource allocation [10]. Often, health-related quality of life (HRQoL) as assessed by HSU instrument and overall QoL, as represented by SWB, are considered interchangeable concepts; little attention has been paid to their potential different roles in informing QoL (i.e. whether SWB could provide a different picture of QoL that may change the management of disease). One study suggested that the focus on HRQoL only may lead to an inadequate understanding of the long-lasting treatment effects that are critical to patients [11]. Therefore, a more complete picture of QoL probably should include both HSU and SWB assessments given that SWB includes non-functional or non-health-related aspects of life that are nevertheless important from the patients' point of view.

SWB and health are closely related, and maintaining wellbeing is growing in importance given the advances in effective treatment that are preventing mortality and improving life expectancy [12]. The association between impaired SWB and increased risk of physical illness [13], plus the possibility of positive SWB being a protective factor [14] for health, undoubtedly highlight the importance of SWB in health. Moreover, for cardiovascular disease (CVD), there is growing evidence that positive psychological factors are associated with a lower risk of CVD mortality [15, 16]. Hence, promoting the well-being of patients with CVD is not only a treatment target but also a potential facilitator of effective anti-CVD treatment. It has been recommended by US Food and Drug Administration (FDA) [17] and European Medicine Agency (EMA) [18] that patient-reported outcome measures such as QoL should be included in both clinical care and research studies. Policy makers have embraced the idea that measuring SWB can provide meaningful information that can be factored into decisions about how to monitor progress, and to inform and evaluate policy [19]. In view of these, SWB could be another important index for QoL and has the potential to be used more broadly as a measure of benefit across different sectors (e.g. social care services, long-lasting consequence of disease) [20].

Although it is an important goal to improve the QoL for patients suffering from heart disease, information concerning the roles and relative merits of the HSU and SWB in measuring QoL in this population is sparse: there is a lack of comprehensive evaluation of the use of SWB in heart disease, and there has been little examination of the relationship between HSU and SWB in this disease area. Nearly all the studies assessing the QoL of patients with heart disease adopted the HSU or a non-preference-based disease-specific QoL instrument (e.g. MacNew Heart disease health-related quality of life, MacNew). This study aimed: (i) to validate the use of SWB measures in patients with heart disease and compare their psychometric properties with HSU measures; (ii) to explore the complementary vs substitute relationship between SWB & HSU; and (iii) to reveal which life domain satisfaction matters more for patients with heart disease as compared to the healthy public.

Methods

Survey

Data for the study were obtained from a large multi-national, multi-instrument comparison (MIC) survey. Details of the survey were reported elsewhere [21]. Briefly, the survey consisted of three subjective wellbeing and six health state utility instruments, and a disease-specific QoL instrument. The online survey (implemented by a global panel company—CINT Australia Pty Ltd) was administered in six countries: Australia, Canada, Germany, Norway, the UK and the USA and completed by more than 8000 participants (healthy public and people with seven chronic diseases). Among the seven chronic disease groups (diabetes, arthritis, heart diseases, depression, asthma, hearing loss, and cancer) included in this multi-country study, the current paper focuses on the heart disease group ($N=943$). Ethics approval was granted by the Monash University Human Research Ethics Committee, Monash University, Australia (Reference no. CF11/3192-2011001748). The study adhered to the principles outlined in the Declaration of Helsinki.

Questionnaires

SWB instruments

The Office for National Statistics 4 (ONS4) was firstly introduced by the ONS in UK in 2011. It uses four survey questions to measure satisfaction, eudemonia, and experience [22]. Individual question response scores (ranging from 0

"not at all" to 10 "completely") are averaged across the four questions to give an ONS4 score.

The Personal Wellbeing Index (PWI) is an overall measure of life satisfaction comprising seven domains: standard of living, health, achieving in life, personal relationships, safety, community connectedness and future security [23]. Each specific life domain is scored from 0 "no satisfaction at all" to 10 "completely satisfied", and the PWI is calculated by taking an average score of the seven life domain scores. A stand-alone general life satisfaction question is also included in the PWI questionnaire "Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole?"; it is used to explore the relative importance of the seven life domains, but it is not part of the PWI.

The Satisfaction with Life Scale (SWLS) is one of the most widely used SWB instruments which uses a five-item scale (ranged from 1 "strongly disagree" to 7 "strongly agree") to measure global cognitive judgements of one's life satisfaction [24]. SWLS is one of the most widely used SWB instruments [25] and it is a valid and reliable measure of life satisfaction, suitable for use with a wide range of age groups and application [26]. The SWLS is calculated by summing up scores on all five items.

HSU instruments

The 15D is a generic 15-dimensional preference-based measure of HRQoL. The 15D (which can define 3.1×10^{10} health states) has been validated in patients with cardiac patients and was scored based on the original Finnish Tariff [27, 28].

The Assessment of Quality of Life-8D (AQoL-8D) is a 35-item comprehensive preference-based measure of HRQoL and was developed to increase the sensitivity of psycho-social health [29]. It contains eight dimensions, including independent living, senses, pain, mental health, happiness, self worth, coping, and relationships, and can define a total of 2.4×10^{23} health states. The AQoL-8D was scored based on an Australian-specific tariff [30].

The EQ-5D-5L is an updated version of the most widely used EQ-5D-3L, which extends the response level of each of the five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) to five levels. The new version can define 3,125 different health states comparing to 243 of EQ-5D-3L [31]. The EQ-5D-5L was scored using the England tariff [32].

The Health Utility Index-3 (HUI3) is capable of measuring 972,000 unique health states [33, 34]. The classification system of HUI3 includes eight dimensions consisting of vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain. The HUI3 was scored based on a Canadian specific tariff [35].

The SF-6D, which has 6 dimensions (physical functioning, role participation, social functioning, bodily pain, mental health, and vitality), was derived from the SF-36 questionnaire. A total of 18,000 health states can be defined by SF-6D. The SF-6D was scored using the UK tariff [36].

Disease-specific quality of life instrument (MacNew)

The MacNew questionnaire, a disease-specific non-preference-based QoL tool focusing on disease-relevant issues, is recommended as an appropriate outcome measure in both therapeutic intervention trials [29] and routine clinical care [30], and has the merits of being more evaluative, predictive and discriminative in assessing QoL [31]. The MacNew questionnaire is one of the most widely administered disease-specific HRQoL tools used for patients with heart disease, which includes an item referring to "your heart problem", is a modification of the Quality of Life after Myocardial Infarction questionnaire [37]. It consists of 27 items which fall into three domains: a 13-item physical limitations domain scale, a 14-item emotional function domain scale, and a 13-item social function domain scale. It is designed to assess a patient's feelings about how their heart problem affects daily functioning. Five items relate to symptoms: angina/chest pain, shortness of breath, fatigue, dizziness, and aching legs [38, 39]. The items and scales are scored from 1 (low HRQoL) to 7 (high HRQoL) and a minimal important difference (MID) on each MacNew scale is 0.50 points [40].

Statistical analysis

Descriptive statistics including means, standard deviation (SD), and histogram distributions were reported. All three SWB scores were normalised to a score sitting between 0 and 1 to facilitate the comparison, with a higher score suggesting a better SWB. To explore the validity and sensitivity of SWBs and to compare them with the HSU instruments in heart disease (Aim 1), both concurrent validity and known-group (construct) validity were undertaken. Particularly for concurrent validity, Spearman's correlation coefficients were estimated, with a correlation coefficient greater than 0.7 indicating strong agreement [41, 42].

To investigate the known-group validity, the whole sample was divided into three subgroups (mild, moderate, severe) according to the mean and 0.5 standard deviations of the MacNew global/dimensional scores. Regression analysis, with ordinary least squares model with each of the SWB/HSU score as the dependent variable, was employed to examine the variation accounted for by MacNew global or each of the MacNew dimensional scores together with other sociodemographic variables (i.e. a set of gender, age, education and country dummies). Owing to the high collinearity among the three MacNew dimensional scores, each dimension was included

at the one time. Standardised beta coefficients were reported to facilitate the comparisons among different outcome measures. It was hypothesised that, compared to the middle severity group, those classified as mild or severe had significantly better or worse SWB and HRQoL, respectively.

To further explore the discrepancy/correlation in the descriptive systems of the different instruments (Aim 2), two exploratory factor analyses (EFAs) include MacNew, SWLS and a HSU (either a brief EQ-5D-5L or the most comprehensive AQoL-8D) were carried out using the maximum likelihood method. The number of factors to be extracted was determined using the parallel analysis. Rotation was performed using an oblique Promax method to allow for potential correlations among factors.

Lastly, this study investigated the relative importance of life domain satisfactions in patients with heart disease as well as the differences compared to a healthy population (Aim 3). To this aim, we further include a healthy public sample from the MIC data defined as the absence of chronic disease and self-rated score of greater than 70 on a 0 (death) to 100 (best possible (physical, mental, and social) health) visual analogue scale [21] in the regression analysis. A set of seven interaction terms between heart disease dummy and each life domain satisfaction was generated and included in the regression analysis. The significance and the direction of the interaction terms revealed the difference on the life domain satisfaction between patients and the healthy public. The analysis framework follows the classic bottom-up approach in which the overall life satisfaction was explained by (regressed on) different life domain satisfactions [43]. Both linear (i.e. ordinary least squares, OLS estimator) and non-linear models were used. Results from linear models are easy to interpret and can be compared to previous literature. However, it is a more restricted function form such that we have further considered potential non-linearity using a more flexible extended estimating equations (EEE) estimator [44, 45]. The link test for model specification indicates that the EEE estimates are preferable to the OLS estimates.

All regressions controlled for gender, age, education, country of participants and a constant. *P* values reported are two-sided and considered statistically significant when the values are below 0.05. All the statistical analyses were performed using Stata 15.0 (StataCorp LP, College Station, TX) except the factor analysis was carried out with EViews version 10 (IHS Global Inc., Irvine, CA, USA).

Results

Descriptive statistics

In total, 943 participants from six countries completed all the outlined instruments online. The majority of surveyed patients diagnosed with heart disease were male (64%) and aged 55 years or over (70%). The socio-demographic characteristics and overall score of each of the HSU, SWB and MacNew are presented in Table 1. Briefly, the mean global score of MacNew is 5.266 (SD 1.096), the mean HSU ranges from 0.700 (SD 0.261) of HUI3, or 0.700 (SD 0.133) of SF-6D to 0.831 (SD 0.128) of 15D, and the mean SWB score varies from 0.571 (0.242) of SWLS to 0.650 (SD 0.216) of ONS4, respectively. See detailed distribution of each instrument in Supplementary Fig. 1. Table 1 also presents the characteristics of the healthy public sample that was used in Aim 3 of this study. It is worth noting that the patients with heart disease were different from the healthy public in terms of the distribution of age and gender and the participant characteristics were controlled for in the regression analyses.

Concurrent validity

Table 2 shows the Spearman's correlation coefficients (r_s) among three type of outcome measures in heart disease patients. The MacNew is more strongly correlated with HSU instruments than with the SWB measures. Within the HSU instruments, the AQoL-8D ($r=0.839$) and 15D ($r=0.788$) outperformed other HSU in terms of magnitude of the correlation coefficient with the MacNew global score; amongst the SWB instruments, ONS4 ($r=0.624$) was associated with a higher correlation coefficient than the other two instruments ($r=0.580$ for PWI and $r=0.567$ for SWLS, respectively). Secondly, between the HSU and SWB measures, the highest correlation coefficient was found between the AQoL-8D and ONS4 ($r=0.664$) while the lowest was between EQ-5D-5L and PWI ($r=0.463$).

Known-group validity

Regression results in Table 3 indicate that the known-groups sufficiently differentiated both the HSU and SWB scores. Based on the standardised beta coefficients, it can be seen that between the mild and moderate severity groups, the AQoL-8D had the largest beta coefficient (−0.493), whilst the SWB measures had smaller beta coefficients compared to any of the HSU measures. Between the moderate and the most severe groups, the SF-6D had the largest beta coefficient (0.453), followed by AQoL-8D (0.396), 15D (0.347), three SWB measures (0.289–0.317), whilst EQ-5D-5L (0.230) and HUI3 (0.285) ranked the bottom. Regarding other socio-demographic characteristics, higher education (i.e. University degree) was significantly associated with SWB but not with HSU. Age and gender show mixed results. Generally, the included variables were able to account for up to 65.2% of variation in AQoL-8D or 37.9% of variation in ONS4.

Table 1 Descriptive statistics

	Heart disease ($N=943$)	Healthy public ($N=1760$)
Panel A: Socio-demographic characteristics (*N*, %)		
Age (years)		
18–44	126 (13.36)	819 (46.53)
45–54	161 (17.07)	347 (19.72)
55–64	335 (35.52)	280 (15.91)
≥65	321 (34.04)	314 (17.84)
Male	605 (64.16)	841 (47.78)
Education		
High school	281 (29.80)	592 (33.64)
Diploma or certificate or similar	417 (44.22)	683 (38.81)
University and over	245 (25.98)	485 (27.56)
Country		
Australia	149 (15.80)	265 (15.06)
Canada	154 (16.33)	328 (18.64)
Germany	152 (16.12)	260 (14.77)
Norway	151 (16.01)	288 (16.36)
United Kingdom	167 (17.71)	298 (16.93)
United States of America	170 (18.03)	321 (18.24)
Panel B: Disease-specific quality of life (mean, SD)		
MacNew global score	5.266 (1.096)	NA
MacNew emotional	5.098 (1.154)	NA
MacNew physical	5.297 (1.254)	NA
MacNew social	5.530 (1.240)	NA
Panel C: Subjective wellbeing (mean, SD)		
ONS4	0.650 (0.216)	0.720 (0.176)
PWI	0.637 (0.196)	0.720 (0.162)
PWI (life as a whole)	0.654 (0.232)	0.722 (0.195)
SWLS	0.571 (0.242)	0.650 (0.207)
Panel D: Health state utility (mean, SD)		
15D	0.831 (0.128)	0.943 (0.064)
AQoL-8D	0.683 (0.226)	0.825 (0.142)
EQ-5D-5L	0.793 (0.210)	0.930 (0.089)
HUI3	0.700 (0.261)	0.884 (0.138)
SF-6D	0.700 (0.133)	0.800 (0.108)

Three subjective wellbeing (ONS4, PWI and SWLS) scores were re-scaled onto a 0–1 scale

ONS4 4-item personal well-being index proposed by the Office for National Statistics, *PWI* Persona Well-being Index, *SWLS* satisfaction with life scale, *15D* 15 dimensional, *AQoL-8D* assessment of quality of life-8 dimension, *EQ-5D-5L* EuroQol-5D-5L, *HUI3* health utility index-3, *SF-6D* Short-Form 6 Dimensions, *SD* standard deviation, *NA* not applicable

In the second set of regressions (Table 4), in which each sub-scale was included separately into the regression, the emotional scale of the MacNew generally contributed more to the variation in SWB than the other two scales. For patients with less severe heart disease (as defined by MacNew), AQoL-8D might be more sensitive to changes in MacNew emotional domain while for patients with more severe heart disease, SF-6D might be a better option. Among the SWB measures, the largest beta coefficient came from the ONS4 (0.423); however, it was still lower than the AQoL-8D (0.524). Similarly for the other two MacNew scales, it can be seen that the sensitivity of different HSU instruments varied and this highlighted the importance to take account of the disease severity when selecting appropriate HSU; in addition, all HSU measures had higher beta coefficients than the SWB measures.

Table 2 Spearman's correlations among outcome measures in heart disease ($N=943$)

	MacNew heart disease				Subjective wellbeing			Health state utility				
	Global	Emotional	Physical	Social	ONS4	PWI	SWLS	15D	AQoL-8D	EQ-5D	HUI3	SF-6D
MacNew global	1											
MacNew emotional	0.929	1										
MacNew physical	0.935	0.750	1									
MacNew social	0.929	0.828	0.945	1								
ONS4	0.624	0.727	0.446	0.511	1							
PWI	0.580	0.632	0.459	0.496	0.750	1						
SWLS	0.567	0.635	0.433	0.475	0.813	0.764	1					
15D	0.788	0.679	0.797	0.749	0.481	0.491	0.493	1				
AQoL-8D	0.839	0.835	0.740	0.755	0.664	0.643	0.643	0.844	1			
EQ-5D	0.744	0.671	0.725	0.698	0.484	0.463	0.480	0.832	0.790	1		
HUI3	0.709	0.643	0.687	0.633	0.510	0.494	0.530	0.846	0.815	0.830	1	
SF-6D	0.770	0.744	0.753	0.743	0.553	0.504	0.504	0.805	0.831	0.761	0.750	1

All Spearman's correlation coefficients are statistically significant ($P<0.001$)

ONS4 4-item personal well-being index proposed by the Office for National Statistics, *PWI* persona wellbeing index, *SWLS* satisfaction with life scale, *15D* 15 dimensional, *AQoL-8D* assessment of quality of life-8 dimension, *EQ-5D-5L* EuroQol-5D-5L, *HUI3* health utility index-3, *SF-6D* Short-Form 6 Dimensions

Table 3 Known-groups validity of generic outcome measures in heart disease

	Subjective wellbeing			Health state utility				
	ONS4	PWI	SWLS	15D	AQoL-8D	EQ-5D-5L	HUI3	SF-6D
Panel A: Heart disease severity (ref.: mean-0.5SD < MacNew global < mean + 0.5SD)								
MacNew global ≤ mean-0.5SD	−0.345**	−0.276**	−0.250**	−0.484**	**−0.493****	−0.487**	−0.458**	−0.420**
MacNew global ≥ mean + 0.5SD	0.291**	0.289**	0.317**	0.347**	0.396**	0.230**	0.285**	**0.453****
Panel B: Socio-demographic characteristics								
Male	−0.060*	−0.023	−0.048	0.031	0.044*	0.042	0.019	0.068**
Age (ref.: 18–44 years)								
Age: 45–54	−0.041	−0.057	−0.078*	−0.103**	−0.063*	−0.138**	−0.133**	−0.037
Age: 55–64	−0.007	−0.022	−0.103*	−0.148**	−0.043	−0.165**	−0.161**	−0.034
Age: ≥65	0.102*	0.092*	0.028	−0.154**	0.024	−0.142**	−0.163**	−0.012
Education (ref: high school or below)								
Education: Diploma	0.031	0.019	0.029	0.012	0.028	0.003	0.004	0.002
Education: University	0.068*	0.103**	0.083*	0.026	0.035	0.004	0.038	0.008
Obs.	943	943	943	943	943	943	943	943
R^2	0.379	0.351	0.325	0.556	0.652	0.452	0.455	0.607

Three subjective wellbeing (ONS4, PWI and SWLS) scores were re-scaled onto a 0–1 scale. Standardised beta coefficients reported in the table. **$p<0.01$, *$p<0.05$. The largest beta coefficients in heart disease severity panel are bolded. Other than what has been reported, covariates also include a set of country dummies and a constant

ONS4 4-item personal well-being index proposed by the Office for National Statistics, *PWI* persona wellbeing index, *SWLS* satisfaction with life scale, *15D* 15 dimensional, *AQoL-8D* assessment of quality of life-8 dimension, *EQ-5D-5L* EuroQol-5D-5L, *HUI3* health utility index-3, *SF-6D* short-form 6 dimensions

Exploratory factor analysis

The EFAs are reported in Table 5 and Table 1 in Online Appendix. The identified latent factors were weakly to moderately correlated in two sets of EFA analyses, with the absolute correlation coefficient ranging from 0.41 to 0.61 in the analysis involving the EQ-5D-5L, and from 0.32 to 0.69 in the analysis involving the AQoL-8D. Both EFAs indicated that the 5-item SWLS instrument fell on a separated factor that was weakly related with either the HSU or MacNew

Table 4 Known-groups validity of generic outcome measures in heart disease (by three domains)

	Subjective wellbeing			Health state utility				
	ONS4	PWI	SWLS	15D	AQoL-8D	EQ-5D-5L	HUI3	SF-6D
Panel A: MacNew heart disease emotional domain								
Emotional function ≤ mean-0.5SD	−0.423**	−0.348**	−0.357**	−0.441**	**−0.524****	−0.454**	−0.468**	−0.404**
Emotional function ≥ mean + 0.5SD	0.344**	0.269**	0.307**	0.273**	0.362**	0.206**	0.212**	**0.415****
Covariates	√	√	√	√	√	√	√	√
R^2	0.492	0.387	0.396	0.425	0.635	0.386	0.391	0.531
Panel B: MacNew heart disease physical domain								
Physical function ≤ mean-0.5SD	−0.276**	−0.226**	−0.179**	**−0.480****	−0.429**	−0.475**	−0.409**	−0.419**
Physical function ≥ mean + 0.5SD	0.176**	0.222**	0.241**	0.339**	0.341**	0.222**	0.286**	**0.409****
Covariates	√	√	√	√	√	√	√	√
R^2	0.251	0.277	0.232	0.563	0.535	0.446	0.417	0.575
Panel C: MacNew heart disease social domain								
Social function ≤ mean-0.5SD	−0.247**	−0.188**	−0.170**	−0.445**	−0.412**	**−0.455****	−0.402**	−0.362**
Social function ≥ mean + 0.5SD	0.241**	0.259**	0.264**	0.326**	0.361**	0.225**	0.275**	**0.447****
Covariates	√	√	√	√	√	√	√	√
R^2	0.274	0.279	0.242	0.512	0.542	0.430	0.403	0.559

Three subjective wellbeing (ONS4, PWI and SWLS) scores were re-scaled onto a 0–1 scale. Standardised beta coefficients reported in the table. ** $p < 0.01$, * $p < 0.05$. The largest beta coefficient in each panel is bolded. Other than what has been reported, covariates also include a set of gender, age, education and country dummies and a constant

ONS4 4-item personal well-being index proposed by the Office for National Statistics, *PWI* Persona Wellbeing Index, *SWLS* satisfaction with life scale, *15D* 15 Dimensional, *AQoL-8D* assessment of quality of life-8 dimension, *EQ-5D-5L* EuroQol-5D-5L, *HUI3* health utility index-3, *SF-6D* short-form 6 dimensions

items. On the other hand, the dimensions characterised by HSU and MacNew loaded on the same factors quite often especially for AQoL-8D.

Life domain importance for patients with heart disease

Table 6 presents regression results based on both OLS and EEE estimators. It should be noted that the reported coefficients between two estimators are not directly comparable since the EEE is a non-linear model. However, it can be seen that the key findings from the patient sample are largely comparable that among the seven life domains studied, standard of living was the most important one in explaining the overall life satisfaction, followed by achieving in life, personal health, personal relationships, and future security (all $p < 0.01$). Personal safety and community connectedness were insignificant regardless of which method was used. In comparison, controlling for socio-demographic characteristics, the OLS estimates suggest that personal health and future security were two significant life domains that matter more for heart patients than the healthy public, whilst standard of living matters less. Slightly different from the linear model, the EEE estimates indicate that personal health was the only significant life domain that matters more for heart patients, whilst achieving in life matters less.

Discussion

This study comprehensively investigated the use of three popular SWB instruments in heart disease patients. Results indicated that in patients diagnosed with heart disease, there were moderate to high degrees of correlations between HSU, MacNew, and SWB scores. Based on disease severity as defined by the MacNew global/domain scores, all the SWB and HSU instruments showed significant between-group differences. Additionally, disease severity and the MacNew scale score were able to explain the variation in SWB and HSU score significantly. Inconsistent with a previous report [46], our study observed a non-significant gender-difference in SWB for two instruments (i.e. SWLS and PWI). Interestingly, our study also indicated that men tended to report poorer SWB while having higher HSU than women with the same condition; this gender difference should be considered when interpreting results of SWB and HSU.

The re-scaled scores of SWB measured by three instruments (i.e. ONS4, PWI and SWLS) were more consistent (ranging from 0.571 to 0.650) compared to the utility scores assessed by HSU instruments (varying from 0.683 to 0.831). This finding has several implications. As is now being recognised, the use of different HSU instruments can generate different results in cost-utility analysis, which would subsequently lead to inconsistent recommendations given the same willingness-to-pay threshold [47]. While for SWB,

Table 5 Exploratory factor analysis comparing the MacNew, SWLS and EQ-5D-5L

	Factor		
	1	2	3
[MacNew26] Physically restricted	0.968		
[MacNew20] Restricted or limited	0.960		
[MacNew17] Sports/exercise limited	0.929		
[MacNew24] Excluded	0.775		
[EQ5D] Mobility	−0.732		
[EQ5D] Usual activities	−0.730		
[MacNew25] Unable to socialize	0.705		
[MacNew21] Unsure about exercise	0.679		
[MacNew9] Short of breath	0.668		
[MacNew12] Social activities	0.613		
[EQ5D] Pain/discomfort	−0.604		
[MacNew11] More dependent	0.557		
[MacNew14] Chest pain	0.554		
[EQ5D] Self-care	−0.515		
[MacNew23] Burden on others	0.489		
[MacNew22] Overprotective family	0.481		
[MacNew16] Aching legs	0.478		
[MacNew13] Others/less confidence in you	0.477		
[MacNew19] Dizzy/Lightheaded	0.428		
[MacNew1] Frustrated		0.866	
[MacNew4] Down in the dumps		0.820	
[MacNew8] Restless		0.794	
[MacNew2] Worthless		0.762	
[MacNew10] Tearful		0.751	
[MacNew15] Lack self-confidence		0.733	
[EQ5D] Anxiety/depression		−0.728	
[MacNew5] Relaxed		0.672	
[MacNew18] Frightened		0.661	
[MacNew7] Happy with personal life		0.495	0.405
[MacNew6] Worn out			
[MacNew3] Confident			
[SWLS] The conditions of my life are excellent			0.887
[SWLS] Am satisfied with my life			0.882
[SWLS] In most ways my life is close to my ideal			0.869
[SWLS] So far I have gotten the important things I want in life			0.737
[SWLS] If I could live my life over, I would change almost nothing			0.688

Extraction Method: Maximum Likelihood. Loadings smaller than 0.4 are not shown in the table. Rotation Method: Promax with Kaiser Normalization

EQ-5D-5L EuroQol-5D-5L, *SWLS* satisfaction with life scale

the highly consistent results with respect to different instruments might ease the concern over using one particular type of SWB instrument over another. The correlation between SWB and HSU exhibited varying degrees of correlation amongst different instruments. In general, the AQoL-8D seemed to outperform other HSU tools in Spearman's correlation coefficients with all three SWB instruments, while EQ-5D and 15D displayed the poorest correlation with SWB instruments.

Although the correlation between HSU and SWB is not considered poor, the empirical evidence from the EFA suggested that these two are complementary rather than substitutable. Both exploratory factor analyses unanimously showed that the dimensions measured by SWB always fell into a separate factor that was different from those characterised in HSU or MacNew instruments. This suggests that measuring SWB in patients with heart disease potentially

Table 6 Life domain importance for patients with heart disease

	Patients ($N=943$)				Patients & healthy public ($N=2703$)			
	OLS		EEE[a]		OLS		EEE[a]	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Personal Wellbeing Index (PWI) Domains								
Standard of living	0.278**	(0.027)	0.399**	(0.044)	0.339**	(0.020)	0.474**	(0.036)
Personal health	0.140**	(0.021)	0.223**	(0.036)	0.022	(0.019)	0.051	(0.028)
Achieving in life	0.243**	(0.027)	0.334**	(0.049)	0.286**	(0.020)	0.406**	(0.036)
Personal relationships	0.140**	(0.021)	0.196**	(0.038)	0.170**	(0.016)	0.236**	(0.026)
Personal safety	0.012	(0.026)	0.014	(0.046)	0.056**	(0.020)	0.070*	(0.033)
Community-connectedness	−0.003	(0.026)	0.003	(0.043)	0.013	(0.018)	0.020	(0.026)
Future security	0.111**	(0.026)	0.152**	(0.043)	0.026	(0.018)	0.047	(0.030)
Interaction terms								
Heart * standard of living					−0.062*	(0.031)	−0.088	(0.056)
Heart * personal health					0.118**	(0.027)	0.152**	(0.045)
Heart * achieving in life					−0.050	(0.032)	−0.120*	(0.060)
Heart * personal relationships					−0.025	(0.024)	−0.026	(0.046)
Heart * personal safety					−0.038	(0.031)	−0.033	(0.059)
Heart * community-connectedness					−0.015	(0.029)	−0.008	(0.049)
Heart * future security					0.088**	(0.029)	0.078	(0.050)
Heart disease					0.006	(0.020)	0.054	(0.033)
Covariates	√		√		√		√	
λ			1.430**	(0.084)			1.212**	(0.077)
θ1			0.033**	(0.002)			0.023**	(0.001)
θ2			−0.686**	(0.142)			−1.458**	(0.144)
R^2	0.716				0.708			

OLS ordinary least squares, *EEE* extended estimating equations. Dependent variable is a genral life satisfaction question, 'Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole', and was re-scaled onto a 0–1 scale. ** $p<0.01$, * $p<0.05$. Interaction terms refer to the heart disease patient dummy multiplying with each of the seven life domains. Other than what has been reported, covariates also include a set of gender, age, education and country dummies and a constant

[a]For the EEE equation, the dependent variable was further re-scaled by its mean

may provide further information that might be overlooked by using HSU instruments exclusively.

This study also revealed the relative importance of different life domains for patients with heart disease. When explaining their overall life satisfaction, the highest importance was attached to the standard of living domain, followed by achieving in life, personal health, personal relationships, and future security, while personal safety and community connection were insignificant in the same cohort of patients. These results are largely similar to those of the healthy public, except that for heart disease patients, personal health is robustly and significantly more important regardless of which statistical method was used, which is to be expected. For the healthy public, the personal health domain was insignificant which may suggest that the importance of life domain also depends on the absolute level of this particular domain. In addition, heart patients place a significantly high value on their future security than healthy public (only evident in the OLS estimate). On the contrary, the standard of living (only evident in OLS estimate) or achieving in life (only evident in EEE estimate) was placed a less important role by the patient as compared to the healthy public.

There are very few studies in the area of SWB for patients with an established diagnosis of heart disease, indicating that the SWB is not currently incorporated into the mode of care or decision-making process [46]. However, evidence in relation to the impact of SWB on cardiovascular health in general population seems plentiful. It was reported that positive SWB may influence health by buffering against the effects of stress [48] and adjusting behaviour through process of engagement and disengagement [49]. Research has shown that positive psychological well-being is associated with better cardiovascular health. For example, optimism is associated with reduced risk of incident heart disease and reduced cardiovascular mortality [16, 50, 51]. Emotional vitality [52] and displays of positive affect [53] have been reported as contributors to reduced risk of heart disease in the general population. A Japanese study assessed "ikigai"

(i.e. have a life worth living) as being associated with decreased cardiovascular mortality [15, 54]. The underlying mechanism of the protective effect of positive SWB might be that well-being is involved in the aetiology of heart disease. It may indirectly affect heart disease via health behaviours such as improved diet and increased physical activity [50, 55] or directly affect heart disease through alterations in the neuroendocrine, cardiovascular, and inflammatory systems [56]. For ongoing care in patients with heart disease, lifestyle modification is an irreplaceable component in addition to pharmacological treatment. Therefore, it is believed that measuring and monitoring SWB in patients diagnosed with heart disease is likely to play a similar role in reducing the future risk of cardiovascular events.

Our study is not without limitations. Firstly, this was a cross-sectional study which does not allow for the tracking of changes in HSU and SWB and the testing of the responsiveness of SWB instruments. Second, patient comorbidities and their specific diagnosis of heart disease (angina, myocardial infarction etc.) were not collected in the survey; therefore, there might be other confounding factors that have not been accounted for in the regression models. Thirdly, there is a potential endogeneity issue in the regression analysis. Take the life satisfaction equation reported in Table 6 as an example, in this study we followed the classic bottom-up approach in which the overall life satisfaction was explained by different life domain satisfactions, if alternatively, a top-down approach should be used (i.e. different life domain satisfactions are explained by the overall life satisfaction), there will be a reverse causality issue. In addition, reporting bias may exist in subjective outcome measures; however, since both dependent and independent variables could be subjective to bias and we are only interested in the relative importance of different life domains, the impact from this potential bias is of less concern [57]. Despite the above limitations, this is the first study to comprehensively examine the association among MacNew, SWB and HSU based on a large multi-county dataset. It explored the life domains that are important to patients with heart disease, thereby providing in-depth information about measuring QoL for patients, healthcare providers and decision-makers.

Conclusions

SWB and HSU measure different dimensions of quality of life for patients with heart disease; measuring both of them provides complementary information on their quality of life. Measuring SWB reveals important additional information from the patients' perspective. Given the adverse psychological impact of heart disease and its potential role to counter effect treatment benefits, addressing the important domains revealed by SWB assessment in management planning is recommended.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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