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Where do measures of health, social care and wellbeing fit within a wider measurement framework? Implications for the measurement of quality of life and the identification of bolt-ons

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ABSTRACT

Background: There is variability across studies in the dimensionality i.e., set of latent variables to which health, social care and wellbeing measures relate. This variability may impact the development of new measures and the identification of bolt-on dimensions. We examine the dimensionality of commonly used measures and identify a set of potential bolt-ons for the EQ-5D-5L.

Methods: We used the OMS dataset, an online survey of health, social care and wellbeing measures in patients and members of the general public. A content analysis provided a theoretical framework for results interpretation. Quantitative analyses were based on a pool of 79 items from 7 measures. Confirmatory factor analysis was used to assess health, social care and wellbeing measures dimensionality and their contribution to quality of life. The relationship between EQ-5D-5L items and the identified factors was used for bolt-ons identification.

Results: The dimensionality comprised of seven factors, namely physical functioning, psychological symptoms, energy/sleep, physical pain, social functioning, needs and satisfaction. Health measures covered five of the seven factors identified, wellbeing measures three and the social care measure one. A list of candidate bolt-on items for the EQ-5D-5L was presented e.g., cognition, energy, dignity.

Conclusions: This study provides evidence on the dimensionality of health, social care and wellbeing measures and presents a list of candidate bolt-ons for the EQ-5D-5L.

1. Introduction

Health related quality of life (HRQoL) measures are commonly used to report patient health status (Brazier et al., 1999). Generic measures of HRQoL describe health in terms of a combination of dimensions, items and levels i.e., descriptive system (Finch et al., 2022), and can be used for clinical studies, effectiveness studies, routine monitoring of health and cost-effectiveness studies. Among the most commonly employed HRQoL measures there are the EQ-5D, the Short-Form 6 Dimensions (SF-6D) (Brazier et al., 2002; Herdman et al., 2011) and the more recently developed Patient-reported Outcomes Measurement System (PROMIS-29) (Cella et al., 2019; Lamu et al., 2017).

While valid, responsive and reliable in different disease areas, patient populations (Brazier et al., 2004; Buchholz et al., 2018; Feng et al., 2021b; Finch et al., 2018; Flynn et al., 2015; Gandhi et al., 2019; Janssen et al., 2008; Janssen et al., 2008; Janssen et al., 2013, 2018; Pan et al., 2022; Pickard et al., 2007, 2019) and cultural contexts (Qian et al., 2019), concerns have been raised regarding the sensitivity of these instruments' descriptive systems to the impacts of specific healthcare interventions. For example, evidence suggests that the EQ-5D does not cover senses related impacts (Ader, 2007; Brazier et al., 2002; Finch et al., 2018) and the EQ-5D and SF-6D only partially cover aspects related to mental health (Ader, 2007; Brazier, 2010; Brazier et al., 2002, 2014; Finch et al., 2018; Saarni et al., 2010). HRQoL measures may have also limited coverage of outcomes beyond health (Bowling, 2014; Forder, 2007), which may be important to capture consequences of health conditions (Mitchell et al., 2015). For example, providing hearing aids can affect the senses and functioning of individuals, but may also impact

Abbreviations: HRQoL, Health related quality of life; QoL, Quality of life; ScrQoL, Social care related quality of life; WB, Wellbeing.

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broader Quality of Life (QoL) aspects such as relationships (Chen and Olsen, 2020; Peasgood et al., 2021).

Measurement of broader aspects of QoL may be relevant not only for healthcare but also for social care users. Non-healthcare services, examples of which are home care facilities, supporting technologies and day activities, are often needed to improve aspects of life considered important by those receiving care (Rand et al., 2021). However, the goals of healthcare services and social care services differ, as the former aims at restoring status while the latter at maintaining long-term independence (Netten, 2011). It is therefore not surprising that specific Social Care related Quality of life (SCrQoL) measures, such as the as the Adult Social Care Outcomes Toolkit (ASCOT), have been developed for use in this population (Malley et al., 2012; Netten et al., 2012).

The use of measures of HRQoL and SCrQoL allows the assessment of interventions within a single sector but may prevent assessments of interventions between sectors. A practical solution could be using different instruments simultaneously. However, this option has its own limits, including possible double counting of dimensions of HRQoL and SCrQoL that may be relevant across populations (Brazier et al., 2022).

Other instruments, commonly referred as wellbeing (WB) measures, may be appropriate for use across sectors (Brazier et al., 2022; Coast et al., 2008). Notable examples of WB instruments include the subjective wellbeing (WB) (Kahneman and Sugden, 2005) Office for National Statistics measure (ONS-4), the mental WB Warwick-Edinburgh Mental Wellbeing Scale (WEMWEBS) measure, and the capability WB (Sen, 1993) ICEpop CAPability (ICECAP) measure. These instruments, based on developers reports, focus on different WB aspects, such as happiness and satisfaction, positive feelings, and abilities and capabilities. Yet, use of WB measures alone is generally discouraged, as arguments in favour of a large role of health aspects in assessing interventions across sectors are prevalent among decision makers (Peasgood et al., 2019).

One solution to these problems consists in developing alternative measures specifically targeted to the aspects of interest, for a specific health condition, or covering aspects important across sectors. For example, condition-specific measures such as the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC) and its EORTC Quality of Life Utility Measure-Core 10 dimensions (QLU-C10D) (Finch et al., 2021b; King et al., 2016; Norman et al., 2016) are employed in cancer populations to overcome the limitations of generic health measures. Similarly, recent work has resulted in the development of the EQ-HWB, a measure of benefit that could be used across health and social care (Augustovski et al., 2022; Brazier et al., 2022; Carlton et al., 2022; Mukuria et al., 2022; Peasgood et al., 2021, 2022).

Another solution is to adapt a reference HRQoL, extending its descriptive system with bolt-ons relevant for a specific disease, or to capture elements of broader QoL relevant across populations. Originally, bolt-on research focused on adding items related to senses, cognition and physical functioning to the EQ-5D-3L (Gandhi et al., 2020; Krabbe et al., 1999; Yang et al., 2015). More recently, a large EQ-5D-5L research program (Finch, 2017; Finch et al., 2017, 2019) led to the identification of 37 bolt-ons, and to the development of 8 of them (using multiple items and wordings), for vision, hearing, speech, cognition/memory, energy, sleep, relationships and satisfaction (Finch et al., 2021a). There are also other bolt-ons for the EQ-5D-5L, including self-confidence and skin irritation (Swinburn et al., 2013), alternative cognition items (Geraerds et al., 2019), and bolt-ons for respiratory problems (Hoogendoorn et al., 2019). A detailed overview of bolt-on studies is available in (Geraerds et al., 2021). Lately, bolt-on research has also started for measures other than the EQ-5D i.e., DLQI (Rencz et al., 2021). Other approaches have also been used in the past, such as merging profiles of different measures (an example is available in (Mulhern et al., 2019)).

Different methods could be used for bolt-on identification, including qualitative interviews with patients, focus groups with decision makers, psychometric studies and mixed methods research. One of such methods is using latent class analysis. Latent class analysis, such as exploratory and confirmatory factor analysis (CFA), can be performed on existing data, providing a cost-effective approach that overcomes some of the limitations of other techniques e.g., scattered evidence in psychometric systematic reviews of the literature (Finch, 2017; Finch et al., 2017) and allows to identify generic bolt-ons that are relevant across disease areas and conditions. More details on criteria for assessing and developing bolt-ons are available in (Mulhern et al., 2022) and on methods to identify and select bolt-ons in (Finch, 2017)). Latent class analysis has also been used to inform measure development. It allows to examine the relationship between measures, including HRQoL, SCrQoL and WB instruments (Engel et al., 2017; Feng et al., 2019, 2021a; Mulhern et al., 2017; Mulhern, 2020) and how they fit within the broader measurement framework of QoL.

This study has two objectives. It will first assess the dimensionality to which commonly used HRQoL, SCrQoL and WB measures relate in a recently available dataset that includes a large pool items. The measurement model will present a list of factors/constructs identified from the item pool and will allow the assessment of each instrument's contribution to the broader QoL framework. It will then use the measurement model and factors to identify generic bolt-ons, including candidate options related to HRQoL (and specifically mental health), SCrQoL and WB. For the latter, it will use the EQ-5D-5L as a case study, as most bolt-on research has been conducted for this instrument. Yet, the approach and methods employed could be generalized to other instruments as well.

2. Methods

2.1. Data and measures

This study used the Outcome Measurement Study (Mulhern, 2020) dataset. The OMS dataset was collected in 2017 in Australia. A detailed explanation of data collection procedures is available in (Mulhern, 2020). Broadly, participants with four common health conditions (back pain, diabetes, arthritis and mild anxiety or depression) and the general population were recruited online in Australia via a panel research company. The survey included demographic questions, three HRQOL measures, the EQ-5D-5L, the SF-36 (from which SF-6Dv1 is derived) and the PROMIS-29, 3 WB measures, the ICECAP, WEMWEBS and ONS-4, and a SCrQoL measure, the ASCOT. This results in a pool of 79 items related to different QoL constructs.

Appendix Table 1 presents the instruments, their dimensions, questions, number of levels, labels wording and recall period.

The EQ-5D-5L consists of 5 dimensions i.e., mobility, selfcare, usual activities, pain/discomfort and anxiety/depression, described in terms of five severity levels. It uses the recall period "today" for all the dimensions.

The SF-36 consists of 8 dimensions i.e., physical functioning, role limitations (physical problems), role limitations (emotional problems), social functioning, pain, mental health, vitality, general health perception. The SF-6D was derived by reducing the number of dimensions from 8 to 6 by excluding the general health dimension and combining the role limitation dimensions. The instrument includes 11 items, 8 from the SF-12 and 3 from the SF-36. It is described in terms of four to six levels. The labels wording varies between items, and the recall period is embedded within the items.

The PROMIS-29 consists of 29 items related to 8 health dimensions i.e., physical functioning, anxiety, depression, fatigue, sleep disturbance, ability to participate in social roles and activities, pain interference and pain intensity. Each item has five levels, with the labels wording varying between items. Some items report the recall period of the last 7 days, while others do not use a recall period.

The ONS-4 consists of 4 items i.e., life satisfaction, feeling worthwhile, happiness and anxiety, each of which has 10 levels, varying from "not at all" to "completely". Two items i.e., happiness and anxiety have recall period" yesterday" embedded in the questions, while the other

two have no recall period.

The WEMWEBS covers 14 items i.e., optimism, usefulness, feeling relaxed, feeling interested in others, energy, dealing with problems, cognition, feeling good, feeling close to others, feeling confident, able to make up mind, feeling loved, feeling interested in new things, feeling cheerful. It has five levels varying from "none of the times" to "all of the times". It has a recall period of two weeks.

The ASCOT has 9 items i.e., control over life, personal cleanness, food and drinks, safety, social participation, occupation, home cleanness and comfort and 2 dignity questions, each of which is described in terms of four levels. The labels wording varies between items, and no recall period is specified.

The ICECAP has 5 items i.e., feeling settled and secure, love, friendship and support, being independent, achievement and progress, enjoyment and pleasure, each of which is described in terms of 4 levels. Response labels vary between dimensions, and no recall period is used.

All items are ordinal categorical with the number of categories varying between 4 and 11. In the EQ-5D, SF-6D, ASCOT and ICECAP the highest score of 1 represent the best possible status, while in the WEMWEBS the worst. PROMIS-29 and ONS-4 have positively and negatively worded items, with the highest possible status being the highest score in some items and the lowest in others. Items for all measures were re-coded so that higher scores are associated with better QoL.

Data quality was ensured by screening out respondents who completed the survey in less than 10 min, and by randomising the order of the instruments to avoid order or fatigue effects.

2.2. Content analysis

A content analysis of the instrument item pool included in the OMS dataset was performed. In line with previous research, the Wilson and Cleary model was used as a conceptual starting point (Wilson and Cleary, 1995). The Wilson and Cleary model was chosen due to its simplicity yet appropriateness to describe the relationship between items of HRQoL, SCrQoL and WB items.

The Wilson and Cleary model combines biological and psychological aspects of health, defining five main areas including physiological factors, symptom status, functioning status, general health, and overall QoL. The broader category of QoL allowed flexibility for the categorization of some constructs related to SCrQol and WB. To reflect items related to constructs commonly measured by HRQOL measures, we further classified the symptoms category into psychological and physical symptoms and the functioning category into physical functioning, psychological functioning, social functioning and role functioning (Finch et al., 2017). Fig. 1 presents a graphical representation of the adapted Wilson and Cleary model.

The content analysis first assigned items to an underlying theme e.g., an item on quality of sleep was coded with the sleep theme. Subsequently, themes were sorted and grouped according to their content e.g., fatigue and sleep themes were sorted together. Finally, themes were assigned to one of the Wilson and Cleary model categories.

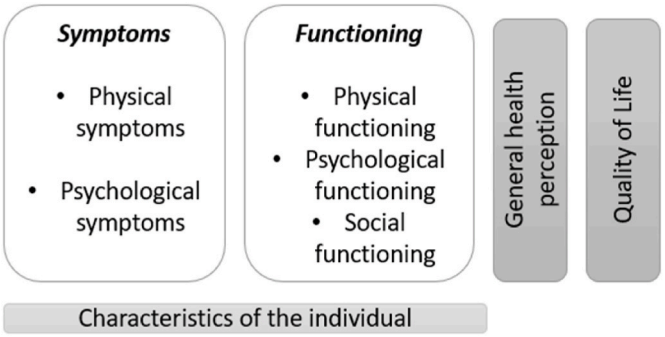

Fig. 1. Adapted Wilson and Cleary conceptual model.

The content analysis of the item pool was used to inform the CFA model. Such assessment included examination of items wordings and how these could influence the item to item, and item to factor relationships. An example of this is provided in the CFA section.

2.2.1. Multivariate statistical analysis

2.2.1.1. Exploratory factor analysis. A set of exploratory factor analyses (EFAs) were conducted using IBM SPSS Statistics for Mac, Version 22.0. Armonk, NY: IBM Corp®, to inform model specification. EFAs summarize the variance included in an item pool by assuming that all items load on all factors. The current study tested three common methods for factor extraction, namely parallel analysis i.e., a Montecarlo simulation (n = 1000) of eigenvalues generated from randomly drawn datasets (Horn, 1965), eigenvalues larger than one (Hayton et al., 2004) and visual examination of scree plots (Cattell, 1966). The interpretation of EFA results was aided by assessing alternative rotation strategies, including orthogonal and oblique rotations. Factors' loadings were interpreted using alternative cut-offs, among which the commonly used 0.3 or higher, and cut-offs robust in presence of non-normality of distributions i.e., 0.45 or higher (Comrey and Lee, 1992). None of the EFA model was taken independently as the point of departure for the CFA model, as the constructs covered in this study had already been investigated in previous research i.e., (Finch et al., 2017; Mulhern, 2020). Decisions on the initial model were based on triangulation of the content analysis, EFA results and previous research. This procedure is common in presence of sufficient theoretical and empirical evidence for factor analytic procedures (e.g., Hurley et al., 1997).

2.2.1.2. Confirmatory factor analysis. CFA differs from EFA in that it is a hypothesis testing technique. Items are not allowed to freely load on all identified factors, but latent traits are used as predictors of the items. This permits to test how well the identified measurement model mimics the pattern of covariance present in the data, and how far this is from the observed covariance pattern, using fit indexes. Therefore, possible misfits due to wrong specifications of the number of factors, the items to factors relationships, and the structural factor covariance specifications are testable.

Analysis were conducted using Mplus version 7© (Muthén and Muthén, n.d.). A measurement model was specified as follows:

$$y_{is} = \mu_{i+}\lambda_i F_{s+}\varepsilon_{is}$$

Where y is the observed response for item **i** and subject **s**, μ is the item specific intercept i.e., expected outcome when F = 0, λ is the factor loading of item i.e., expected change in y for a one unit change in F, F is the factor score for subject s and **ε** is the error variance for item i and subject s.

To allow the identification of the measurement model, factors were scaled with a mean of 0 and a standard deviation of 1. The identified congeneric model assumes local independence of items loading on the same factor, which means that items related to the same factor are associated exclusively in terms of their correlation, given by $\lambda 11 * 1 * \lambda 21$, where 11 represent item 1 loading on factor 1, 21 item 2 loading on factor 1 and 1 is the standard deviation of the factor. Similarly, the identified congeneric model assumes local independence between items related to different factors, which means that items related to different factors are associated exclusively in terms of their relationship with the factor and the covariance between factors.

Model refinements followed a process of specification, refinement, and re-specification, including tests of uni-dimensionality for alternative factor structures e.g., sleep and energy as independent factors were compared with sleep/energy loading on the same factor, investigations of normalized model residuals i.e., difference between the predicted and observed covariance matrix and relaxations of the congeneric model

assumptions i.e., local dependencies. Refinements made use of the content analysis examining items wordings e.g., ASCOT social participation was assigned to the needs factor instead of the social functioning factor as content analysis revealed its wording tapped on emotions and feelings and not ability to function socially, and the theoretical consistency of items with the latent constructs, alongside the quantitative indicators.

Tests of uni-dimensionality were performed by specifying a bi-factor model i.e., methods factors and a global factor model, imposing no strain between factor solutions i.e., no correlation between methods-factors and global factor, and comparing the common variance accounted by the three. If at least 50% of the common variance was explained by the global factor this was taken as a demonstration of sufficient uni-dimensionality (Reise et al., 2013). For example, a model was specified with positively worded mental health items loading on a method factor and negatively worded mental health items on a separate method factor, and all items loading on a global factor. The amount of common variance for methods and global factor were compared.

Two practical goodness-of-fit-indexes were used to assess model appropriateness, the root mean square error of approximation (RMSEA) and the comparative fit index (CFI). An RMSEA of 0.08 or less was considered acceptable and of 0.05 or less good, and a CFI of 0.90 or more was considered acceptable and of 0.95 or more good (Browne and Cudeck, 1992; Fabrigar et al., 1999; Hu and Bentler, 1999).

2.2.1.3. Dimensionality, identification of bolt-on traits and bolt-on items. The identified dimensionality was used to investigate the instruments and items contribution to QoL, assessing the number and type of factors identified and the items relationship to the factors.

The measurement model was then used for bolt-on identification following two approaches. The first approach aimed at identifying QoL constructs and bolt-ons that are not included or explicitly covered in the core EQ-5D descriptive system (Finch et al., 2017). Based on this approach, items were considered as candidate bolt-ons if their main loading was on factors not covered by any of the EQ-5D dimensions.

The second approach aimed at identifying QoL constructs and bolt-ons that may expand the content of the instrument for a specific aspect that is already partially covered by the instrument. To illustrate this, we used mental health as an example, considering bolt-ons those items loading on the same factor as the EQ-5D anxiety/depression item.

3. Results

3.1. Data

The final sample comprised of 794 responders. Table 1 presents the socio-demographic characteristics of the sample. As it can be seen, there was a generally balanced distribution of genders and a good representativeness across age groups. Most participants stated they were affected by a health condition (n = 500; 63.1%). Appendix Table 2 presents the instruments level sum score range, the reported minimum, maximum and median score, and the percentage of floor and ceiling effects.

Table 1
Background socio-demographic characteristics of the sample.

Question	Level/Specification	Sample frequency	Sample Percentage
Gender	Male	380	47.9%
	Female	414	52.1%
Age	18 <	2	0.2%
	18–29	128	16.1%
	30–44	202	25.4%
	45–59	222	28.0%
	60–74	220	27.7%
	75 >	20	2.6%
Children	0	405	51.0%
	1	110	13.9%
	2	168	21.1%
	3 or more	111	14.0%
Condition	No	292	36.9%
	Yes	500	63.1%

3.2. Content analysis

Table 2 provides the results of the content analysis. Among the included items, 22 related to physical functioning, with 2 of them coming from WB measures, 3 from SCrQoL measures and the remaining ones from HRQOL measures. Sixteen items from HRQOL and WB measures were assigned to the psychological symptoms' category. One category covered a single theme (pain in physical symptoms), while other categories (e.g., QoL) covered multiple themes (safety, happiness etc.). Some items related to multiple categories and themes. For example, the PROMIS-29 pain interference with usual activities item was assigned to both physical symptoms and functioning, and the PROMIS-29 trouble with family activities item to both physical and social functioning.

3.3. Exploratory factor analysis

Testing of alternative dimensional structure identification strategies suggested a variable number of factors ranging between 6 and 11. Parallel analysis indicated the smallest number of factors i.e., six-factor solution, while the eigenvalues larger than 1 rule the greatest i.e., eleven-factor solution. Among the different possible rotation strategies, Promax oblique rotation was selected to aid the results interpretation as numerous studies show that HRQoL, WB and SCrQoL factors are correlated (e.g. 52–54).

3.4. Confirmatory factor analysis

An initial measurement model was specified. As in some EFA psychological symptoms loaded on two different factors, positively worded psychological symptoms, and negatively worded psychological symptoms, we tested this factor uni-dimensionality. The global factor accounted for 63.35% of the common variance, compared to the 26.50% of positively worded psychological symptoms and 10.15% of the negatively worded psychological symptoms, demonstrating uni-dimensionality. A test of uni-dimensionality was performed also for the energy/sleep factor. Once again, the global factor accounted for 55.54% of the common variance, while energy for the 18.92% and sleep for the 25.54%. Sleep and energy were therefore considered a single factor.

Further model re-specification followed an iterative process which included assessing the items to factors theoretical consistency and statistical performance, the size of residual correlations and local dependencies. The process resulted in specifying two factors not identified in EFAs, satisfaction and pain. One item i.e., ASCOT dignity was poorly associated with all factors identified in the measurement model, as demonstrated by the large local dependencies and residual correlations with numerous other variables. This item was removed from the factor analysis. Alternative items-factor associations were tested and assigned to a factor e.g., PROMIS sleep quality was assigned to the factor sleep while some EFA suggested an association with psychological symptoms. The final measurement model exhibited general good fit, with an RMSEA of 0.059 (90% CI 0.058–0.061) and a CFI of 0.95.

3.5. Dimensionality, bolt-on traits and bolt-on items

The dimensionality of the final confirmatory measurement model and its factor loadings is presented in Table 3. The identified measurement model comprised of 7 factors, namely physical functioning, psychological symptoms, energy/sleep, physical pain, social functioning, needs and satisfaction. The factor including the largest number of items i.e., 23 was psychological symptoms. The factor to which the smallest

Table 2
Content analysis of the OMS dataset.

Symptom status			
Physical symptoms	*Measure*	*Psychological symptoms*	*Measure*
Pain	HRQOL	Anxiety/depression	HRQOL
EQ-5D pain/ discomfort	HRQOL	EQ-5D anxiety/depression	WB
SF-6D pain	HRQOL	ONS-4 anxiety yesterday	HRQOL
PROMIS pain interference activities*	HRQOL	PROMIS anxiety	HRQOL
PROMIS pain interference work*	HRQOL	PROMIS overwhelmed worry	HRQOL
PROMIS pain interference social act*	HRQOL	PROMIS felt uneasy	HRQOL
PROMIS pain interference house chores*	HRQOL	PROMIS felt worthless	HRQOL
PROMIS average pain		PROMIS felt helpless	HRQOL
		PROMIS felt depressed	HRQOL
		PROMIS felt hopeless	WB
		Coping	SCrQoL
		WEMWEBS dealing prob	HRQOL
		Isolation and exclusion	WB
		ASCOT social part	WB
		Other items	WB
		SF-6D mental health	WB
		WEMWEBS feel useful	
		WEMWEBS feel relaxed	
		WEMWEBS feel interest	
		WEMWEBS interest new thing	
Functioning status			
Physical functioning	*Measure*	*Psychological functioning*	*Measure*
Independent living/self care	HRQOL	Energy	HRQOL
EQ-5D self-care	HRQOL	SF-6D vitality*	WB
ICECAP being independent	WB	WEMWEBS energy	HRQOL
ASCOT cleanness and comfort	SCrQoL	PROMIS tiredness	HRQOL
ASCOT food and drink	SCrQoL	PROMIS difficult start as tired	HRQOL
ASCOT accommodation	WB	PROMIS felt run down	HRQOL
ICECAP able to do things	HRQOL	PROMIS felt fatigue	HRQOL
Ambulation	HRQOL	PROMIS sleep quality	HRQOL
EQ-5D mobility	HRQOL	PROMIS sleep freshness	HRQOL
SF-6D physical functioning	HRQOL	PROMIS problem sleep	WB
PROMIS up down stairs	HRQOL	Other items	WB
PROMIS walk15min	HRQOL	WEMWEBS think clearly	HRQOL
Usual activities	SCrQoL	WEMWEBS make mind up	HRQOL
EQ-5D usual activities	HRQOL		
ASCOT occupation	HRQOL		
PROMIS able do chores	HRQOL		
PROMIS able to shop	HRQOL		
PROMIS troubles doing things	HRQOL		
PROMIS troubles family activity*	HRQOL		
PROMIS trouble usual work*	HRQOL		
PROMIS trouble activity friend*	HRQOL		
PROMIS pain interference activity*	HRQOL		
PROMIS pain interference work*	HRQOL		
PROMIS pain interference social act*	HRQOL		
PROMIS pain interference house chores*	HRQOL		
Social functioning	*Measure*	*Role functioning*	*Measure*
Relationships	WB	SF-6D role*	HRQOL
ICECAP love, friend, support	WB		
WEMWEBS feel close people	HRQOL		
WEMWEBS feel loved	HRQOL		
Other items	HRQOL		
SF-6D social functioning	HRQOL		
PROMIS trouble fam activity*	HRQOL		
PROMIS trouble usual work*	HRQOL		
PROMIS trouble activity friend*	HRQOL		
PROMIS pain interference work*	HRQOL		
PROMIS pain interference social act*	HRQOL		
PROMIS pain interference house chores*	HRQOL		
General health perception	*Measure*	**Overall quality of life (happiness, satisfaction and wellbeing)**	*Measure*
PWI satisfaction health	WB	Contentment with life	WB
		ONS-4 satisfied with life	WB
		Purposefulness	WB
		ONS-4 life worthwhile	WB
		Happiness	WB
		ONS-4 happiness yesterday	WB
		WEMWEBS feel cheerful	SCrQoL
		ICECAP enjoyment	HRQOL
		Safety	SCrQoL
		ICECAP feeling secure	SCrQoL
		ASCOT personal safety	
		PROMIS feel fearful	
		Control over life	
		ASCOT control over life	
		Getting help	
		ASCOT dignity	
Characteristic of the individual	*Measure*		
WEMWEBS optimism	WB		
WEMWEBS feel good yourself	WB		
WEMWEBS feel confident	WB		

Note: * Items that are theoretically related to more than one category of the Wilson and Cleary model.
Legend: HRQOL: Health related quality of life; WB: Wellbeing; SCrQoL: Social care-related quality of life; EQ-5D; SF-6D: Six-dimensional health state short form; PROMIS: Patient-reported Outcomes Measurement System; ICECAP: ICEpop CAPability measure; ONS-4: Office for National Statistics; WEMWEBS: The Warwick-Edibburgh Mental Wellbeing Scale; ASCOT: The Adult Social Care Outcomes Toolkit.

number of items loaded on i.e., 4 was satisfaction. Factor loadings were generally large. For example, the highest loading for physical functioning was for the EQ-5D usual activities item (0.951; SE 0.013), while the lowest loading for the same factor was for the SF-6D physical functioning item (0.712; SE 0.020). Similarly, the highest loading for the factor energy/sleep was for the PROMIS fatigue item (0.950; SE 0.005) while the lowest loading was for PROMIS sleep quality (0.733; SE 0.020).

Some instruments related to multiple aspects of QoL e.g., WEMWEBS while others measured one i.e., ICECAP. Broadly, HRQOL measures covered 5 of the 7 factors identified, namely physical functioning, psychological symptoms, social functioning, energy/sleep and pain. WB measures covered 3 factors, psychological symptoms, needs and satisfaction. And the SCrQoL measure included in the dataset covered 1 factor i.e., needs.

Table 4 presents a list of QoL constructs and candidate bolt-ons for the EQ-5D. Candidate bolt-on dimensions were based on the two chosen identification approaches described in the methods i.e., missing from the EQ-5D-5L descriptive system, and partially covered in the EQ-5D-5L descriptive system.

Table 3
Confirmatory factor analysis (CFA) standardized factor loadings and standard errors.

	Physical functioning		Psychological symptoms		Energy/Sleep		Social functioning		Pain		Needs		Satisfaction	
	Loading	SE	Loading	SE	Loading	SE	Loading	SE	Loading	SE	Loading	SE	Loading	SE
EQ5D Usual activities	0.951	0.013												
PROMIS Run errands	0.907	0.016												
PROMIS Walk 15 min	0.901	0.012												
PROMIS Do chores	0.877	0.015												
EQ5D Mobility	0.868	0.014												
PROMIS up down the stairs	0.841	0.015												
EQ5D Self Care	0.826	0.027												
SF 6D Physical Functioning	0.712	0.020												
PROMIS Felt hopeless			0.935	0.006										
PROMIS Felt helpless			0.915	0.009										
PROMIS Felt worthless			0.909	0.008										
PROMIS Felt depressed			0.906	0.008										
WEMWEBS Feeling good			0.889	0.009										
WEMWEBS Feeling confident			0.857	0.010										
PROMIS Felt uneasy			0.856	0.011										
PROMIS Anxiety			0.853	0.011										
PROMIS Overwhelmed worries			0.842	0.011										
Anxiety/Depression			0.820	0.014										
SF 6D Mental health			0.820	0.013										
PROMIS Felt fearful			0.795	0.014										
WEMWEBS Feeling relaxed			0.793	0.014										
WEMWEBS Feeling useful			0.783	0.015										
WEMWEBS Dealing with problems			0.765	0.017										
WEMWEBS Feeling close			0.758	0.015										
WEMWEBS Thinking clearly			0.753	0.016										
WEMWEBS Able to make up mind			0.699	0.019										
WEMWEBS Interested in things			0.697	0.019										
WEMWEBS Optimism			0.658	0.021										
WEMWEBS Interested in others			0.655	0.021										
ONS-4 Anxiety			0.557	0.021										
WEMWEBS feeling cheerful			0.419	0.031									0.483	0.031
PROMIS Fatigue					0.950	0.005								
PROMIS Run down					0.940	0.007								
PROMIS fatigue on average					0.927	0.006								
PROMIS difficulty start things fatigue					0.866	0.010								
PROMIS Problems with sleep					0.761	0.020								
WEMWEBS Energy					0.759	0.020								
PROMIS Sleep refreshing					0.750	0.020								
PROMIS difficulty falling a sleep					0.743	0.023								
SF 6D Vitality					0.738	0.021								
PROMIS Sleep quality					0.733	0.020								
PROMIS Trouble Activities friends							0.933	0.008						
PROMIS Trouble Family Activities							0.918	0.009						
PROMIS Trouble Working							0.906	0.009						
PROMIS Trouble doing things							0.904	0.010						
SF 6D Social							0.776	0.018						
SF 6D Role							0.621	0.026						
PROMIS Pain interfere work									0.974	0.004				
PROMIS Pain interfere house chores									0.963	0.004				
PROMIS Pain interfere activities									0.956	0.005				
PROMIS Pain interfere social									0.941	0.008				
SF 6D Pain									0.856	0.011				
EQ 5D Pain Discomfort									0.814	0.015				
PROMIS Average Pain									0.805	0.014				
ICECAP Independence											0.858	0.014		

(*continued on next page*)

Table 3 (*continued*)

	Physical functioning		Psychological symptoms		Energy/Sleep		Social functioning		Pain		Needs		Satisfaction	
	Loading	SE	Loading	SE	Loading	SE	Loading	SE	Loading	SE	Loading	SE	Loading	SE
ICECAP Enjoyment and pleasure											0.853	0.014		
ICECAP Love, Friendship, Support											0.844	0.015		
ASCOT Social Participation											0.782	0.017		
WEMWEBS Feeling Loved											0.779	0.019		
ICECAP Security											0.775	0.018		
ASCOT Occupation											0.770	0.019		
ASCOT Cleanness and comfort											0.755	0.023		
ICECAP Achievement											0.721	0.022		
ASCOT Control Over life											0.716	0.023		
ASCOT Personal Safety											0.685	0.027		
ASCOT Food and Drink											0.617	0.031		
ASCOT Accommodation											0.599	0.030		
ONS-4 Happiness													0.931	0.008
ONS-4 Life Satisfaction													0.928	0.008
ONS-4 Worthwhile													0.909	0.009

Legend: EQ-5D; SF-6D: Six-dimensional health state short form; PROMIS: Patient-reported Outcomes Measurement System; ICECAP: ICEpop CAPability measure; ONS-4: Office for National Statistics; WEMWEBS: The Warwick-Ediburgh Mental Wellbeing Scale; ASCOT: The Adult Social Care Outcomes Toolkit.

3.6. Summary of results

The CFA showed overlap in the constructs measured by SCrQoL and capability WB, when measured using the ASCOT and ICECAP. Moreover, the CFA highlighted how the measurement of mental health aspects overlaps between HRQoL instruments (the EQ-5D, SF-6D and PROMIS-29) and mental WB instruments (the WEMWEBS), as all items assess the same latent trait i.e., psychological symptoms. By contrast, differences were observed in the traits measured by subjective WB and capability WB, and in the traits measured by SCrQoL and HRQoL measures.

The results demonstrate that the EQ-5D taps on three QoL constructs defined as physical functioning, psychological symptoms and pain. Other HRQoL measures include constructs related to social functioning and energy/sleep. These aspects may be relevant to capture the impact of healthcare interventions. As the EQ-5D does not cover aspects related to SCrQoL, it may have limited applicability for the assessment of social care interventions, and it may benefit from SCrQoL bolt-ons.

4. Discussion

This study assessed the dimensionality of health, social care and WB measures in a dataset that included items related to HRQoL, SCrQoL and WB. It identified 7 factors to which the selected measures relate, namely physical functioning, psychological symptoms, energy/sleep, pain, social functioning, needs and satisfaction. As different measures are developed for different purposes, the approach helps assessing possible overlaps, and consequently how measurement can be improved. The results demonstrate that there may be overlaps in the construct measured by HRQoL and mental WB measures and by SCRQoL and capability WB measures. They also provide evidence of the multidimensionality of HRQoL constructs measured by HRQoL measures and of the distinction between subjective and capability WB.

Five of the seven identified factors, with some variation in the items due to the instruments included, were found in both this study and the study of Finch et al. which used the Multi-Instrument Comparison (MIC) dataset (Finch et al., 2017). This demonstrates that datasets with a large pool of items allow to reproduce the dimensional structure of previous studies with reasonable precision. The limited availability of such types of datasets highlights the importance of supporting new data collection efforts that include comparisons of multiple measures of HRQoL, SCrQoL and WB. Recent efforts have been initiated in this direction (EuroQol, 2021).

Of the 4 instruments included in both the OMS and the MIC datasets, two (EQ-5D-5L and ONS) retained identical factor structures to those identified by Finch et al. (2017). More specifically, the EQ-5D items mobility, self-care and usual activities loaded on the factor physical functioning, the item pain/discomfort on the factor pain, and the item anxiety/depression on the factor psychological symptoms in both analyses. Similarly, three of the 4 ONS-4 items loaded on the satisfaction factor, with the last one i.e., ONS-4 anxiety loading on psychological symptoms. One instrument (SF-6D) retained an almost identical factor structure, with four of the six items i.e., pain, physical functioning, mental functioning, and vitality loading on the same factors pain, physical functioning, psychological symptoms, and energy/sleep in both datasets. The two remaining items, social functioning, and role functioning, loaded on social functioning in the current study. This factor was not identified in the MIC dataset and the two SF-6D items reported problems i.e., cross-loadings between physical functioning and psychological symptoms and residual correlations. The items of the ICECAP were well represented by the needs factor in the current analysis, while they were poorly represented in the MIC. This finding is reasonable given that the OMS dataset includes a larger pool of items related to SCrQoL and WB and a smaller pool of HRQoL items compared to the MIC, which improved the ICECAP representation within the measurement model.

The study also confirmed the appropriateness of a set of previously identified candidate items for the EQ-5D-5L e.g., ICECAP love, friendship, and support and SF-6D vitality which may be develop into bolt-ons, and further pointed at a list of candidate options for items related to constructs missing from the EQ-5D-5L descriptive system. Differently from previous studies, the current analysis also suggested a list of candidate bolt-ons that may improve the EQ-5D-5L coverage in a specific chosen area already partially covered by the instrument descriptive system i.e., mental health. For bolt-on research, such approach is in line with recent debates that encourage the expansion of the EQ-5D with a particular focus to psycho-social aspects of health (Chen and Olsen, 2020; Olsen and Misajon, 2020). More generally, such use of factor analysis can help the identification of items related to different health dimensions but same health constructs, alongside the identification of items related to different constructs. This can be useful for the development of a range of instruments. For example, it may allow for the future development of broader QoL instruments, adaptive measures, or for identifying items that could be 'bolted-off' from the existing instruments.

Based on the content analysis and following the observation of

Table 4
List of bolt-ons identified using the BRG dataset.

Selection criteria	Bolt-on	Domain/factor	Broader construct
Missing from EQ-5D descriptive system	WEMWEBS energy	Energy/Sleep	HRQoL
	SF-6D Vitality		
	PROMIS run down		
	PROMIS fatigue		
	PROMIS sleep quality		
	PROMIS sleep refreshing		
	PROMIS problem with my sleep		
	PROMIS difficulty felling a sleep		
	SF Role limitation	Social functioning	HRQoL/ SCrQol/WB
	SF Social functioning		
	PROMIS trouble usual work		
	PROMIS family activities		
	PROMIS activities friends		
	ASCOT cleanness	Needs	SCrQoL/ WB
	ASCOT food and drink		
	ASCOT clean and comfort home		
	ASCOT safety		
	ICECAP settled and secure		
	ICECAP love, friendship and support		
	ICECAP independence		
	ICECAP achievement and progress		
	ICECAP enjoyment and pleasure		
	ASCOT control life		
	ASCOT social participation		
	ASCOT occupation		
	ASCOT dignity		
	ONS-4 Life Satisfaction	Satisfaction	SWB
	ONS-4 Worthwhile		
	ONS-4 Happiness		
	WEMWEBS cheerful		
Partially covered by the EQ-5D descriptive system	WEMWEBS feeling interested in others	Psychological symptoms/Mental health	HRQoL
	WEMWEBS feeling close to others		
	WEMWEBS optimism		
	WEMWEBS interested in things		
	WEMWEBS feeling loved		
	WEMWEBS dealing with problems		
	WEMWEBS feeling useful		
	WEMWEBS feeling good		
	WEMWEBS feeling confident		
	WEMWEBS feeling cheerful		
	WEMWEBS feeling relaxed		
	SF mental		
	PROMIS felt fearful		
	PROMIS anxiety		
	PROMIS overwhelmed		
	worries		
	PROMIS felt uneasy		
	PROMIS felt worthless		
	PROMIS felt helpless		
	PROMIS depressed		
	PROMIS hopeless		
	ONS-4 anxiety		
	WEMWEBS think clearly		
	WEMWEBS able to make up mind		

Legend: EQ-5D; SF-6D: Six-dimensional health state short form; PROMIS: Patient-reported Outcomes Measurement System; ICECAP: ICEpop CAPability measure; ONS-4: Office for National Statistics; WEMWEBS: The Warwick-Ediburgh Mental Wellbeing Scale; ASCOT: The Adult Social Care Outcomes Toolkit. HRQoL: Health related quality of life; WB: wellbeing; SWB: subjective wellbeing; SCRQoL: Social care related quality of life.

residual correlations for some of the positively worded psychological symptom items, this study tested the presence of a positively worded psychological symptoms method-factor, but did not find evidence in its support. The influence of wording on HRQoL and WB instrument has been previously observed in other studies, with varying reports (Anatchkova et al., 2011; Ryff and Keyes, 1995; Tomas and Oliver, 1999; Watt et al., 2014). While the results of this study suggest that both positively and negatively worded psychological symptoms items relate to the same latent factor, other considerations may still support the inclusion of both items wordings when choosing bolt-ons or developing new measures. For example, previous researchers have argued for the inclusion of both positively and negatively worded items to better capture the breadth of a patient's journey (Keetharuth et al., 2019).

Of note, the ASCOT dignity question did not fit the dimensional structure identified in the current study and was for this reason removed. A potential explanation for this may be that not all responders in the study were social care users, which may have affected the relationship of this item with other SCrQoL ones. Similarly, this study identified that the ASCOT social participation question related to the needs factor and not the social functioning factor. An explanation for this could be found in the wording of this item, which emphasize feelings over the ability of doing things.

In this study, the ONS-4 happiness question related to the satisfaction factor and not psychological symptoms factor, and that the WEMWEBS questions loaded all on the same factor, despite possible differences identified in the content analysis. Different measures have different labels, recall periods, and response options. These aspects may have impacted the item to factor associations found in this study.

This study has various limitations. First, only 4 of the 7 instruments available in the current analysis were present also in the MIC dataset, and some of the MIC dataset instruments e.g., SWLS were not included in the OMS dataset used in this study. As the identified dimensionality depends on the measures included, it is not possible to perfectly compare the measurement models obtained from the two datasets. However, the similarity in the identified dimensionality suggests reasonable overlap between the constructs identified. It also informs how different constructs of QoL align with each other within a broader measurement framework. Second, this study suggests an appropriate method for bolt-on identification exclusively if the dimensions of interest are already covered by at least one of the instruments that were included in the dataset used. There might be other dimensions that were not included in any of the existing instruments that might still represent equivalently

relevant candidate bolt-ons. Third, this study collected data in Australia. As there might be response heterogeneity between different cultural groups, the identified measurement model generalizability might be limited, albeit the MIC had an Australian arm as well. Fourth, this study used a dataset that includes healthy people and those with a variety of health conditions. Our study took the standpoint of identifying generic bolt-ons relevant across conditions and populations, for which the chosen sample is appropriate. However, differential item functioning i.e., differences in the degree to which an item relates to the underlying trait between groups, has been observed in HRQoL and WB measures for a number of characteristics, including age, gender, and condition groups (e.g., Bjorner, 2019; Penton et al., 2022). If the objective is identifying bolt-ons for a specific health condition, assessment including a sample of patients with the condition is recommended. Fifth, the dimensionality identified with factor analysis depends on the measures included. For this reason, results may differ between datasets which include different measures.

Despite these limitations, this study provides important evidence as it demonstrates how instruments of health and WB fit within a broader measurement framework of QoL. It validates a previously identified list of bolt-ons for the EQ-5D-5L (Finch et al., 2017) and it identifies additional bolt-ons for SCrQoL and WB constructs. It shows how CFA can be used to identify additional items and dimensions related to the same health constructs already covered by a measure of interest. The latter could support the development of adaptive instruments of health or could help to expand the content of a measure with bolt-ons for a specific health aspect.

Credit authors statement

Aureliano Paolo Finch: Funding acquisition, conceptualization, methodology, formal analysis, project administration and writing. Brendan Mulhern: Funding acquisition, conceptualization, methodology, formal analysis, project administration and writing.

Declaration of competing interest

AF and BM are members of the EuroQol Group; AF works for the EuroQol Office.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2022.115370.

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