

Health-related quality of life in Singapore: Population norms for the EQ-5D-5L and EORTC QLQ-C30

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ABSTRACT

Introduction: Comparison of patient health-related quality of life (HRQOL) scores to a reference group is needed to quantify the HRQOL impact of disease or treatment. This study aimed to establish population norms for 2 HRQOL questionnaires—EuroQol 5-dimension 5-level questionnaire (EQ-5D-5L) and European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire-Core Questionnaire 30 (EORTC QLQ-C30) according to age, sex and ethnicity—and to explore relationships between the EQ-5D-5L, EORTC QLQ-C30 and sociodemographic characteristics. We used a representative sample of adult Singapore residents aged 21 years and above.

Method: This study used data collected from a cross-sectional household survey in which 600 adult Singaporeans completed questions on sociodemographic characteristics—the EQ-5D-5L and the EORTC QLQ-C30. Multiple linear regression analyses were conducted to explore associations between sociodemographic characteristics, the EQ-5D-5L scores and the EORTC QLQ-C30 scores. Regression-based population norms were computed for each subgroup using a post-stratification method.

Results: In multiple linear regression analysis, age was significantly associated with EQ-5D-5L index and visual analogue scale (VAS) scores, while no sociodemographic characteristics were significantly associated with EORTC QLQ-C30 summary scores. The normative EQ-5D-5L index and VAS scores decreased in adults aged 65 years and above, and EQ-5D-5L index scores were slightly lower in females than males and in non-Chinese than Chinese. The normative EORTC QLQ-C30 summary scores were slightly higher in Chinese than in the non-Chinese group and in the 45–64 age group than other age groups.

Conclusion: This study provides population norms for the EQ-5D-5L and EORTC QLQ-C30 for the general

adult population in Singapore. Future studies of patient populations in Singapore using EQ-5D-5L or QLQ-C30 can use these normative data to interpret the HRQOL data collected.

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Keywords: EQ-5D, health-related quality of life, population norms, QLQ-C30, Singapore

CLINICAL IMPACT

What is New

- Normative EuroQol 5-dimension 5-level questionnaire (EQ-5D-5L) index scores in Singapore decreased with increasing age and were lower in females and non-Chinese individuals.
- Normative Quality of Life Questionnaire-Core Questionnaire 30 (QLQ-C30) summary scores are higher in middle-aged individuals than in young and older individuals.

Clinical Implications

- Future studies of patient populations in Singapore using EQ-5D-5L or QLQ-C30 can use these regression-based norms to interpret data.
- These normative data can also facilitate population health monitoring in Singapore through informing the priorities of public health programmes and evaluating the effectiveness of disease management policies.

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INTRODUCTION

Health-related quality of life (HRQOL) is a multidimensional assessment of the impact of disease and treatment on physical, psychological and social aspects of individuals' lives.^{1,2} HRQOL is an important outcome measure of healthcare interventions that is increasingly used in clinical research and practice.^{1,3} HRQOL instruments may be generic or disease-specific.⁴ Generic instruments are broadly applicable across disease groups, whereas disease-specific instruments are designed for particular diseases and patient populations.⁵ While generic instruments are useful for comparing HRQOL among different populations, they are usually less sensitive than disease-specific instruments to the impact of particular aspects of diseases and their treatments on HRQOL.^{4,5} Hence, using generic and disease-specific HRQOL instruments in conjunction allows for both cross-population comparisons and deep dive into symptoms or health aspects particular to the condition.⁵

For quantifying the HRQOL impact of disease or treatment, comparison of HRQOL scores of a target patient group with a reference group is needed.⁶ In randomised trials, the control group provides the ideal reference group for assessing specific effects of alternative treatment options. The general population is another relevant reference group, providing interpretive value about the impact of any specific disease relative to the background level of health in a general population. Therefore, HRQOL scores of the general population provide useful information for interpreting patients' HRQOL scores for any study design and may be the only option for single-arm clinical studies.

These scores, also called population norms, are usually derived from general population health surveys using the questionnaires of certain HRQOL instruments.⁶ Population norms are published as means and standard deviations (SDs) of HRQOL scores for subgroups stratified by sociodemographic variables such as age, sex and ethnicity⁶ so that adjusted comparisons can be made when quantifying disease burden, given that the prevalence of health conditions may vary by sociodemographic variables. The HRQOL of general populations in different countries may differ due to real health differences and different perceptions of and responses to HRQOL questionnaires influenced by respondents' cultural background including values, beliefs and religion.^{6,7} As a result, it is necessary to establish country-specific population norms for HRQOL instruments.

EQ-5D is a generic HRQOL instrument developed by the EuroQol Group in 1990.⁸ The original version

of the EQ-5D (the EQ-5D-3L) includes 3 response levels for each of its 5 dimensions including mobility, self-care, usual activities, pain or discomfort, and anxiety or depression.⁹ The EQ-5D-5L, which has 5 response levels for each dimension, was introduced in 2009 to increase sensitivity and reduce ceiling effects in measurement.⁸ According to a recent systematic review, the EQ-5D-5L was associated with better measurement properties compared to the EQ-5D-3L.¹⁰ Population norms for the EQ-5D-5L have been established for many countries including the US,¹¹ China¹² and Spain.¹³ The European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire-Core Questionnaire 30 (EORTC QLQ-C30) is the core of a series of cancer-specific HRQOL instruments that cover the most commonly seen cancers such as lung, colorectal and breast cancers.¹⁴ Population norms for the EORTC QLQ-C30 have been established for several countries including Germany,¹⁵ the Netherlands¹⁶ and Australia.¹⁷

The EQ-5D has been shown to be a valid HRQOL instrument for various health conditions including cancers in Singapore,¹⁸ a city-state in Southeast Asia inhabited by a multicultural, multi-ethnic population of 6 million consisting of Chinese (74.0%), Malays (13.5%), Indians (9.0%) and other ethnic groups (3.4%).¹⁹ However, Singaporeans' population norms are available for only EQ-5D-3L based on a survey conducted from 2009 to 2010.²⁰ Similarly, EORTC QLQ-C30 was validated in local cancer patients,²¹ but local normative data have not been available.

The present study aimed to establish population norms for both the EQ-5D-5L and the EORTC QLQ-C30 according to age, sex and ethnicity using a representative sample of adult Singapore residents aged 21 years and above. In addition, the study explored relationships between the EQ-5D-5L, EORTC QLQ-C30 and the sociodemographic characteristics of the Singapore population.

METHOD

Study design and data collection

In a cross-sectional household survey, we used a 3-stage sampling method to recruit community-dwelling adult Singaporeans according to demographic quotas for age, sex, ethnic group and apartment size. Eligibility criteria were: (1) 21 years old or above (age of adult by law in Singapore), (2) Singapore citizen or permanent resident, (3) ability to read and communicate in English or Chinese, (4) able to provide informed consent. The survey form was available in 2 languages (English and Chinese)

for participants to choose from. Detailed sampling and data collection processes are reported in Supplementary Material S1. This study received ethical approval from the SingHealth Centralised Institutional Review Board (CIRB 2018/2345).

Instruments

EQ-5D-5L

The EQ-5D-5L is a self-administered questionnaire describing respondents' health on the day of survey in 5 dimensions (i.e. mobility, self-care, usual activities, pain or discomfort, and anxiety or depression). The questionnaire includes a hash-marked EuroQol visual analogue scale (EQ VAS) for respondents to rate their overall health on the day of survey. Detailed scoring methods are reported in Supplementary Material S2.

QLQ-C30

The QLQ-C30 is a questionnaire designed to measure the HRQOL of cancer patients.²² It consists of 30 questions. Detailed scoring methods are provided in Supplementary Material S3.

Statistical analysis

Statistical analyses were carried out using R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria) and RStudio version 2022.07.2 (Posit, Boston, MA, US). Means and SDs were calculated for continuous variables, and frequencies and percentages for categorical variables. Data were presented separately by age, sex, ethnicity and language of survey used. We used 3 categories

of age to present the data: 21–44, 45–64 and ≥65 years. Multiple linear regression analyses were used to identify sociodemographic characteristics that were statistically significant predictors of EQ-5D-5L and QLQ-C30 scores, which would be accounted for in the computation of population norms. Age, sex, ethnicity, language, marital status, educational level and housing type were included as categorical variables in the regression models (see Table 1 for categories of each variable). We examined the associations between EQ-5D-5L and QLQ-C30 scores using Spearman's correlations. For all analyses, a *P* value of <0.05 was considered statistically significant.

Raking, a post-stratification technique, was used to create sample weights to match the population distributions for age, sex, ethnicity, education level and income shown in Table 1.²³ We utilised a regression-based method to compute the population norms for each subgroup rather than presenting the observed means and SDs of scores, because this would allow us to control for the effect of other sociodemographic variables by including them as predictors in the regression models (Supplementary Material S4).^{24,25} This method also allowed us to provide norms for subgroups where there were no or very few observations. Using separate linear regression models, we generated normative data for EQ-5D-5L index, VAS, QLQ-C30 summary scale, functional and symptom subscales, each for a total of 12 subgroups defined by age (21–44, 45–64 and ≥65 years), sex (male and female), ethnicity (Chinese and non-Chinese).

Table 1. Sample sociodemographic characteristics (n=600).

Variable	Sample, no. (%)	Population (%)
Language of survey		Not applicable
English	452 (75.3)	
Mandarin	148 (24.7)	
Sex, male	292 (48.7)	48.7
Age, median (IQR), years	45.0 (34.0–59.0)	42.4
21–44	289 (48.2)	42.9
45–64	215 (35.8)	35.7
≥65	96 (16.0)	21.4
Ethnicity		
Chinese	451 (75.2)	74.0

Table 1. Sample sociodemographic characteristics (n=600). (Cont'd)

Variable	Sample, no. (%)	Population (%)
Malay	76 (12.7)	13.5
Indian	60 (10.0)	9.0
Others	13 (2.2)	3.4
Highest level of education (n=597)		
Primary or lower	65 (10.9)	20.9
Secondary	75 (12.6)	16.0
O level/A level/diploma	195 (32.7)	26.9
University and above	262 (43.9)	36.2
Current marital status (n=597)		
Never married	158 (26.3)	28.6
Currently married	393 (65.5)	61.8
Separated	4 (0.7)	4.7
Divorced	28 (4.7)	
Widowed	14 (2.3)	4.9
Type of housing		Not available
1-, 2- or 3-room HDB flat	149 (24.8)	
4-room HDB flat	251 (41.8)	
5-room or executive HDB flat	200 (33.3)	
Current employment status (n=596)		Not available
Working	406 (67.7)	
Student (full-time)	25 (4.2)	
National Service	3 (0.5)	
Homemaker/housewife	75 (12.5)	
Retired	60 (10.0)	
Unemployed (able to work)	26 (4.3)	
Unemployed (unable to work because of disability or other medical conditions)	1 (0.2)	
Monthly household income, SGD (n=508)		
Below 2000	97 (16.2)	18.4
2000–3999	127 (21.2)	8.5
4000–5999	111 (18.5)	8.8
6000–9999	111 (18.5)	17.1
10,000 and above	62 (10.3)	47.2

IQR: interquartile range; HDB: Housing & Development Board; SGD: Singapore dollar

RESULTS

There was a total of 600 respondents, comprising 452 (75.3%) English-speaking and 148 (24.7%) Chinese-speaking respondents. There were 289 (48.2%) respondents aged 21–44 years, 215 (35.8%) aged 45–64 years and 215 (35.8%) respondents aged ≥65 years; 292 (48.7%) respondents were male; and 451 (75.2%) respondents were Chinese, 76 (12.7%) were Malay, 60 (10.0%) respondents were Indian, and 13 (2.2%) were of other ethnic groups. The total number of participants by sex, age and ethnicity are shown in Supplementary Table S1.

The highest level of education was university degree and above in 262 (43.9%) respondents, O level/A level/diploma in 195 (32.7%), and secondary education or lower in 140 (23.5%). Most respondents (251, 41.8%) were living in 4-room Housing & Development Board (HDB) apartments,

were employed (406, 67.7%) and were married (393, 65.5%). The monthly household income was below SGD2000 in 97 (16.2%) respondents, SGD2000–3999 in 127 (21.2%), SGD4000–5999 in 111 (18.5%), SGD4000–9999 in 111 (18.5%) and SGD10,000 and above in 62 (10.3%). The demographic characteristics of the sample were similar to census data except that our sample was slightly younger, better educated and earned less (Table 1).

Spearman's correlations between the EQ-5D-5L and the QLQ-C30 scores were all statistically significant (Table 2). Conceptually similar domains (e.g. the QLQ-C30 pain subscale and the EQ-5D-5L pain/discomfort dimension: 0.61) had higher absolute correlations, while conceptually dissimilar domains (e.g. the QLQ-C30 cognitive functioning subscale and the EQ-5D-5L self-care dimension: -0.05) had lower absolute correlations.

Table 2. Spearman's correlation coefficients between EQ-5D and QLQ-C30 items/scores (n=600).

QLQ-C30	EQ-5D						
	Mobility	Self-care	Usual activities	Pain/discomfort	Anxiety/depression	Index	VAS
Global health/QoL	-0.18 ^a	-0.14 ^a	-0.22 ^a	-0.30 ^a	-0.28 ^a	0.38 ^a	0.62 ^a
Physical functioning	-0.34 ^a	-0.13 ^b	-0.24 ^a	-0.34 ^a	-0.22 ^a	0.40 ^a	0.33 ^a
Role functioning	-0.19 ^a	-0.19 ^a	-0.34 ^a	-0.22 ^a	-0.15 ^a	0.25 ^a	0.15 ^a
Emotional functioning	-0.11 ^b	-0.08 ^c	-0.23 ^a	-0.27 ^a	-0.46 ^a	0.42 ^a	0.24 ^a
Cognitive functioning	-0.13 ^b	-0.05	-0.15 ^a	-0.30 ^a	-0.31 ^a	0.36 ^a	0.26 ^a
Social functioning	-0.29 ^a	-0.23 ^a	-0.39 ^a	-0.33 ^a	-0.31 ^a	0.39 ^a	0.31 ^a
Fatigue	0.19 ^a	0.16 ^a	0.25 ^a	0.39 ^a	0.32 ^a	-0.45 ^a	-0.34 ^a
Nausea/vomiting	0.08	0.10 ^c	0.20 ^a	0.15 ^a	0.16 ^a	-0.16 ^a	-0.14 ^a
Pain	0.35 ^a	0.17 ^a	0.30 ^a	0.61 ^a	0.21 ^a	-0.55 ^a	-0.28 ^a
Dyspnoea	0.22 ^a	0.16 ^a	0.29 ^a	0.23 ^a	0.19 ^a	-0.25 ^a	-0.21 ^a
Insomnia	0.14 ^a	0.16 ^a	0.14 ^a	0.36 ^a	0.26 ^a	-0.35 ^a	-0.21 ^a
Appetite	0.18 ^a	0.17 ^a	0.24 ^a	0.28 ^a	0.24 ^a	-0.31 ^a	-0.18 ^a
Constipation	0.15 ^a	0.06	0.21 ^a	0.17 ^a	0.19 ^a	-0.21 ^a	-0.13 ^b
Diarrhoea	0.06	0.09 ^c	0.08	0.07	0.06	-0.06	-0.05
Financial difficulties	0.24 ^a	0.21 ^a	0.45 ^a	0.27 ^a	0.22 ^a	-0.30 ^a	-0.27 ^a
QLQ-C30 summary score	-0.30 ^a	-0.16 ^a	-0.28 ^a	-0.54 ^a	-0.40 ^a	0.60 ^a	0.37 ^a

^a $P<0.001$; ^b $P<0.01$; ^c $P<0.05$

EQ-5D: EuroQol 5-dimension questionnaire; QLQ-C30: Quality of Life Questionnaire-Core Questionnaire 30; QoL: quality of life; VAS: visual analogue scale

In the multivariate linear regression analysis, older age (≥ 65 years) was associated with lower EQ-5D-5L index (β -0.04; standard error [SE] 0.02; $P=0.008$) and EQ VAS (β -6.0; SE 1.56; $P<0.001$). No variables were significantly associated with the QLQ-C30 summary score (Table 3).

Population norms were computed using estimated marginal means for the EQ-5D-5L index, EQ VAS and QLQ-C30 summary score (Table 4), each functional subscale of the QLQ-C30 (Table 5), and each symptom subscale of the QLQ-C30 and financial difficulties (Supplementary Table S2) for age, sex and ethnicity groups. The normative EQ-5D-5L index and EQ VAS scores were similar for the young and middle-aged subgroups, which were higher than those for the old subgroup; EQ-5D-5L index scores were slightly lower in females and non-Chinese participants.

The normative QLQ-C30 scores decreased with age for the physical functioning, social functioning, nausea/vomiting and appetite loss subscales; increased with age for the emotional functioning, pain and financial difficulties subscales; and exhibited a non-monotonic relationship with age for global health, role functioning, cognitive functioning, fatigue, dyspnoea, insomnia, constipation and diarrhoea subscales. The normative QLQ-C30 scores for males were similar to those for females for the physical functioning, cognitive functioning, social functioning and fatigue scales; higher than those for females for the role functioning, emotional functioning, nausea/vomiting, dyspnoea, insomnia and financial difficulties subscales; but lower than those for females for the global health, pain, constipation and diarrhoea subscales. The normative QLQ-C30 scores for Chinese were similar to or higher than those for non-Chinese for all functional scales, and lower than those for non-Chinese for all the symptom scales and financial difficulties. Following post-stratification weighting, the normative score for Chinese females aged ≥ 65 years on the fatigue subscale was -0.35. As scores range from 0 to 100, a score of 0 can be considered the normative score for this subgroup.

DISCUSSION

More than a decade has passed since Singapore's population norms for the EQ-5D-3L were published, and before this study, there was a lack of population norms for the EQ-5D-5L and QLQ-C30 in Singapore. Given the improved sensitivity of the EQ-5D-5L compared to the EQ-5D-3L, establishing population norms for the EQ-5D-5L would provide useful reference data for studies in Singapore. Using

multivariate linear regression models and estimated marginal means, we produced population norms for the EQ-5D-5L and QLQ-C30 questionnaires for the general adult population in Singapore.

The trends found in the EQ-5D-5L index scores in this study were similar to other countries' population norms and the previously published EQ-5D-3L population norms.²⁰ EQ-5D-5L index scores were negatively associated with age in both studies, indicating a trend of worsening mobility, self-care, usual activities, pain/discomfort and anxiety/depression with ageing. The normative EQ-5D-5L index scores were slightly higher for male respondents. These findings were consistent with other studies, which showed that EQ-5D-5L index and EQ VAS scores decreased with increasing age^{11,20} and that women had lower EQ-5D-5L index scores than men.¹² These trends were also consistent with patterns in population norms of other countries, such as Vietnam, China and Australia.^{12,26,27} Normative EQ-5D-5L index scores were slightly higher for Chinese compared to non-Chinese groups. This is consistent with evidence for wide socioeconomic disparities experienced by ethnic minorities in Singapore, which has led to disparities in health literacy, health-seeking behaviours and financial resources.^{28,29} The higher EQ-5D-5L index scores for Chinese respondents could also be attributed to face-saving culture, characterised by a greater reluctance to admit health problems due to their social undesirability.³⁰

Consistent with existing studies, the QLQ-C30 subscale scores in our population sample decreased with age for the physical functioning subscales, but increased with age for the emotional functioning subscale.^{15-17,31} The non-monotonicity of the QLQ-C30 summary score was likely driven by the non-monotonicity of the global health, role functioning, cognitive functioning and symptom subscales. Similar non-monotonicity has been found in other countries for several of the QLQ-C30 subscales including role functioning, cognitive functioning, fatigue and dyspnoea.^{17,31} This differing association with age may be due to the different constituent dimensions of EQ-5D-5L and QLQ-C30. EQ-5D-5L comprises primarily physical health dimensions, while QLQ-C30 consists of psychological, social and symptom dimensions which tend to have complex association with age. The absence of association between age and the QLQ-C30 summary score in multiple linear regression analysis and the minimal non-monotonicity in the normative data could be due to the cancellation of the various monotonic and non-monotonic relationships of the subscales with age after aggregation.

Table 3. Linear regression analysis of QLQ-C30 and EQ-5D scale scores: regression coefficients of sociodemographic characteristics (n=600).

	Global QoL	Physical functioning	Role functioning	Emotional functioning	Cognitive functioning	Social functioning	Fatigue	Pain	Insomnia	C30 summary score	EQ-5D index	EQ-5D VAS
Language												
English	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mandarin	2.8 (1.9)	-2.7 ^c (1.2)	1.6 (1.8)	5.6 ^a (1.9)	0.04 (1.6)	0.64 (1.6)	-1.6 (1.9)	-0.63 (1.9)	0.36 (2.5)	-0.47 (1.1)	0.01 (0.0)	1.8 (1.3)
Sex												
Male	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Female	1.8 (1.4)	-0.54 (0.9)	-0.11 (1.3)	-2.1 (1.3)	-1.1 (1.1)	1.0 (1.1)	2.3 (1.4)	2.9 ^c (1.4)	2.2 (1.8)	0.87 (0.8)	-0.01 (0.0)	-0.11 (0.9)
Age (years)												
21–44	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45–64	-0.29 (1.8)	-3.7 ^a (1.1)	0.19 (1.6)	2.7 (1.7)	-0.38 (2.7)	-0.13 (1.4)	-3.8 ^c (1.8)	2.2 (1.8)	-0.44 (2.3)	0.19 (1.0)	-0.01 (0.0)	-2.0 (2.1)
≥65	-3.8 (2.4)	-6.4 ^a (1.5)	-1.5 (2.2)	7.1 ^a (2.3)	0.59 (1.5)	-0.20 (2.0)	-1.9 (2.4)	4.2 (2.4)	-1.5 (3.1)	0.50 (1.4)	-0.04 ^a (0.0)	-6.0 ^a (1.2)
Ethnicity												
Chinese/other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Malay	-1.1 (2.3)	-2.6 (1.5)	-0.14 (2.2)	3.6 (2.2)	3.1 (1.9)	-0.52 (1.9)	3.3 (2.3)	-0.48 (2.3)	-0.79 (3.0)	0.32 (1.3)	-0.03 (0.0)	0.77 (1.5)
Indian	3.9 (2.3)	-5.6 ^a (1.5)	-5.1 ^c (2.2)	1.6 (2.3)	-1.6 (2.0)	-2.4 (1.9)	-2.4 (2.3)	0.21 (2.4)	0.00 (3.0)	-1.4 (1.3)	-0.02 (0.0)	-0.08 (1.5)
Highest level of education												
PSLE/primary or lower	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Secondary	0.80 (2.8)	-1.0 (1.8)	-2.2 (2.7)	-3.7 (2.8)	-1.3 (2.4)	1.4 (2.3)	2.8 (2.8)	5.2 (2.9)	1.3 (3.6)	-0.60 (1.6)	-0.02 (0.0)	-2.1 (1.9)

Table 3. Linear regression analysis of QLQ-C30 and EQ-5D scale scores: regression coefficients of sociodemographic characteristics (n=600). (Cont'd)

	Global QoL	Physical functioning	Role functioning	Emotional functioning	Cognitive functioning	Social functioning	Fatigue	Pain	Insomnia	C30 summary score	EQ-5D index	EQ-5D VAS
O level/N level or NTC 3 certificate or its equivalent/A level or NTC 1–2 or certificate in office/business skills or its equivalent/ other diploma and professional qualification	0.46 (2.6)	0.67 (1.6)	-1.0 (2.4)	3.0 (2.5)	4.7 ^c (2.2)	1.1 (2.1)	-1.0 (2.6)	-0.51 (2.6)	-2.0 (3.3)	1.7 (1.5)	0.01 (0.0)	-0.72 (1.7)
Polytechnic diploma/ university and above	5.4 (2.9)	0.91 (1.8)	0.01 (2.7)	4.0 (2.8)	4.9 ^c (2.4)	2.7 (2.4)	-3.2 (2.9)	-2.3 (3.0)	-2.1 (3.7)	3.1 (1.7)	0.01 (0.0)	2.0 (1.9)
Current marital status												
Never married	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Currently married	1.4 (1.7)	0.32 (1.1)	0.84 (1.6)	0.35 (1.6)	1.0 (1.4)	-1.2 (1.4)	-1.8 (1.7)	-1.7 (1.7)	-1.5 (2.1)	0.79 (1.0)	0.01 (0.0)	0.65 (1.1)
Separated/divorced/ widowed	-0.19 (2.9)	-1.3 (1.8)	-2.1 (2.7)	-1.3 (2.8)	-0.71 (2.4)	-0.52 (2.4)	-2.4 (2.9)	-2.0 (2.9)	-2.2 (3.7)	1.0 (1.7)	-0.03 (0.0)	1.2 (1.9)
Type of housing												
1-, 2- or 3-room HDB flat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-room HDB flat	-0.44 (1.8)	0.27 (1.1)	0.66 (1.7)	-1.4 (1.7)	0.27 (1.5)	-0.27 (1.5)	0.93 (1.8)	-1.9 (1.8)	-1.4 (2.3)	0.17 (1.0)	0.00 (0.0)	0.08 (1.2)
5-room or executive HDB flat	1.0 (1.9)	-1.1 (1.2)	-0.60 (1.8)	-0.57 (1.9)	2.1 (1.6)	-1.3 (1.6)	2.0 (1.9)	-2.1 (2.0)	-2.0 (2.5)	-0.03 (1.1)	0.00 (0.0)	0.48 (1.3)

EQ-5D: EuroQol 5-dimension questionnaire; HDB: Housing & Development Board; NA: not applicable; NTC: national technical certificate; PSLE: primary school leaving examination;
QLQ-C30: Quality of Life Questionnaire-Core Questionnaire 30; QoL: quality of life; VAS: visual analogue scale
^aP<0.001; ^bP<0.01; ^cP<0.5

Table 4. Model-predicted mean (standard error) EQ-5D index, EQ-5D visual analogue scale and QLQ-C30 summary scores by sex, age and ethnicity.

EQ-5D index score				Visual analogue scale				QLQ-C30 summary score				
	Male		Female		Male		Female		Male		Female	
	21-44 years	45-64 years	≥65 years	21-44 years	45-64 years	≥65 years	21-44 years	45-64 years	≥65 years	21-44 years	45-64 years	≥65 years
Chinese, no. (%)	0.982 (0.018)	0.976 (0.011)	0.940 (0.018)	0.968 (0.015)	0.962 (0.012)	0.926 (0.021)	81.9 (2.2)	81.8 (2.1)	77.7 (3.3)	82.9 (2.1)	82.8 (2.2)	78.6 (2.7)
							91.8 (2.0)	93.7 (1.2)	92.2 (1.0)	91.4 (1.5)	93.3 (1.5)	91.8 (1.3)
Non-Chinese, no. (%)	0.939 (0.016)	0.933 (0.021)	0.897 (0.027)	0.925 (0.022)	0.920 (0.027)	0.883 (0.034)	81.6 (1.9)	81.5 (2.0)	77.3 (3.6)	82.5 (2.0)	82.4 (2.2)	78.3 (3.1)
							89.6 (1.8)	91.5 (2.2)	90.1 (2.2)	89.2 (2.1)	91.1 (3.0)	89.7 (2.9)

EQ-5D: EuroQol 5-dimension questionnaire; QLQ-C30: Quality of Life Questionnaire-Core Questionnaire 30

Table 5. Model-predicted mean (SE) QLQ-C30 global health/QoL and functional subscale scores by sex, age and ethnicity.

	Male			Female		
	21–44 years	45–64 years	≥65 years	21–44 years	45–64 years	≥65 years
Global health/QoL, no. (%)						
Chinese	72.8 (2.7)	76.2 (2.5)	71.4 (2.7)	75.2 (2.7)	78.6 (2.4)	73.8 (2.6)
Non-Chinese	72.8 (2.7)	76.2 (3.2)	71.4 (3.7)	75.2 (2.8)	78.5 (3.3)	73.7 (3.8)
Physical functioning, no. (%)						
Chinese	95.7 (2.2)	94.1 (1.5)	89.9 (2.0)	95.1 (1.7)	93.5 (1.8)	89.3 (2.0)
Non-Chinese	91.3 (1.7)	89.7 (2.5)	85.5 (2.9)	90.7 (2.1)	89.1 (3.2)	84.9 (3.4)
Role functioning, no. (%)						
Chinese	97.2 (2.2)	98.0 (1.2)	95.5 (1.8)	95.7 (1.7)	96.4 (1.6)	94.0 (2.2)
Non-Chinese	93.0 (1.8)	93.7 (2.9)	91.3 (3.0)	91.5 (2.6)	92.2 (3.9)	89.8 (4.0)
Emotional functioning, no. (%)						
Chinese	86.5 (2.8)	89.1 (2.5)	92.2 (1.9)	83.4 (2.5)	86.0 (2.8)	89.1 (2.2)
Non-Chinese	86.3 (2.2)	89.0 (3.1)	92.0 (3.3)	83.2 (2.9)	85.9 (4.0)	88.9 (4.1)
Cognitive functioning, no. (%)						
Chinese	90.8 (2.5)	93.3 (1.8)	91.1 (2.3)	91.2 (2.1)	93.8 (1.8)	91.5 (2.0)
Non-Chinese	90.5 (2.2)	93.0 (2.0)	90.8 (2.7)	90.9 (2.4)	93.5 (2.6)	91.2 (3.0)
Social functioning, no. (%)						
Chinese	97.2 (1.7)	96.7 (1.3)	94.6 (1.8)	97.6 (1.4)	97.1 (1.2)	95.0 (1.9)
Non-Chinese	95.0 (1.5)	94.5 (1.9)	92.5 (2.2)	95.4 (1.8)	94.9 (2.3)	92.8 (2.7)

QoL: quality of life

The trend in the QLQ-C30 global health/quality of life and social functioning scores differed from that in other studies. Our study showed higher levels of global health for the 45–64 age group than both younger and older groups. In contrast, the results of a multinational study showed higher global health/quality of life for the youngest and oldest age groups, compared to the middle-aged group (30–59 years old).³¹ In an Australian study, participants aged 70 years or more had the highest mean scores on the global health/quality-of-life functional subscale.¹⁷ While social functioning scores increased with age in several countries' population norms,^{16,17} social functioning decreased with age in our study. These opposite trends between Singapore and other countries could be attributed to the ever-increasing healthcare and living costs in Singapore, which affects older adults more because of their greater healthcare needs

and diminishing income compared to younger adults. The high living costs may have reduced social participation among the elderly.^{16,17,32}

Non-Chinese respondents in our study had significantly lower QLQ-C30 physical and role functioning scores. This finding supported the previously published study that established the EQ-5D-3L norms, which had also showed that non-Chinese respondents reported more problems with mobility and self-care compared to Chinese respondents in Singapore,²⁰ as well as a study that found poorer 36-Item Short Form Survey physical functioning scores in non-Chinese respondents compared to Chinese respondents.³³ Factors influencing the physical functioning dimension of HRQOL may have differed across ethnic groups.³³ Otherwise, there may have been differences in how individuals from different ethnic groups answered these questions.³³ This underlines the importance

of accounting for differences in sociodemographic characteristics when analysing and interpreting HRQOL outcomes, particularly in unrandomised comparisons and when estimating population norms.

The EQ-5D-5L was significantly correlated with the QLQ-C30 on all subscales. This was consistent with existing international research³⁴ showing that generic HRQOL measures correlated well with measures of cancer-related HRQOL in the Singaporean population. While older age significantly predicted poorer EQ-5D-5L index and EQ VAS scores, age did not significantly predict scores on the QLQ-C30 subscales apart from the physical functioning, emotional functioning and fatigue subscales. Taken together, these suggest that age has a larger impact on the specific constructs assessed by EQ-5D-5L compared to those assessed by the QLQ-C30, especially on the self-care dimension (i.e. whether one has problems washing or dressing oneself). The weak correlations between the self-care item and some QLQ-C30 subscales suggest that problems with self-care may not necessarily impact certain domains of HRQOL, such as cognitive functioning.

These population norms can facilitate population health monitoring by helping to inform the priorities of public health programmes and evaluate the effectiveness of disease management policies. By establishing benchmarks for HRQOL, these norms can guide the allocation of resources according to the needs of the population.³⁵ Lower normative scores could indicate areas that may benefit from preventative interventions, such as reducing social isolation among the elderly to address the decline in social functioning. Utilising normative data in cost-utility analyses can also inform healthcare interventions and insurance reimbursement policies.³⁶ Further studies employing these instruments are encouraged to allow for cross-national analyses in both Southeast Asian and global contexts.

The strengths of this study were that it comprised a representative sample of the adult population in Singapore, and provided norms for multiple sociodemographic characteristics of the Singapore population. Singapore offers a case study for population health in a multi-ethnic society, and the findings from this study can contribute to global discussions on HRQOL measurements by providing insights into how culture impacts health perceptions. Additionally, this study utilised marginal means estimated with multivariate linear regression models that adjusted for confounders in computing population norms. We encourage

other countries to adopt similar methodologies to establish comparable HRQOL data for cross-national analyses. Our quota sampling strategy—set up to achieve national representativeness by age, sex, ethnicity and housing type—resulted in eligible participants being rejected from the study. Due to the lack of data on non-respondents, response rates could not be estimated. We do not think this incurred response bias because respondents were screened out by a local survey company during home visits rather than opting out. However, some response bias may have occurred in the selection of eligible individuals at that stage of sampling.

In addition, we only surveyed Singaporeans living in HDB apartments. People who live in private housing, who might have better or worse HRQOL, were not represented. As private housing is associated with higher socioeconomic status,³⁷ this may have introduced a socioeconomic bias, limiting generalisability. It would be helpful for future studies to include a more diverse housing sample to more accurately reflect the Singaporean population. Lastly, due to small sample sizes for some subgroups, Malay, Indian and other races were combined into a non-Chinese subgroup, and English and Chinese language groups were combined. Although this was not ideal, this allowed us to ensure adequate sample sizes for statistical analysis, enhancing the reliability of the results. We believe combining language groups for the EQ-5D-5L was appropriate, given strong evidence for measurement equivalence between the English and Chinese versions of the EQ-5D-5L in Singapore.^{38,39} Further research on measurement equivalence between the English and Chinese versions of the QLQ-C30 in Singapore is required.

CONCLUSION

This study provides Singaporean population norms for both the EQ-5D-5L and EORTC QLQ-C30 scores. Future studies involving patient populations in Singapore can use these normative data to aid interpretation of the HRQOL data collected.

Supplementary materials

Material S1. Sampling and data collection.

Material S2. EQ-5D-5L.

Material S3. EORTC QLQ-C30.

Material S4. Regression-based method for computing population norms.

Table S1. Number of participants by sex, age and ethnicity (n=600).

Table S2. Model-predicted mean (SE) QLQ-C30 symptom and financial difficulties subscale scores by sex, age and ethnicity.

Ethics statement

This study was approved by the SingHealth Centralised Institutional Review Board (CIRB 2018/2345).

Declaration

The authors declare there are no affiliations with or involvement in any organisation or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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REFERENCES

1. Sitlinger A, Zafar SY. Health-Related Quality of Life: The Impact on Morbidity and Mortality. *Surg Oncol Clin N Am* 2018;27:675-84.
2. Cella DF. Measuring quality of life in palliative care. *Semin Oncol* 1995;22:73-81.
3. Rodríguez-Artalejo F, Guallar-Castillón P, Pascual CR, et al. Health-related quality of life as a predictor of hospital readmission and death among patients with heart failure. *Arch Intern Med* 2005;165:1274-9.
4. Hernandez-Segura N, Marcos-Delgado A, Pinto-Carral A, et al. Health-Related Quality of Life (HRQOL) Instruments and Mobility: A Systematic Review. *Int J Environ Res Public Health* 2022;19:16493.
5. Patrick DL, Deyo RA. Generic and disease-specific measures in assessing health status and quality of life. *Med Care* 1989;27:S217-S32.
6. Fayers P, Machin D. Quality of life: The assessment, analysis and interpretation of patient-reported outcomes. England: Wiley; 2007.
7. Li M, Bao Z, Lv G, et al. Culture-Related Health Disparities in Quality of Life: Assessment of Instrument Dimensions Among Chinese. *Front Public Health* 2021;9:663904.
8. EuroQol Group. EQ-5D-5L About. <https://euroqol.org/eq-5d-instruments/eq-5d-5l-about/>. Accessed 17 November 2022.
9. EuroQol Group. EQ-5D-3L About. <https://euroqol.org/eq-5d-instruments/eq-5d-3l-about/>. Accessed 7 December 2022.
10. Yang F, Wong CKH, Luo N, et al. Mapping the kidney disease quality of life 36-item short form survey (KDQOL-36) to the EQ-5D-3L and the EQ-5D-5L in patients undergoing dialysis. *Eur J Health Econ* 2019;20:1195-206.
11. Jiang R, Janssen MFB, Pickard AS. US population norms for the EQ-5D-5L and comparison of norms from face-to-face and online samples. *Qual Life Res* 2021;30:803-16.
12. Yang Z, Busschbach J, Liu G, et al. EQ-5D-5L norms for the urban Chinese population in China. *Health Qual Life Outcomes* 2018;16:210.
13. Hernandez G, Garin O, Pardo Y, et al. Validity of the EQ-5D-5L and reference norms for the Spanish population. *Qual Life Res* 2018;27:2337-48.
14. Aaronson NK, Ahmedzai S, Bergman B, et al. The European Organization for Research and Treatment of Cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. *J Natl Cancer Inst* 1993;85:365-76.
15. Nolte S, Waldmann A, Liegl G, et al. Updated EORTC QLQ-C30 general population norm data for Germany. *Eur J Cancer* 2020;137:161-70.
16. de Ligt KM, Aaronson NK, Liegl G, et al. Updated normative data for the EORTC QLQ-C30 in the general Dutch population by age and sex: a cross-sectional panel research study. *Qual Life Res* 2023.
17. Mercieca-Bebber R, Costa DS, Norman R, et al. The EORTC Quality of Life Questionnaire for cancer patients (QLQ-C30): Australian general population reference values. *Med J Aust* 2019;210:499-506.
18. Gao F, Ng GY, Cheung YB, et al. The Singaporean English and Chinese versions of the EQ-5D achieved measurement equivalence in cancer patients. *J Clin Epidemiol* 2009;62:206-13.
19. Department of Statistics Singapore. Population Trends ,2024. <https://www.singstat.gov.sg/-/media/files/publications/population/population2024.ashx>. Accessed 7 March 2025.
20. Abdin E, Subramaniam M, Vaingankar JA, et al. Measuring health-related quality of life among adults in Singapore: population norms for the EQ-5D. *Qual Life Res* 2013;22:2983-91.
21. Luo N, Fones CSL, Lim SE, et al. The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-c30): validation of English version in Singapore. *Qual Life Res* 2005;14:1181-6.
22. European Organisation for Research and Treatment of Cancer. EORTC QLQ-C30 Scoring Manual. <https://www.eortc.org/app/uploads/sites/2/2018/02/SCmanual.pdf>. Accessed 17 November 2022.
23. Gary S, Lenhard W, Lenhard A, et al. A tutorial on automatic post-stratification and weighting in conventional and regression-based norming of psychometric tests. *Behav Res Methods* 2024;56:4632-42.
24. Lenhard A, Lenhard W, Suggate S, et al. A Continuous Solution to the Norming Problem. *Assessment* 2018;25:112-25.
25. Yu ZB, Bao CZ, Wu MY, et al. Regression-based normative data for social health scale for the elderly (short version) in eastern China. *Health Qual Life Outcomes* 2020;18:54.
26. McCaffrey N, Kaambwa B, Currow DC, et al. Health-related quality of life measured using the EQ-5D-5L: South Australian population norms. *Health Qual Life Outcomes* 2016;14:133.
27. Nguyen LH, Tran BX, Hoang Le QN, et al. Quality of life profile of general Vietnamese population using EQ-5D-5L. *Health Qual Life Outcomes* 2017;15:199.
28. Chan CQH, Lee KH, Low LL. A systematic review of health status, health seeking behaviour and healthcare utilisation of low socioeconomic status populations in urban Singapore. *Int J Equity Health* 2018;17:39.
29. Rakun A, Allen J, Shahidah N, et al. Ethnic and Neighborhood Socioeconomic Differences In Incidence and Survival From Out-Of-Hospital Cardiac Arrest In Singapore. *Prehosp Emerg Care* 2019;23:619-30.
30. Young DKW, Ng PYN, Kwok T. Predictors of the health-related quality of life of Chinese people with major neurocognitive

- disorders and their caregivers: The roles of self-esteem and caregiver's burden. *Geriatr Gerontol Int* 2017;17:2319-28.
31. Nolte S, Liegl G, Petersen MA, et al. General population normative data for the EORTC QLQ-C30 health-related quality of life questionnaire based on 15,386 persons across 13 European countries, Canada and the United States. *Eur J Cancer* 2019;107:153-63.
 32. Wong YS, Verbrugge LM. Living alone: elderly Chinese Singaporeans. *J Cross Cult Gerontol* 2009;24:209-24.
 33. Thumboo J, Fong KY, Machin D, et al. Quality of life in an urban Asian population: the impact of ethnicity and socio-economic status. *Soc Sci Med* 2003;56:1761-72.
 34. Xu RH, Wong ELY, Jin J, et al. Mapping of the EORTC QLQ-C30 to EQ-5D-5L index in patients with lymphomas. *Eur J Health Econ* 2020;21:1363-73.
 35. Congdon P. Health status and healthy life measures for population health need assessment: modelling variability and uncertainty. *Health Place* 2001;7:13-25.
 36. Ara R, Brazier J, Zouraq IA. The Use of Health State Utility Values in Decision Models. *Pharmacoeconomics* 2017;35:77-88.
 37. Yuen B, Kwee LK, Tu Y. Housing Affordability in Singapore: Can We Move from Public to Private Housing? *Urban Policy Res* 2006;24:253-70.
 38. Wang Y, Tan NC, Tay EG, et al. Cross-cultural measurement equivalence of the 5-level EQ-5D (EQ-5D-5L) in patients with type 2 diabetes mellitus in Singapore. *Health Qual Life Outcomes* 2015;13:103.
 39. Luo N, Wang Y, How CH, et al. Cross-cultural measurement equivalence of the EQ-5D-5L items for English-speaking Asians in Singapore. *Qual Life Res* 2015;24:1565-74.