



Normative profile of the EQ-5D-5L dimensions, EQ-5D-5L index and EQ-VAS scores for the general Thai population

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Accepted: 7 April 2023 / Published online: 15 April 2023
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Abstract

Purpose To generate a normative profile for the EQ-5D-5L dimensions, EQ-5D-5L index, and EQ-VAS scores of the general Thai population and to examine the associations between sociodemographic characteristics and their norm-based scores.

Methods Data from 2019 general Thai samples were employed to estimate the norm-based scores elicited using the Thai EQ-5D-5L value set. Descriptive statistics were used to estimate the norm-based scores stratified by gender and six age bands to obtain the normative profile for the general Thai population. Multivariable logistic and Tobit regression models were used to investigate the relationships between sociodemographic characteristics and EQ-5D-5L dimensions, EQ-5D-5L index, and EQ-VAS scores.

Results The mean EQ-5D-5L index and EQ-VAS scores were 0.931 and 82.3, respectively. Approximately 88.9% of the participants reported 19 out of 3125 (3%) possible health states. The odds of having problems with mobility was greatest for the sample aged ≥ 65 years and declined with decreasing age. Women, samples with advancing age, and those with a household income of $\leq 10,000$ Baht/month and fair and poor health perceptions were more likely to report a lower EQ-5D-5L index. Furthermore, advanced age and fair and poor health perception were significantly associated with lower EQ-VAS scores.

Conclusion The EQ-5D-5L population norms were established as the benchmark for both EQ-5D-5L index and EQ-VAS scores for the general Thai population. This is expected to support the health service research and inform policymakers on the allocation of limited healthcare resources.

Keywords EQ-5D-5L · Thai population · Population norms · Quality of Life · Utility measurement

Plain English summary

The EQ-5D-5L is the most commonly used health preference-based instrument for health technology assessment and health-related quality of life measurement worldwide including Thailand. However, a normative profile of the EQ-5D-5L for the reference values is not available for the general Thai population. This study constructed the population norms for the EQ-5D-5L index and EQ-VAS scores stratified by age and sex, and the result indicates that the EQ-5D-5L index and EQ-VAS scores decreased when advancing age and samples with poor health perception. Moreover, variations of the

EQ-5D-5L index and EQ-VAS for the ceiling effects and the associations with sociodemographic factors, which deserves further investigation. Findings from this study inspires more research on health-related quality of life measurement for health care research and policy makers.

Introduction

The EQ-5D questionnaire is a generic multi-attribute instrument developed by the EuroQoL group in the 1980s. It is designed to measure the health-related quality of life (HRQoL) levels as humanistic outcomes in a way that can be compared across different types of patients, disease areas, treatments, and in the general population [1, 2]. The EQ-5D is commonly used and applied in various fields of health sciences research such as economic analyses especially for cost-utility analysis (CUA), health population survey, and clinical study [2–5]. Moreover, this health

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utility index score can be used to generate a calculation of health metric outcomes in the form of quality-adjusted life-years (QALYs) for CUA as recommended by several health technology assessment guidelines [3, 6–9].

The original version of the EQ-5D is now referred to as the EQ-5D-3L. It has five dimensions with three levels of health impairments, representing no problem, some/moderate problems, and extreme problems [10]. Nevertheless, the EQ-5D-3L has certain psychometric problems including high ceiling effects and less discriminatory power that can limit its capability to capture any clinical changes in regard to HRQoL levels [11]. To eliminate those problems, a newer version (the EQ-5D-5L) was developed by expanding the number of health impairments from three to five levels for each health dimension, expressed as no problem, slight problem, moderate problem, severe problem, and extreme/unable to perform. In addition, evidence has supported the use of EQ-5D-5L because it has a lower ceiling effect and greater discriminative power than those of the EQ-5D-3L in both patient groups and the general population [12, 13].

Due to the EQ-5D-5L's promising psychometric properties and applications in both general population and therapeutic areas, population norms have been used as a benchmark for the HRQoL levels of the general population [14]. Furthermore, the population norms for the EQ-5D-5L have been useful for determining the burden of disease by comparing the HRQoL levels of individuals/groups with specific health problems and by identifying high-risk groups with diminished HRQoL levels [14–16]. In general, population norms are reported through health utility index scores and the vertical visual analog scale (EQ-VAS) according to age group, gender, and sociodemographic factors (e.g., education, health conditions, and ethnicity).

As for Thailand, it is an upper middle-income country [17] with approximately 66.2 million people. Since the majority of the population is Buddhist (95.3%) [18], it naturally influences the cultures, beliefs, and lifestyles of individuals. The EQ-5D-5L has been widely used to assess health interventions in clinical practice and is strongly recommended by the Thai health technology assessment (HTA) guidelines [19]. Moreover, it is a practical, reliable, valid, and responsive instrument, which has been proven to be a better psychometric measurement than the EQ-5D-3L in both the general Thai population and Thai patients with chronic diseases [13, 20, 21]. Currently, the Thai EQ-5D-5L includes its own value set for calculating the EQ-5D-5L index [22]. However, the Thai population norms for the EQ-5D-5L are non-existent. Therefore, the purpose of this study is to present the scores for both the EQ-5D-5L index, and the EQ-VAS scores based on age group, gender, and sociodemographic factors. Additionally, it examines the relationship between the sociodemographic factors and the components

of the EQ-5D-5L descriptive system, the EQ-VAS scores, and the EQ-5D-5L index scores.

Methods

Study design

This study was conducted using the dataset derived from the project of “Psychometric properties comparison between the EQ-5D-5L and EQ-5D-3L in the general Thai population [13].” A cross-sectional survey study was conducted with 1200 individuals recruited from the general Thai population. The interviews were conducted with the samples residing in five provinces across Thailand. Based on a previous general Thai population study [23], four-stage stratified random sampling was employed to select the provinces, districts, sub-districts, and villages for data collection. Each representative province was selected from each of the five Thai regions: North (Chaing-Mai), Northeast (Khon-Kaen), Central (Bangkok), East (Chonburi), and South (Nakhon Sri Thammarat). Furthermore, interviews occurred at several locations covering both city and rural areas within each province. A stratified quota-sampled in proportion to age and gender was employed to select the samples within each location according to the general Thai population structure. These interviews were conducted between July and September 2019.

Data collection

A sample of individuals aged 20–70 years living in both municipality and rural areas were recruited, after which they were asked to complete the questionnaire on their own. However, face-to-face interviews were employed in cases the respondents could not read the questions and answers due to their eyesight problems. Specifically, the interviewers were allowed to read the questions and answers without explaining their meaning to the respondents. Thus, the respondents were able to complete the questionnaire based on their understanding of the questions and answers.

Prior to each interview, the participant information sheet was given to each of the respondents, written informed consent was obtained, and all respondents were informed of their withdrawal rights. Moreover, the data were kept confidential and anonymous.

Each respondent was asked to complete the Thai EQ-5D-5L for both the descriptive system and the EQ-VAS in addition to their demographic information with the interviewers. The demographic information covered the following aspects: gender, age, education level, household income, type of health insurance, health conditions, smoking, and alcohol consumption. The respondent was also asked to rate

their general health perception. The official Thai EQ-5D-5L was granted by the EuroQoL group, and ethical approval was obtained from the Burapha University Institutional Review Board (BUU-IRB; 108/2562).

Instrument

The EQ-5D-5L has two sections: a descriptive system and a visual analog scale (EQ-VAS). Its descriptive system consists of five dimensions: (1) Mobility (MO), (2) Self-care (SC), (3) Usual activities (UA), (4) Pain/discomfort (PD), and (5) Anxiety/depression (AD). The EQ-5D-5L's descriptive responses can be converted to a single score, EQ-5D-5L index, using a national-specific value set. The national-specific value set was developed by using the stated preference data elicited from the general population to provide the weights attached to each level of health dimension, thereby converting the health descriptive responses into a single value ranging from a value ranging from 0 (the worst possible health state or dead) to 1 (the best health status or full health) [24–26]. Regarding the EQ-VAS, it is the respondent's self-rated health on a visual analog scale, anchored at 0 for the “worst imaginable health state” and 100 for the “best imaginable health state” to provide the EQ-VAS scores ranging from 0 to 100 [27]. Consequently, two summary scores, health utility index and EQ-VAS, were obtained from the EQ-5D-5L for each respondent.

The health utility index score was computed using the Thai EQ-5D-5L value set. It was developed from 1207 individuals from the general Thai population living in 12 provinces across Thailand using a stratified multi-stage quota sampling technique. According to the EQ-VT protocol, each sample was assigned to provide the values for a given health state using time-trade-off technique for 10 health states and discrete choice experiment (DCE) for seven pairs of health states to elicit the EQ-5D-5L index scores. Consequently, the Thai EQ-5D-5L index scores developed from Hybrid model (TTO and DCE) range from -0.4212 to 1.00 .

The Thai population norms were reported in the form of EQ-5D-5L index scores and EQ-VAS. The self-reported descriptive system was used to compute the EQ-5D-5L index scores by employing the Thai-specific value set developed based on the Hybrid model [22]. In addition, the EQ-VAS was used to report in terms of EQ-VAS scores and index-based scores wherein the EQ-VAS scores divided by 100.

Data analyses

Sociodemographic information was reported for the recruited samples using descriptive statistics, frequencies, percentage to compare with the data of general Thai population in 2019. The population norms, EQ-5D-5L index and EQ-VAS scores, were reported using the mean, standard

deviation, median, and interquartile range according to stratified sociodemographic information. Both the EQ-5D-5L index and EQ-VAS scores were analyzed as continuous variables, so univariate analysis was used to analyze the differences in mean EQ-5D-5L index and EQ-VAS scores using independent t-test or ANOVA where appropriate.

Frequencies and percentages were also employed to report the distribution of the responses to each EQ-5D-5L dimension for the whole samples and stratified by the predefined age groups (<25 , $25-34$, $35-44$, $45-54$, $55-64$, ≥ 65), and the top 10 most frequently self-rated health states.

Multivariable logistic regression was used to investigate the association between the sociodemographic variables and the reported problems in each EQ-5D-5L dimension, where the responses for the EQ-5D-5L dimensions were recorded as dummy variables (0 for “no problem” and 1 for “slight,” “moderate,” “severe,” and “extreme/unable to perform”). Due to the ceiling effects of the two population norms, multivariable Tobit regression models were also employed to individually examine the association between the sociodemographic variables and the EQ-5D-5L index and EQ-VAS scores [28]. All of the data analyses were performed using IBM SPSS version 23 (IBM Corporation, Armonk, NY, USA) and STATA version 17.0 (StataCorp LLC, College Station, TX, USA), with the $p < 0.05$ was designated as statistical difference.

Results

Sample characteristics

Table 1 shows the sample characteristics and a comparison of the structure of the general Thai population. The majority of the sample was female (53.3%) and the mean age was 42.7 years ($SD = 13.7$). Other demographic information is presented in Table 1. Compared to the general Thai population in 2019, the sample had similar characteristic distributions, including gender, age, residence of origin, and certain medical illnesses. The sample characteristics of this study were also similar to those of a previous Thai valuation study in terms of gender and average age. However, the sample in the former had a lower education level (College/University) and higher household income than the sample in the latter. Moreover, according to age and gender, the sample in this study had a similar structure to the general Thai population, especially for the $25-34$, $35-44$, $45-54$, and ≥ 65 age groups (Supplementary Table 1).

Responses distribution to EQ-5D-5L dimensions

Table 2 shows the most frequent self-reported EQ-5D-5L health states. Of the 3125 possible health states, 94 (3%)

Table 1 The sample characteristics as compared to the general Thai population

Characteristics	Study samples		Study samples from the Thai valuation study [22]	General Thai population ^b
	n	% ^a	%	%
<i>Sex</i>				
Male	560	46.67	48.38	48.67
Female	640	53.33	51.62	51.33
<i>Marital status</i>				
Single	347	28.92	19.14	–
Married	765	63.75	67.61	–
Widow	41	3.4	–	–
Divorced/seperated	47	3.9	–	–
<i>Age groups</i>				
< 25	138	11.50	–	10.27
25–34	247	20.58	–	20.56
35–44	256	21.33	–	22.44
45–54	275	22.92	–	22.73
55–64	212	17.67	–	17.85
≥ 65	72	6.00	–	6.150
Mean ± SD	42.70 ± 13.71		43.55 ± 15.03	
<i>Education level</i>				
No or Elementary	436	36.33	44.99	41.97
Secondary	255	21.25	44.16	37.33
College/ University	509	42.42	10.85	20.70
<i>Health insurance</i>				
Civil servant benefit scheme	59	4.92	–	6.13
Universal coverage	737	61.42	–	70.51
Social security	364	30.33	–	16.55
Private health insurance	40	3.33	–	6.81
<i>Average household income (Baht/month)</i>				
Up to 10,000	661	55.08	–	–
10,001–50,000	525	43.75	–	–
50,001–100,000	10	0.83	–	–
> 100,001	4	0.33	–	–
Mean ± SD	12,631.5 ± 10,276.5		22,602.86 ± 26,757.98	
<i>General health perception</i>				
Excellence	70	5.83	–	–
Very good	349	29.08	–	–
Good	580	48.33	–	–
Fair and poor	201	16.75	–	–
<i>Residence of origin</i>				
Municipality	428	35.67	43.33	34.54
Rural	772	64.33	56.67	65.46
<i>Self-reported health conditions</i>				
Healthy	844	70.33	–	–
Reported health conditions	356	29.67	–	–
<i>Medical illnesses</i>				
Hypertension	167	13.92	–	16.46 ^c
Diabetes	82	6.83	–	7.83 ^c
Asthma/COPD ^d	17	1.42	–	0.48 ^c
Stroke	1	0.08	–	0.72 ^c
Musculoskeletal diseases	71	5.92	–	–

Table 1 (continued)

Characteristics	Study samples		Study samples from the Thai valuation study [22]	General Thai population ^b
	n	% ^a	%	%
Renal failure	11	0.92	–	–
Heart diseases	17	1.42	–	–
Hyperlipidemia	79	6.58	–	–
<i>Smoking status</i>				
Smokers	335	27.92	–	18.35 ^e
Non-smokers	865	72.08	–	81.65 ^e
<i>Alcohol consumptions</i>				
Drinkers	452	37.67	–	28.00 ^e
Non-drinkers	748	62.33	–	72.00 ^e

^aSome columns do not sum to 100% due to rounding errors

^bUsing general population in 2019 from National Statistical Office in Thailand

^cUsing general population in 2019 from Ministry of Public Health in Thailand

^dChronic Obstructive Pulmonary Disease

^eUsing general population in 2021 from National Statistical Office in Thailand

Table 2 Most frequency of self-rated EQ-5D-5L health states in the general Thai population (frequencies greater than or equal to 0.5% were reported)

EQ-5D-5L health states	n	%	EQ-5D-5L health states	n	%
11111	589	49.08	11221	11	0.92
11121	166	13.83	11222	11	0.92
21121	47	3.92	31131	10	0.83
11112	43	3.58	11132	8	0.67
11122	42	3.50	31121	8	0.67
21111	29	2.42	21222	8	0.67
21122	26	2.17	31122	6	0.50
11131	19	1.58	31132	6	0.50
21221	19	1.58	41131	6	0.50
21112	12	1.00			

health states were reported by the Thai samples. Moreover, 19 health states were mainly reported by the majority of the Thai sample (88.9%), and 12 health states mainly settled around level 1 (no problem) and level 2 (slight problem), while the level 5 (extreme problem/unable to perform) of any dimensions was unrelated to these 19 health states. As shown in Table 2, the respondents reported five most health states as follows: 11111 (n = 589, 49.1%), 11121 (n = 166, 13.8%), 21121 (n = 47, 3.9%), 11112 (n = 43, 3.6%) and 11122 (n = 42, 3.5%) yielding EQ-5D-5L index scores of 1.000, 0.9436, 0.8775, 0.9419, and 0.8855, respectively. Notably, 49.1% of the samples responding to health states of 11111 were regarded as the ceiling effects of this study, while no floor effects were observed.

Table 3 also presents the responses to the EQ-5D-5L dimensions regarding the numbers and percentages across six age groups. The highest percentage of respondents reporting any problems (level 2–5) in PD (42.2%), were followed by MO (22.9%), AD (19.8%), UA (11.3%) and, with the lowest percentage, SC (2.5%) dimensions. The samples were more likely to report any problems with increasing age, and the sample group of ≥ 65 years had the highest proportions of reporting any problems for most of the EQ-5D-5L dimensions except for the UA dimension. Among the younger age groups (age < 25 and age 25–35), the youngest (age < 25) experienced greater problems in the dimensions of UA, PD, and AD than their counterparts; however, their proportions were still lower than those in the older age bands. In addition, Supplementary Table 2 shows that the females in the six age groups were more likely to report problems in the five dimensions compared to the males in the groups. This resulted in lower EQ-5D-5L index and EQ-VAS scores (Supplementary Table 3).

EQ-5D-5L index and EQ-VAS scores for the general Thai population

Table 4 conveys the descriptive statistics of the EQ-5D-5L index and EQ-VAS scores stratified by sociodemographic variables. The mean EQ-5D-5L index, using the EQ-5D-5L Thai value set, for the general Thai population was 0.931 (SD 0.101), with values ranging from 0.2285 to 1.000. The univariate analysis showed that mean EQ-5D-5L index and EQ-VAS scores generally decreased among females and older samples (p < 0.05). In addition, both the EQ-5D-5L index and EQ-VAS scores could be affected by other

Table 3 Self-reported EQ-5D-5L descriptive system stratified by age group

Domains	Response options	Age groups n(%) ^a						Total n(%) ^a
		< 25	25–34	35–44	45–54	55–64	≥ 65	
Mobility								
	No problems	134 (97.10)	227 (91.90)	205 (80.08)	206 (74.91)	125 (58.96)	28 (38.89)	925 (77.08)
	Slight problems	4 (2.90)	13 (5.26)	38 (14.84)	47 (17.09)	47 (22.17)	27 (37.50)	176 (14.67)
	Moderate problems	–	6 (2.43)	11 (4.30)	16 (5.82)	25 (11.79)	11 (15.28)	69 (5.75)
	Severe problems	–	1 (0.40)	2 (0.78)	6 (2.18)	15 (7.08)	5 (6.94)	29 (2.42)
	Unable to walk	–	–	–	–	–	1 (1.39)	1 (0.08)
Self-care								
	No problems	138 (100.0)	246 (99.60)	250 (97.66)	268 (97.45)	201 (94.81)	67 (93.06)	1170 (97.50)
	Slight problems	–	1 (0.40)	4 (1.56)	6 (2.18)	9 (4.25)	4 (5.56)	24 (2.00)
	Moderate problems	–	–	1 (0.39)	1 (0.36)	2 (0.94)	1 (1.39)	5 (0.42)
	Severe problems	–	–	1 (0.39)	–	–	–	1 (0.08)
	Unable to wash or dress	–	–	–	–	–	–	–
Usual activities								
	No problems	131 (94.93)	241 (97.57)	236 (92.19)	238 (86.55)	163 (76.87)	56 (77.78)	1065 (88.75)
	Slight problems	6 (4.35)	5 (2.02)	17 (6.64)	31 (11.27)	33 (15.57)	13 (18.06)	105 (8.75)
	Moderate problems	1 (0.72)	1 (0.40)	3 (1.17)	6 (2.18)	15 (7.08)	3 (4.17)	29 (2.42)
	Severe problems	–	–	–	–	1 (0.47)	–	1 (0.08)
	Unable to do	–	–	–	–	–	–	–
Pain/discomfort								
	No problems	98 (71.01)	186 (75.30)	154 (60.16)	145 (52.73)	91 (42.92)	20 (27.78)	694 (57.83)
	Slight problems	35 (25.36)	55 (22.27)	89 (34.77)	95 (34.55)	78 (36.79)	34 (47.22)	386 (32.17)
	Moderate problems	4 (2.90)	5 (2.02)	12 (4.69)	29 (10.55)	35 (16.51)	18 (25.00)	103 (8.58)
	Severe problems	1 (0.72)	1 (0.40)	1 (0.39)	6 (2.18)	8 (3.77)	–	17 (1.42)
	Extreme problems	–	–	–	–	–	–	–
Anxiety/depression								
	No problems	117 (84.78)	211 (85.43)	207 (80.86)	217 (78.91)	158 (74.53)	52 (72.22)	962 (80.17)
	Slight problems	18 (13.04)	32 (12.96)	40 (15.63)	48 (17.45)	44 (20.75)	17 (23.61)	199 (16.58)
	Moderate problems	3 (2.17)	3 (1.21)	7 (2.73)	7 (2.55)	9 (4.25)	2 (2.78)	31 (2.58)
	Severe problems	–	1 (0.40)	1 (0.39)	3 (1.09)	–	1 (1.39)	6 (0.50)
	Extreme problems	–	–	1 (0.39)	–	1 (0.47)	–	2 (0.17)

^aSome columns do not sum to 100% due to rounding errors

sociodemographic factors, including marital status, education level, health insurance, average household income, general health perception, self-reported health conditions, smoking status, and alcohol consumption because those scores differed across subgroups of sociodemographic factors ($p < 0.05$).

Table 5 depicts the EQ-5D-5L index and EQ-VAS scores individually estimated by gender with some additional stratifications of the six age groups and general health perceptions. Males had a higher mean EQ-5D-5L index and EQ-VAS than females across age groups, and both genders had consistently diminished mean EQ-5D-5L index and EQ-VAS scores when decreasing general health perception.

Association between sociodemographic characteristics and EQ-5D-5L descriptive system, EQ-5D-5L index, and EQ-VAS scores

Table 6 presents the results of the logistic regression models for the association between the sociodemographic characteristics and the reported problems for each EQ-5D-5L dimension. Specifically, females reported more problems in MO, PD, and AD (OR 1.811; 95% confidence interval [CI] 1.218 to 2.694, OR 1.744; 95% CI 1.264 to 2.406, and OR 1.512; 95% CI 1.028 to 2.223, respectively). Regarding the age groups, the sample aged ≥ 35 years had higher odds of MO problems (OR 8.038, 95% CI 2.739 to 22.589) than the sample aged < 25 years, whereas the highest odds were observed in the sample aged ≥ 65 years (OR 32.563, 95% CI 10.245 to 103.499). Similarly, the sample aged ≥ 55 years had higher

Table 4 Thai EQ-5D-5L index and EQ-VAS population norms by sample characteristics

Sample characteristics	n	% ^a	Thai EQ-5D-5L index scores					EQ-VAS				
			Mean	Standard deviation	Median	Interquartile range	P-value	Mean	Standard deviation	Median	Interquartile range	P-value
<i>Overall</i>	1200	100	0.931	0.101	0.944	(0.885, 1.000)	<0.01	82.3	12.8	80.0	(75.0, 90.0)	<0.01
<i>Sex</i>												
Male	560	46.67	0.946	0.085	1.000	(0.934, 1.000)	<0.01	83.2	11.8	80.0	(80.0, 90.0)	0.02
Female	640	53.33	0.918	0.112	0.944	(0.876, 1.000)		81.4	13.5	80.0	(75.0, 90.0)	
<i>Marital status</i>												
Single	347	28.92	0.957	0.072	1.000	(0.942, 1.000)	<0.01	84.3	11.6	85	(80.0, 95.0)	<0.01
Married	765	63.75	0.924	0.106	0.944	(0.878, 1.000)		81.6	13.1	80	(75.0, 90.0)	
Widow	41	3.42	0.881	0.113	0.886	(0.793, 1.000)		76.1	14.0	80	(70.0, 80.0)	
Divorced/ Separated	47	3.25	0.896	0.144	0.942	(0.847, 1.000)		83.0	12.1	80	(80.0, 90.0)	
<i>Age group</i>												
<25	138	11.50	0.968	0.053	1.000	(0.944, 1.000)	<0.01	86.8	10.6	90.0	(80.0, 95.0)	<0.01
25–34	247	20.58	0.967	0.061	1.000	(0.944, 1.000)		85.1	10.9	90.0	(80.0, 90.0)	
35–44	256	21.33	0.941	0.091	0.972	(0.934, 1.000)		82.5	12.7	80.0	(80.0, 90.0)	
45–54	275	22.92	0.923	0.102	0.944	(0.876, 1.000)		81.3	12.8	80.0	(75.0, 90.0)	
55–64	212	17.67	0.886	0.130	0.938	(0.819, 1.000)		78.9	14.2	80.0	(70.0, 90.0)	
≥65	72	6.00	0.862	0.118	0.877	(0.809, 0.944)		76.3	13.3	80.0	(70.0, 80.0)	
<i>Education level</i>												
No or Elementary	436	36.33	0.899	0.125	0.943	(0.827, 1.000)	<0.01	78.8	14.0	80.0	(70.0, 90.0)	<0.01
Secondary	255	21.25	0.940	0.093	1.000	(0.886, 1.000)		83.9	12.4	85.0	(80.0, 90.0)	
College/ University	509	42.42	0.953	0.070	1.000	(0.942, 1.000)		83.6	11.5	80.0	(80.0, 90.0)	
<i>Health insurance</i>												
Civil servant benefit scheme	59	4.92	0.963	0.066	1.000	(0.944, 1.000)	<0.01	84.6	11.0	85.0	(76.0, 95.0)	0.04
Universal coverage	737	61.42	0.919	0.111	0.944	(0.876, 1.000)		81.4	13.3	80.0	(75.0, 90.0)	
Social security	364	30.33	0.949	0.076	1.000	(0.936, 1.000)		83.7	11.7	85.0	(80.0, 90.0)	
Private health insurance	40	3.33	0.942	0.104	1.000	(0.942, 1.000)		82.3	13.5	80.0	(75.0, 90.0)	
<i>Average household income (Baht/month)</i>												
Up to 10,000	661	55.08	0.916	0.117	0.944	(0.876, 1.000)	<0.01	80.8	13.6	80.0	(70.0, 90.0)	<0.01
10,001–50,000	525	43.75	0.950	0.072	1.000	(0.934, 1.000)		84.0	11.4	85.0	(80.0, 90.0)	
50,001–100,000	10	0.83	0.917	0.081	0.943	(0.864, 1.000)		82.0	13.8	80.0	(80.0, 88.8)	
> 100,001	4	0.33	0.929	0.083	0.934	(0.852, 1.000)		86.3	13.8	87.5	(72.5, 98.8)	
<i>General health perception</i>												
Excellence	70	5.83	0.986	0.037	1.000	(1.000, 1.000)	<0.01	92.1	8.8	95.0	(85.0, 100.0)	<0.01
Very good	349	29.08	0.972	0.051	1.000	(0.944, 1.000)		87.7	9.4	90.0	(80.0, 95.0)	
Good	580	48.33	0.936	0.078	0.944	(0.886, 1.000)		81.7	11.7	80.0	(78.5, 90.0)	
Fair and poor	201	16.75	0.826	0.152	0.857	(0.761, 0.944)		71.0	13.7	70.0	(60.0, 80.0)	

Table 4 (continued)

Sample characteristics	n	% ^a	Thai EQ-5D-5L index scores					EQ-VAS				
			Mean	Standard deviation	Median	Interquartile range	P-value	Mean	Standard deviation	Median	Interquartile range	P-value
<i>Self-reported health conditions</i>												
Healthy	844	70.33	0.956	0.065	1.000	(0.942, 1.000)	<0.01	84.6	10.9	85.0	(80.0, 90.0)	<0.01
Reported health conditions	356	29.67	0.867	0.135	0.886	(0.817, 0.944)		76.7	15.0	80.0	(70.0, 90.0)	
<i>Medical illnesses</i>												
Hypertension	167	13.92	0.861	0.151	0.878	(0.793, 1.000)		75.2	15.2	80.0	(70.0, 80.0)	
Diabetes	82	6.83	0.854	0.144	0.878	(0.794, 0.944)		76.4	14.0	80.0	(70.0, 90.0)	
Hyperlipidemia	79	6.58	0.837	0.160	0.878	(0.786, 0.944)		73.9	16.5	75.0	(60.0, 90.0)	
Asthma/COPD ^b	17	1.45	0.767	0.148	0.809	(0.661, 0.855)		68.5	15.8	70.0	(50.0, 80.0)	
Musculoskeletal	71	5.92	0.795	0.133	0.819	(0.718, 0.876)		73.4	15.4	70.0	(60.0, 80.0)	
Stroke	1	0.08	1.000	N/A	1.000	(1.000, 1.000)		70.0	N/A	70.0	(70.0, 70.0)	
Renal	11	0.92	0.827	0.137	0.867	(0.705, 0.942)		68.2	17.2	70.0	(50.0, 80.0)	
Heart	17	1.42	0.859	0.126	0.904	(0.785, 0.944)		77.7	13.5	80.0	(70.0, 90.0)	
<i>Smoking</i>												
Smokers	335	27.92	0.945	0.075	1.000	(0.886, 1.000)	<0.01	83.8	12.0	85.0	(80.0, 90.0)	0.02
Non-smokers	865	72.08	0.925	0.109	0.944	(0.878, 1.000)		81.7	13.0	80.0	(75.0, 90.0)	
<i>Alcohol consumption</i>												
Drinkers	452	37.67	0.941	0.085	1.000	(0.886, 1.000)	<0.01	83.4	12.2	85.0	(80.0, 90.0)	0.02
Non-drinkers	748	62.33	0.925	0.109	0.944	(0.878, 1.000)		81.2	13.1	80.0	(75.0, 90.0)	

^aSome columns do not sum to 100% due to rounding errors

Table 5 EQ-5D-5L index and EQ-VAS-based norms by age and general health perceptions stratified by gender

	Men					Women						
	n	% ^a	Mean	Standard deviation	Median	Interquartile range	n	% ^a	Mean	Standard deviation	Median	Interquartile range
<i>EQ-5D-5L index scores</i>												
Overall	560	46.67	0.946	0.085	1.000	(0.934, 1.000)	640	53.33	0.918	0.112	0.944	(0.878, 1.000)
<i>Age</i>												
<25	77	13.75	0.975	0.049	1.000	(0.944, 1.000)	61	9.53	0.958	0.058	1.000	(0.942, 1.000)
25–34	117	20.89	0.969	0.054	1.000	(0.944, 1.000)	130	20.31	0.966	0.068	1.000	(0.944, 1.000)
35–44	121	21.61	0.953	0.081	1.000	(0.942, 1.000)	135	21.09	0.930	0.098	0.944	(0.886, 1.000)
45–54	124	22.14	0.935	0.086	0.944	(0.885, 1.000)	151	23.59	0.913	0.114	0.944	(0.878, 1.000)
55–64	89	15.89	0.917	0.100	0.944	(0.875, 1.000)	123	19.22	0.862	0.144	0.886	(0.799, 1.000)
≥65	32	5.71	0.877	0.134	0.878	(0.827, 0.986)	40	6.25	0.850	0.104	0.867	(0.771, 0.934)
<i>General health perception</i>												
Excellent	44	7.86	0.994	0.025	1.000	(1.000, 1.000)	26	4.06	0.974	0.049	1.000	(0.944, 1.000)
Very good	170	30.36	0.973	0.054	1.000	(0.944, 1.000)	179	27.97	0.972	0.047	1.000	(0.944, 1.000)
Good	260	46.43	0.948	0.066	0.944	(0.934, 1.000)	320	50.00	0.926	0.086	0.944	(0.878, 1.000)
Fair and poor	86	15.36	0.861	0.135	0.878	(0.799, 0.944)	115	17.97	0.799	0.159	0.819	(0.731, 0.886)
<i>EQ-VAS scores</i>												
Overall	560	46.67	83.2	11.8	80.0	(80.0, 90.0)	640	53.33	81.4	13.5	80.0	(75.0, 90.0)
<i>Age</i>												
<25	77	13.75	85.8	10.0	90.0	(80.0, 95.0)	61	9.53	88.0	11.2	90.0	(80.0, 97.5)
25–34	117	20.89	85.0	11.1	85.0	(80.0, 90.0)	130	20.31	85.2	10.9	90.0	(80.0, 91.3)
35–44	121	21.61	83.5	11.5	80.0	(80.0, 90.0)	135	21.09	81.7	13.7	80.0	(80.0, 90.0)
45–54	124	22.14	82.3	12.4	80.0	(80.0, 90.0)	151	23.59	80.5	13.1	80.0	(70.0, 90.0)
55–64	89	15.89	81.4	12.8	80.0	(70.0, 90.0)	123	19.22	77.1	15.0	80.0	(70.0, 90.0)
≥65	32	5.71	78.0	12.8	80.0	(70.0, 87.5)	40	6.25	75.0	13.7	80.0	(66.3, 80.0)
<i>General health perception</i>												
Excellent	44	7.86	89.6	9.4	90.0	(80.0, 100.0)	26	4.06	96.3	5.7	100.0	(95.0, 100.0)
Very good	170	30.36	88.1	9.1	90.0	(80.0, 95.0)	179	27.97	87.3	9.6	90.0	(80.0, 95.0)
Good	260	46.43	82.7	10.8	80.0	(80.0, 90.0)	320	50.00	80.9	12.4	80.0	(75.0, 90.0)
Fair and poor	86	15.36	71.8	12.6	70.0	(68.8, 80.0)	115	17.97	70.3	14.6	70.0	(60.0, 80.0)

^aSome columns do not sum to 100% due to rounding errors

odds of PD than the sample aged < 25 years (OR 1.852, 95% CI 1.119 to 3.066), whereas the highest odds were detected in the sample aged ≥ 65 years (OR 3.511, 95% CI 1.742 to 7.075). Furthermore, only the sample aged 55–64 years had higher odds of UA problems than the sample aged < 25 years (OR 3.195, 95% CI 1.334 to 7.654). Notably, the odds of reporting problems in SC could not be computed because there were no reporting any problems in the SC dimension for some age groups.

Compared with the “fair” and “poor” health perception groups, the lowest odds of reporting problems with UA occurred in the “excellent” health perception group (OR 0.046, 95% CI 0.006 to 0.355). Similar to UA, the odds of problems with SC for the “very good” health perception group were 0.158 (95% CI 0.031 to 0.801) times lower than those of the “fair” and “poor” health perception groups. Meanwhile, the “excellent” health perception group reported

the lowest problems of AD (OR 0.019, 95% CI 0.003 to 0.147). However, the highest odds ratio was found in the “good” health perception group (OR 0.369, 95% CI 0.250 to 0.544). Notably, the odds of certain dimensions could not be computed because there were no reporting problems for some health perception groups.

Table 6 also shows the association between the selected sociodemographic characteristics and the EQ-5D-5L index and EQ-VAS scores based on the multivariable Tobit regression models. According to the results of the EQ-5D-5L dimensions, gender, age, and general health perceptions can affect the EQ-5D-5L index, after adjusting for demographic factors. Specifically, females had a lower mean EQ-5D-5L index than males (− 0.042, 95% CI − 0.063 to − 0.020). Compared with the sample aged < 25 years, the older age groups (except for the 25–34 age group) had a lower mean EQ-5D-5L index where the greatest difference was found in the

Table 6 The associations between the sample characteristics and EQ-5D-5L index, EQ-VAS-based norms, and having any problems/impairments in the EQ-5D-5L dimensions

Variables	Having any problems/impairments in the EQ-5D-5L dimensions Odds Ratio (95%CI)					EQ-5D-5L index score Coefficient (95% CI)	EQ-VAS score Coefficient (95% CI)
	Mobility	Self-care	Usual activity	Pain /discom- fort	Anxiety / depression		
Gender (Ref: Male)	1.00	1.00	1.00	1.00	1.00		
Female	1.811 (1.218, 2.694)	0.930	0.921	1.744 (1.264, 2.406)	1.512 (1.028, 2.223)	-0.042 (-0.063, -0.020)	0.556
Marital status (Ref:Single)	1.00	1.00	1.00	1.00	1.00		
Married	0.826	1.646	0.767	0.912	0.777	0.014	0.747
Widow	0.987	3.762	0.819	0.814	0.595	0.012	-0.615
Divorced/Sepa- rated	0.737	4.920	0.744	0.681	0.718	0.022	3.252
Age group (Ref: < 25 years group)	1.00	1.00	1.00	1.00	1.00		
25–34 years group	2.944	0.217	0.461	0.659	0.768	0.012	-0.841
35–44 years group	8.038 (2.739, 22.589)	1.074	1.339	1.293	0.957	-0.041 (-0.076, -0.007)	-2.402
45–54 years group	8.482 (2.923, 24.608)	0.816	2.001	1.444	0.860	-0.048 (-0.082, -0.014)	-2.150
55–64 years group	15.339 (5.287, 44.500)	1.094	3.195 (1.334, 7.654)	1.852 (1.119, 3.066)	0.986	-0.086 (-0.121, -0.051)	-3.106 (-5.939, -0.272)
≥ 65 years group	32.563 (10.245, 103.499)	N/A	2.386	3.511 (1.742, 7.075)	0.916	-0.107 (-0.151, -0.062)	-3.809 (-7.577, -0.041)
Education (Ref: No or elemen- tary)	1.00	1.00	1.00	1.00	1.00		
Secondary	1.025	0.162	0.536	1.094	0.810	-0.004	-0.688
University	0.804	1.016	0.969	1.047	0.994	-0.004	-0.569
Health insurance (Ref: Social security)	1.00	1.00	1.00	1.00	1.00		
Universal cover- age	1.264	0.949	1.060	1.446 (1.074, 1.946)	1.031	-0.017	0.029
Civil servant ben- efit scheme	2.035	N/A	1.282	2.300 (1.225, 4.318)	1.251	-0.032	0.301
Private health insurance	1.132	2.571	0.797	0.962	1.259	-0.008	0.410
Income (Ref: ≤ 10,000 Baht/month)	1.00	1.00	1.00	1.00	1.00		
10,001–50,000	0.803	0.540	0.733	0.862	0.869	0.019 (0.001, 0.038)	1.567
50,001–100,000	1.282	2.293	1.908	1.205	1.610	-0.020	1.866
> 100,001	3.271	N/A	N/A	1.380	N/A	0.041	7.390
General health perception (Ref: Fair and Poor)	1.00	1.00	1.00	1.00	1.00		
Good	0.324 (0.215, 0.484)	0.501	0.296 (0.184, 0.477)	0.062 (0.028, 0.139)	0.369 (0.250, 0.544)	0.120 (0.095, 0.145)	10.555 (8.366, 12.744)

Table 6 (continued)

Variables	Having any problems/impairments in the EQ-5D-5L dimensions Odds Ratio (95%CI)					EQ-5D-5L index score Coefficient (95% CI)	EQ-VAS score Coefficient (95% CI)
	Mobility	Self-care	Usual activity	Pain /discom- fort	Anxiety / depression		
Very good	0.141 (0.084, 0.237)	0.158 (0.031, 0.801)	0.112 (0.055, 0.228)	0.112 (0.071, 0.178)	0.112 (0.065, 0.193)	0.195 (0.166, 0.225)	16.955 (14.476, 19.434)
Excellent	0.054 (0.012, 0.238)	N/A	0.046 (0.006, 0.355)	0.062 (0.028, 0.139)	0.019 (0.003, 0.147)	0.252 (0.198, 0.307)	23.393 (19.492, 27.293)
Self-reported health conditions (Ref: Reported health conditions)	1.00	1.00	1.00	1.00	1.00		
Healthy	0.745	0.620	0.945	0.940	0.831	0.018	0.489
Smoking status (Ref: Smoker)							
Non-smoker	1.389	1.426	1.244	0.798	1.022	−0.001	−2.300 (−4.235, −0.364)
Alcohol consump- tions (Ref: Drinker)							
Non-drinker	0.725	2.649	1.086	0.960	0.744	0.014	0.039

Statistical significance was presented as bolded odds ratio with 95% confidence interval

NA non assessment

oldest age group (≥ 65 years). Meanwhile, the groups that reported the “excellent,” “very good,” and “good” health perceptions had a higher mean EQ-5D-5L index (0.252, 95% CI 0.198 to 0.307; 0.195, 95% CI 0.166 to 0.225; and 0.120, 95% CI 0.095 to 0.145, respectively) than those that reported the “fair” and “poor” health perceptions. Moreover, the mean EQ-5D-5L index of the samples with a monthly household income of 10,001 to 50,000 baht was higher than that of the $\leq 10,000$ baht/month group (0.019, 95% CI 0.001 to 0.038), except for the mean of the $\geq 50,001$ baht/month group.

Overall, the results indicate that age and general health perceptions were two significant factors that affected the EQ-VAS scores. Consistent with the EQ-5D-5L index, the sample aged ≥ 55 years had lower mean EQ-VAS scores than the sample aged < 25 years, except for the 25–54 age group, where the greatest difference was 3.809 (95% CI -7.577 to -0.041) for the sample aged ≥ 65 years. Furthermore, the groups with the “excellent,” “very good,” and “good” health perceptions had higher mean EQ-VAS scores (23.393, 95% CI 19.492 to 27.293; 16.955, 95% CI 14.476 to 19.434; and 10.555, 95% CI 8.366 to 12.744, respectively) than those with “fair” and “poor” health perceptions.

Discussion

This study revealed that the mean EQ-5D-5L index for the general Thai population was 0.931; this value is close to the mean EQ-5D-5L index for general populations of various other middle-income countries, including China (0.957) [29], Indonesia (0.911) [30], Iran (0.79) [31], and Vietnam (0.91) [32].

Approximately half of the participants (49.1%) reported “no problems” in all five dimensions of the EQ-5D-5L, known as the “ceiling effect.” This also aligns with the findings from other population norms studies in Indonesia (44.07%) [30] and China (54%) [29]. However, it contradicts a previous Thai valuation study [22] which reported a lower ceiling effect (30.32%) than that of the present study. A possible explanation could be that the previous study was conducted with a sample from wider age range (≥ 18 years) than that in the present study (20–70 years), with the majority reporting themselves as healthy (70.3%), thus resulting in higher ceiling effects.

Similar to previous population norms studies [33–36], the results showed that the highest percentage of participants reporting “no problem” for each EQ-5D-5L dimension was SC (97.5%), followed by UA (88.8%), AD (80.2%), MO (77.1%), and PD (57.8%). Unlike a previous Thai valuation study [22], it showed that the pattern was

dissimilar, with a lower percentage reporting “no problem” for all five dimensions: SC (96.35%), UA (78.87%), MO (72.33%), AD (68.19%), and PD (47.31%). Again, a possible explanation is that the previous Thai valuation study was conducted with a wider age range (≥ 18 years) than that in the present study (20–70 years). Furthermore, the older participants reported more problems with AD than the younger participants, and the proportions of reporting problems declined with decreasing age. This pattern was similar to the results of previous research with the general population in Vietnam [32], whereas it was in contradiction with those of previous research in China [29]. Hence, certain sociodemographic variations seem to impose more varied health perceptions for the EQ-5D-5L dimensions across countries.

As for the regression results, they showed that the EQ-5D-5L index consistently decreased with increasing age, except for the 25–34 age group. This pattern was also found in previous population norms studies in Iran [31] and Vietnam [32], although their age groups somewhat overlapped with those in the present study. Additionally, females reported slightly diminished EQ-5D-5L index scores, compared to males, which is a common finding in previous population norms studies [30–32]. Similar to previous research [14, 37], there were higher EQ-5D-5L index scores for the respondents with the “excellent,” “very good,” and “good” health perceptions than those with the “poor” and “fair” health perceptions.

Furthermore, certain variations between the EQ-5D-5L index and EQ-VAS scores were found regarding the ceiling effects and the association with sociodemographic factors. Specifically, the ceiling effect of the EQ-VAS scores was only 12.6%, which was lower than that of the EQ-5D-5L index. Evidently, the participants rating 11111 for the EQ-5D-5L descriptive system achieved a mean value of 86.61 on the EQ-VAS. This aligns with the findings of research in Vietnam [32]. The multivariate analysis also suggested that the association between the EQ-VAS scores and the sociodemographic information aligned with those of the EQ-5D-5L index. The exception was gender and household income factors, which aligns with previous research [29]. Based on these findings, the EQ-VAS could have conceptually measured some aspects beyond the EQ-5D-5L descriptive system, which requires further investigation.

This study includes several limitations that should be noted. First, sampling bias was possible because the participants were selected in proportion to age and gender by the local village leaders. Second, the samples aged < 20 and > 70 years were excluded because this study was part of a psychometric testing project between the EQ-5D-3L and EQ-5D-5L in the general Thai population. Since there was a sensitive question in relation to sexual behaviors from the WHOQOL-BREF, the ethical committee was aware of

obtaining the invalidated information from these age groups. Consequently, EQ-5D-5L population norms should be further investigated with a wider sample to better represent the general Thai population. Third, since this study recruited mostly healthy individuals, the EQ-5D-5L index and EQ-VAS scores might be underestimated for those with severe health problems/conditions. Fourth, since the individuals were selected based on age and gender from the general Thai population, other characteristics might be over or under proportioned. Moreover, in terms of age and gender, the sample in this study was similar to the general Thai sample for some age groups. Thus, future population norms studies should recruit a wider sample of individuals to better represent the general Thai population. Fifth, this study was conducted with only 1200 individuals, which is a relatively small sample size, compared to the majority of population norms studies. This was due to the limited budget from the funding agency. Therefore, future research should be conducted with a larger sample size to better represent the general Thai population. Finally, this study selected the samples based on their ability to quickly facilitate the data collection process which could lead to recruit more healthy samples.

Conclusion

The first general Thai population norms for the EQ-5D-5L index elicited from the Thai-specific EQ-5D-5L value set was established. Despite disparities between the EQ-5D-5L index and EQ-VAS scores across sociodemographic factors, age, and general health perceptions significantly affected both scores. Therefore, this study provides the EQ-5D-5L index and EQ-VAS norms for the general Thai population as the benchmark to support health service research and inform policymakers on better allocation of the limited health care resources to those with diminished population norm-based scores.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11136-023-03420-2>.

Acknowledgements The author expresses sincere gratitude to the EuroQoL group for their permission to use the EQ-5D-5L questionnaire in this study, and also thanks all local village leaders and participants from the provinces of Nakhon-Sri Thammarat, Khon-Kaen, Chonburi, Chaing-Mai, and Bangkok in Thailand who facilitated or participated in the data collection process. Special thanks to all interviewers for their assistance with the data collection process.

Author contributions KK was the only one involved in study conception and design, data collection, data analyses, interpretation, drafting, and final approval of this manuscript.

Funding This work was supported by Grants Rx2/2562 from the Burapha University through the National Research Council of Thailand. However, the funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the

data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Data availability The data analyzed and reported in this manuscript is not available for public sharing because all raw data should be kept it with researcher for privacy in order to comply with the ethical standard.

Declarations

Competing interests The author has no relevant financial or non-financial to disclose.

Ethical approval This work was approved by the Burapha University Institutional Review Board (BUU-IRB): 108/2562 before the study commenced.

Consent to participate The written consent form was obtained from each study subject before the study commenced; however, they were informed to be able to withdraw from this study at any time if they felt uncomfortable.

References

- Brooks, R. (1996). EuroQol: The current state of play. *Health Policy*, 37(1), 53–72.
- Devlin, N., Parkin, D., & Janssen, B. (2020). An introduction to EQ-5D instruments and their applications. In N. Devlin, D. Parkin, & B. Janssen (Eds.), *Methods for analysing and reporting EQ-5D Data* (pp. 1–22). Springer.
- Kennedy-Martin, M., Slaap, B., Herdman, M., van Reenen, M., Kennedy-Martin, T., Greiner, W., et al. (2020). Which multi-attribute utility instruments are recommended for use in cost-utility analysis? A review of national health technology assessment (HTA) guidelines. *The European Journal of Health Economics*, 2, 8. <https://doi.org/10.1007/s10198-020-01195-8>
- Nordlund, A., Ekberg, K., & Kristenson, M. (2005). EQ-5D in a general population survey—A description of the most commonly reported EQ-5D health states using the SF-36. *Quality of Life Research*, 14(4), 1099–1109. <https://doi.org/10.1007/s11136-11004-13062-11132>
- Martí-Pastor, M., Pont, A., Ávila, M., Garin, O., Vilagut, G., Forero, C. G., et al. (2018). Head-to-head comparison between the EQ-5D-5L and the EQ-5D-3L in general population health surveys. *Population Health Metrics*, 16(1), 14. <https://doi.org/10.1186/s12963-018-0170-8>
- Sassi, F. (2006). Calculating QALYs, comparing QALY and DALY calculations. *Health Policy and Planning*, 21(5), 402–408. <https://doi.org/10.1093/heapol/czl018>
- Rawlins, M. D., & Culyer, A. J. (2004). National Institute for Clinical Excellence and its value judgments. *BMJ*, 329(7459), 224–227. <https://doi.org/10.1136/bmj.1329.7459.1224>
- Weinstein, M. C., Siegel, J. E., Gold, M. R., Kamlet, M. S., & Russell, L. B. (1996). Recommendations of the panel on cost-effectiveness in health and medicine. *JAMA*, 276(15), 1253–1258.
- Rencz, F., Gulácsi, L., Drummond, M., Golicki, D., Prevolnik Rupel, V., Simon, J., et al. (2016). EQ-5D in Central and Eastern Europe: 2000–2015. *Quality of Life Research*, 25(11), 2693–2710. <https://doi.org/10.1007/s11136-016-1375-6>
- Devlin, N. J., & Brooks, R. (2017). EQ-5D and the EuroQol group: Past, present and future. *Applied Health Economics and Health Policy*, 15(2), 127–137. <https://doi.org/10.1007/s40258-017-0310-5>
- Herdman, M., Gudex, C., Lloyd, A., Janssen, M. F., Kind, P., Parkin, D., et al. (2011). Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Quality of Life Research*, 20(10), 1727–1736. <https://doi.org/10.1007/s11136-011-9903-x>
- Buchholz, I., Janssen, M. F., Kohlmann, T., & Feng, Y. S. (2018). A systematic review of studies comparing the measurement properties of the three-level and five-level versions of the EQ-5D. *Pharmacoeconomics*, 36(6), 645–661. <https://doi.org/10.1007/s40273-40018-40642-40275>
- Kangwanrattanakul, K., & Parmontree, P. (2020). Psychometric properties comparison between EQ-5D-5L and EQ-5D-3L in the general Thai population. *Quality of Life Research*, 29(12), 3407–3417. <https://doi.org/10.1007/s11136-020-02595-2>
- Jiang, R., Janssen, M. F. B., & Pickard, A. S. (2021). US population norms for the EQ-5D-5L and comparison of norms from face-to-face and online samples. *Quality of Life Research*, 30(3), 803–816. <https://doi.org/10.1007/s11136-020-02650-y>
- Garratt, A. M., Hansen, T. M., Augestad, L. A., Rand, K., & Stavem, K. (2022). Norwegian population norms for the EQ-5D-5L: Results from a general population survey. *Quality of Life Research*, 31(2), 517–526. <https://doi.org/10.1007/s11136-021-02938-7>
- Jensen, M. B., Jensen, C. E., Gudex, C., Pedersen, K. M., Sørensen, S. S., & Ehlers, L. H. (2021). Danish population health measured by the EQ-5D-5L. *Scandinavian Journal of Public Health*. <https://doi.org/10.1177/14034948211058060>
- The World Bank. (2021). GNI per capita, Atlas method (current US\$). Retrieved March 14, 2023, from <https://data.worldbank.org/indicator/NY.GNP.PCAP.CD>.
- National Statistical Office. (2021). Retrieved November 30, 2022, from <http://statbi.nso.go.th/staticreport/page/sector/en/index.aspx>. 2022.
- Tavorncharoensap, M., & Sakthong, P. (2019). Health utility. In S. Pannarunothai, S. Pilasant, W. Saengsri, & P. Kingkaew (Eds.), *The guideline of health technology assessment in Thailand* (pp. 77–94). Health Systems Research Institute.
- Pattanaphesaj, J., & Thavorncharoensap, M. (2015). Measurement properties of the EQ-5D-5L compared to EQ-5D-3L in the Thai diabetes patients. *Health and Quality of Life Outcomes*, 13, 14. <https://doi.org/10.1186/s12955-014-0203-3>
- Sakthong, P., Sonsa-Ardjit, N., Sukarnjanaset, P., & Munpan, W. (2015). Psychometric properties of the EQ-5D-5L in Thai patients with chronic diseases. *Quality of Life Research*, 24(12), 3015–3022. <https://doi.org/10.1007/s11136-11015-11038-z>
- Pattanaphesaj, J., Thavorncharoensap, M., Ramos-Goni, J. M., Tongsir, S., Ingsrisawang, L., & Teerawattananon, Y. (2018). The EQ-5D-5L valuation study in Thailand. *Expert Review of Pharmacoeconomics & Outcomes Research*, 18(5), 551–558. <https://doi.org/10.1080/14737167.14732018.11494574>
- Kangwanrattanakul, K., Gross, C. R., Sunantiwat, M., & Thavorncharoensap, M. (2019). Exploration of a cultural-adaptation of the EQ-5D for Thai population: A “bolt-on” experiment. *Quality of Life Research*, 28(5), 1207–1215. <https://doi.org/10.1007/s11136-018-2072-4>
- Sakthong, P. (2008). Measurement of clinical-effect: Utility. *Journal of the Medical Association of Thailand*, 91(Suppl 2), S43–52.
- Thavorncharoensap, M. (2014). Measurement of utility. *Journal of the Medical Association of Thailand*, 97(Suppl 5), S43–49.
- Devlin, N., Parkin, D., & Janssen, B. (2020). Analysis of EQ-5D values. In N. Devlin, D. Parkin, & B. Janssen (Eds.), *Methods for analysing and reporting EQ-5D data* (pp. 61–86). Springer.
- Oemar, M., & Janssen, B. (2013). EQ-5D-5L User Guide Basic information on how to use the EQ-5D-5L instrument. EuroQol group.

28. Austin, P. C., Escobar, M., & Kopec, J. A. (2000). The use of the Tobit model for analyzing measures of health status. *Quality of Life Research*, 9(8), 901–910. <https://doi.org/10.1023/a:1008938326604>
29. Yang, Z., Busschbach, J., Liu, G., & Luo, N. (2018). EQ-5D-5L norms for the urban Chinese population in China. *Health and Quality of Life Outcomes*, 16(1), 210. <https://doi.org/10.1186/s12955-018-1036-2>
30. Purba, F. D., Hunfeld, J. A. M., Iskandarsyah, A., Fitriana, T. S., Sadarjoen, S. S., Passchier, J., et al. (2018). Quality of life of the Indonesian general population: Test-retest reliability and population norms of the EQ-5D-5L and WHOQOL-BREF. *PLoS ONE*, 13(5), e0197098. <https://doi.org/10.1371/journal.pone.0197098>
31. Emrani, Z., Akbari Sari, A., Zeraati, H., Olyaeemanesh, A., & Daroudi, R. (2020). Health-related quality of life measured using the EQ-5D-5L: Population norms for the capital of Iran. *Health and Quality of Life Outcomes*, 18(1), 108. <https://doi.org/10.1186/s12955-020-01365-5>
32. Nguyen, L. H., Tran, B. X., Le, Q. N. H., Tran, T. T., & Latkin, C. A. (2017). Quality of life profile of general Vietnamese population using EQ-5D-5L. *Health and Quality of Life Outcomes*, 15(1), 199. <https://doi.org/10.1186/s12955-017-0771-0>
33. McCaffrey, N., Kaambwa, B., Currow, D. C., & Ratcliffe, J. (2016). Health-related quality of life measured using the EQ-5D-5L: South Australian population norms. *Health and Quality of Life Outcomes*, 14(1), 133. <https://doi.org/10.1186/s12955-016-0537-0>
34. Wong, E. L., Cheung, A. W., Wong, A. Y., Xu, R. H., Ramos-Goñi, J. M., & Rivero-Arias, O. (2019). Normative profile of health-related quality of life for Hong Kong general population using preference-based instrument EQ-5D-5L. *Value Health*, 22(8), 916–924. <https://doi.org/10.1016/j.jval.2019.02.014>
35. Grochtdreis, T., Dams, J., König, H. H., & Konnopka, A. (2019). Health-related quality of life measured with the EQ-5D-5L: Estimation of normative index values based on a representative German population sample and value set. *The European Journal of Health Economics*, 20(6), 933–944. <https://doi.org/10.1007/s10198-019-01054-1>
36. Bailey, H., Janssen, M. F., La Foucade, A., & Kind, P. (2019). EQ-5D-5L population norms and health inequalities for Trinidad and Tobago. *PLoS ONE*, 14(4), e0214283. <https://doi.org/10.1371/journal.pone.0214283>
37. Poder, T. G., Carrier, N., & Kouakou, C. R. C. (2020). Quebec health-related quality-of-life population norms using the EQ-5D-5L: Decomposition by sociodemographic data and health problems. *Value Health*, 23(2), 251–259. <https://doi.org/10.1016/j.jval.2019.08.008>

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