



# Exploration of a cultural-adaptation of the EQ-5D for Thai population: A “bolt-on” experiment

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## Abstract

**Purpose** As the EQ-5D was developed in western countries with only five dimensions, it might be insensitive to non-western populations including Thai. This study examined the impact of adding two candidate dimensions, “interpersonal relationships (IR)” and “activities related to bending knees (AK),” to the EQ-5D questionnaire, and evaluated their psychometric properties in a Thai population sample.

**Methods** Face-to-face interviews were conducted with 600 Thai. Ceiling effect for the EQ-5D and the EQ-5D-5L+AK+IR were compared. Spearman’s rho correlation was used to determine whether the two new dimensions were redundant with the existing EQ-5D dimensions. Correlations between the two dimensions and similar dimensions of the SF-36v2 were also assessed. Hierarchical multiple regression was performed to evaluate the incremental value of the EQ-5D-5L+AK+IR over the EQ-5D in predicting VAS scores.

**Results** The two new dimensions were not redundant with the existing five dimensions of the EQ-5D. The highest correlation (0.371) was found between MO and AK. The overall ceiling effect decreased by 5% (50.5–45.5%) when using the EQ-5D-5L+AK+IR. Moderate correlations were found between the candidate dimensions and similar dimensions of the SF-36v2. Multiple regression indicated that adding AK (adjusted  $r^2$  0.329 vs. 0.306) but not IR (adjusted  $r^2$  0.307 vs. 0.306) significantly increased ability to predict VAS scores.

**Conclusions** Our preliminary results suggested that AK holds promise for making the EQ-5D more relevant to Thai while it is premature to conclude on the impact of IR. Nevertheless, more work is required to carefully assess the value of the new dimensions as well as the trade-off for the modification.

**Keywords** EQ-5D · Health-related quality of life · Bolt-on · Psychometric properties · Culture

## Introduction

The EQ-5D questionnaire is one of the most widely used health-related quality of life (HRQoL) instruments. It was developed in the 1980s by the EuroQoL group, a multi-disciplinary group of researchers from England, Finland, the Netherlands, Norway, and Sweden, as a generic instrument designed to use across a wide range of therapeutic areas and populations [1, 2].

Because of its brevity, the EQ-5D can be administered in a short period of time, with the low burden to patients and at relatively low cost. As it has only five dimensions, there is concern that the EQ-5D may be insensitive, unable to capture important aspects of health, and lack discriminatory power to distinguish among severity levels for a particular condition or population [1]. Current evidence indicates that

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the EQ-5D lacks sensitivity for health problems related to cognition, vision, hearing impairment, and psychosis [3].

It has been proposed that adding one or more specific “bolt-on dimensions” to the existing five dimensions could capture important aspects of a disease condition or population not addressed by the EQ-5D, and may offer a solution to the insensitivity problem [4]. Recently, there has been great interest in the development of “bolt-on” versions of the EQ-5D. Many studies have been conducted to identify “bolt-on” dimensions and to explore whether or not measurement properties of the “bolt-on” instrument are superior to those of the original EQ-5D.

Up to now, the identified “bolt-on” dimensions included vision [5–7], cognition [8], sleep [7, 9], memory/concentration [7], fatigue/energy [7], hearing [5, 7], tiredness [5], and contacts with others [7]. Skin irritation and self-confidence were identified as “bolt-on” dimensions for patients with psoriasis. Studies have shown that “bolt-on” dimensions for vision, cognition, memory/concentration, energy/fatigue, sight/hearing, and contacts with others as well as skin irritation and self-confidence for psoriasis, may enhance the measurement properties of the standard EQ-5D [5–8] in selected populations or for particular conditions. Evidence of psychometric enhancement for the sleep bolt-on dimension is mixed [7, 9]. Recent work suggests that the impact of a bolt-on item will depend on the severity of the EQ-5D health state and the severity levels of the bolt-on dimension [5] in the study samples.

Based on our literature review, no published studies have been conducted to explore and to evaluate a “bolt-on” version of the EQ-5D for a specific ethnicity/culture. The previous “bolt-on” studies [5–9] were primarily conducted in response to the criticism that EQ-5D, as a generic instrument, may not cover all important dimensions of health especially for specific medical conditions such as vision, hearing, tiredness, and sleep. In these studies, “bolt-on” dimensions were either identified from a literature review on the validity and responsiveness of generic measures of HRQoL which found that the performance of the EQ-5D was poor in hearing and vision [5, 7] or the review of existing health-utility instruments and general health status questionnaires [7]. As the concepts of quality of life and health may vary from culture to culture [10], and the five current dimensions of the EQ-5D were developed from the perspectives of researchers based in western cultures and finalized without any formal testing in non-western cultures [1], there is concern that the EQ-5D might not adequately capture some aspects of health among non-western populations. Whether or not the culture-specific bolt-on dimensions bring a significant improvement to the measurement properties of the current EQ-5D also deserved further investigation.

Thailand is a country located in Southeast Asia. Most Thai people are Buddhist. Thai people differ from their

western counterparts in term of lifestyle, belief, and culture. The use of the EQ-5D for health resource allocation in Thailand is increasing, and it has been recommended as the preferred utility measure by the Thai Health Technology Assessment Guideline [11, 12]. As the EQ-5D was originally developed from western perspectives, there is a reasonable concern that the EQ-5D might be insensitive to capture some aspects of HRQoL uniquely important to a non-western population like Thais. Therefore, there is a clear need to explore culture-specific “bolt-on” EQ-5D dimensions of health for Thailand.

In this study, two culture-specific bolt-on dimensions, “interpersonal relationships (IR)” and “activities related to bending knees (AK),” were identified through systematic reviews, in-depth interviews, and focus group discussion among Thai people. The “AK” and “IR” dimensions were selected as the candidate dimensions because they are specific to Thai culture and lifestyle. “AK” means being able to perform various daily and routine activities by assuming a meditation position, squatting, kneeling, or sitting with legs folded to one side. Many common Thai daily activities involve activities related to bending knee, such as sitting on the floor for family meals, kneeling, washing clothes/dishes, using squatting style toilets, as well as performing cultural and religious activities. It is also congruent to the findings of previous studies which found that being able to perform these knee-based positions were specific to Asian culture and positively affected HRQoL as these activities enable various daily and religious activities [13, 14]. On the other hand, “IR” refers to maintaining harmonious relationships with other people including family members, siblings’ families, and other relatives as well as with friends, neighbors, and work colleagues. Its definition denotes a concept of extended family specific to Asian culture and consistent with findings from a previous study conducted with other Asian populations [15]. Like many Asian cultures, Thais tend to be “collectivistic” in which more emphasis is on cohesiveness among individuals and prioritization of the group over self [16]. With collectivist culture, a wide social network, which involves family, relatives, friends, neighbors, and community, is observed [17–19]. Consistent with the findings from our in-depth interviews, our literature review found that relationships with family, friends, and relatives, as well as with neighbors are very important for the health of Asian populations [17, 20]. In addition, a previous study confirmed that family and social relationships have significant impact on health for Thais [21].

There was a previous attempt to add a “social relationships” dimension into the EQ-5D questionnaire by the Euro-QoL group in 1987. However, the analysis in the western countries showed that this dimension played little part in determining health state valuations [2]. Instead, the phrase “social relationships” was added to the description of the

usual activities dimension [2]. However, given the importance of family and societal harmony in Thai culture, it is reasonable to examine whether a separate IR dimension is an influential health indicator for the Thai population.

This exploratory study aims to examine the impact of adding the two culture-specific bolt-on dimensions, “interpersonal relationships (IR)” and “activities related to bending knees (AK),” to the current EQ-5D questionnaire, and to evaluate the psychometric properties of the culture-specific “bolt-on” EQ-5D (EQ-5D-5L+AK+IR) among Thai population.

## Methods

### Samples and settings

A cross-sectional survey using face-to-face interviews was conducted with a sample of 600 members of the general Thai population living in five provinces across Thailand: Chumphon, Chachoengsao, Bangkok (capital city), Chaing-Mai, and Loei. To ensure representativeness of Thai population, sample size calculations and a stratified four-stage sampling were undertaken by the National Statistical Office (NSO). In the sampling process, provinces, districts, and sub-districts, were randomly selected resulting in 10 sub-districts in Bangkok and 40 sub-districts outside Bangkok (22 urban and 18 rural areas). In each sub-district, a community leader selected a pre-defined number of individuals in each specified age and gender group to form the convenience sample for interviews. Inclusion criteria included (1) being between 18 and 70 years of age, (2) able to read Thai, and (3) understood the tasks determined by the interviewers. Persons presenting with an acute or life-threatening illness, cognitive impairment, or disability were excluded.

### Data collection

Four interviewers were trained by the researcher (KK) before conducting the interviews. Prior to each of the interviews, an information sheet explaining the project, objectives, and procedure in plain language was given to each of the respondents, and written informed consent was obtained from all respondents. Each of the respondents was asked to complete a 4-part questionnaire: (1) General information; (2) EQ-5D-5L+AK+IR dimensions; (3) Short-Form 36 version 2 (SF-36v2); and (4) Acceptability of IR and AK. Questions regarding acceptability of the new dimensions were as follows: Do you think the new dimensions are easy to understand? How important are the new dimensions in measuring HRQoL among Thai population? Which version of the questionnaire (EQ-5D-5L or EQ-5D-5L+AK+IR) can better describe your health status? All respondents received

2.84 USD (1 USD = 35.19 THB) compensation for their time after completing the questionnaires.

The culture-specific “bolt-on” EQ-5D-5L consists of the original five dimensions: mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and anxiety/depression (AD), plus the culture-specific dimensions: interpersonal relationships (IR) and activities related to bending knees (AK). Each dimension has five response levels: no problem, slight problem, moderate problem, severe problem, and extreme problems/unable to perform. The description along with the 5-level choices of the two culture-specific bolt-on dimensions is presented in Fig. 1. Also included is the EQ-5D VAS, a vertical visual analog scale to record the individual’s assessment of their current HRQoL level, with responses ranging from 0 (the worst imaginable health state) to 100 (the best imaginable health state) [22].

The SF-36v2 includes 35 items grouped into eight dimensions/subscales as follows: (1) physical functioning (PF: ten items), (2) role limitations due to physical problems (RP: four items), (3) bodily pain (BP: two items), (4) general health perception (GH: five items), (5) vitality (VT: four items), (6) social functioning (SF: two items), (7) role limitations due to emotional problems (RE: three items), and (8) mental health (MH: five items) [23, 24]. A final item is perceived health transition (better or worse) [25, 26]. SF-36v2 results can be transformed from 0 (the worst possible health status) to 100 (the best possible health status) for each dimension or converted to norm-based *T* scores (mean = 50, SD = 10). The eight dimensions can also be summarized into two summary scales: (1) Physical component score (PCS) and (2) Mental component score (MPS) which are typically reported as *T* scores [25].

Permission to use the official Thai versions of the EQ-5D-5L and the SF-36v2 was obtained before this study commenced. This study was conducted after obtaining ethical approval from the Mahidol University Institutional Review Board (MU-IRB), Thailand.

### Data analysis

Responses to the three acceptability questions (ease of understanding, importance of concept, better description of health status) were summarized using percentages.

Spearman’s rho correlation was used to determine whether the two new dimensions were redundant with the existing EQ-5D dimensions. Ceiling effect was calculated as the proportion of respondents reporting “no problem” in each dimension and across all dimensions divided by the total number of respondents. Ceiling effects of the EQ-5D-5L and the EQ-5D-5L+AK+IR were then compared. We hypothesized that by adding AK and IR into the EQ-5D-5L, the ceiling effect would reduce.

**Activities related to bending knees** (e.g. Performing activities through meditation position, squatting, kneeling, sitting with folded legs to one side, crawling, etc.)

I have no problems with performing activities related to bending knees

I have slight problems with performing activities related to bending knees

I have moderate problems with performing activities related to bending knees

I have severe problems with performing activities related to bending knees

I am unable to perform activities related to bending knees

**Interpersonal relationships** (e.g. family members, siblings and relatives, friends, colleagues, neighbors, etc.)

I have no problems with interpersonal relationships

I have slight problems with interpersonal relationships

I have moderate problems with interpersonal relationships

I have severe problems with interpersonal relationships

I have extreme problems with interpersonal relationships

**Fig. 1** Thai-specific dimensions description

Correlations between the two Thai-specific dimensions and the eight SF-36v2 subscales were assessed using Spearman's rho correlations. The strength of correlation was determined based on Colton's rules as follows: weak or no ( $r < 0.25$ ), moderate ( $0.25 \leq r < 0.50$ ), moderate to strong ( $0.50 \leq r < 0.75$ ), and strong ( $r \geq 0.75$ ) [27]. Since better health on the SF-36v2 and the EQ-5D-5L+AK+IR are scored in opposite directions, a negative correlation represents the consistency between these scales. We hypothesized that the strength of correlations between the two bolt-on items and the SF-36v2 dimensions would be as follows: strong (IR/SF, AK/PF), moderate (IR/MH, AK/BP, AK/RP), moderate to weak (IR/RE), weak or no association (IR/PF, IR/BP, AK/SF, AK/MH).

Hierarchical multiple regression was performed to evaluate the incremental value of the EQ-5D-5L+AK+IR over the EQ-5D-5L in predicting health utility measured by the VAS. For each bolt-on item, binary dummy variables—no problem (level 1) versus any problems (level 2–5)—were used. Explained variances ( $R^2$ , Adjusted  $R^2$ ) for prediction of the VAS were used to compare the EQ-5D-5L and the EQ-5D-5L+AK+IR. As a sensitivity analysis, a model was also run coding each dimension linearly (from level 1 to 5).

All analyses were carried out using SPSS software version 18.  $p$  values  $< 0.05$  were considered statistically significant.

## Results

### Characteristics of respondents

Table 1 shows the demographic characteristics of all 600 respondents. The majorities of respondents were married (61.7%) and were educated at the high school level (41.3%) or beyond. Most rated themselves as healthy (69.2%). The average age was 41.3 years (SD 14.0), with 51.3% being female. There were no missing values in responses to the EQ-5D and bolt-on dimensions.

### Acceptability

Almost all respondents indicated that questions on both IR (99.3%) and AK (99.7%) were easy to understand, and the majority agreed that IR (63.2%) and AK (63.3%) items were very important dimensions of HRQoL for the Thai population. Furthermore, almost all of the respondents (97.3%) thought the combination between the original five dimensions and the two Thai-specific bolt-on items could better describe their health status.

### The ceiling effect

Table 2 shows that for each dimension of the EQ-5D and for the two culture-specific dimensions, most of the

**Table 1** Characteristics of respondents

| Characteristics                        | <i>n</i> (%) |
|--|--------------|
| Gender                                 |              |
| Male                                   | 292 (48.7)   |
| Female                                 | 308 (51.3)   |
| Age                                    |              |
| 18–28                                  | 129 (21.5)   |
| 29–39                                  | 152 (25.3)   |
| 40–50                                  | 157 (26.2)   |
| 51–60                                  | 99 (16.5)    |
| 61–70                                  | 63 (10.5)    |
| Area                                   |              |
| Urban areas                            | 384 (64.0)   |
| Rural areas                            | 216 (36.0)   |
| Marital status                         |              |
| Single                                 | 182 (30.3)   |
| Married                                | 370 (61.7)   |
| Widowed                                | 24 (4.0)     |
| Divorced/separated                     | 24 (4.0)     |
| Education                              |              |
| Primary school or lower                | 220 (36.7)   |
| Secondary school                       | 248 (41.3)   |
| College's degree                       | 41 (6.8)     |
| Bachelor's degree                      | 81 (13.5)    |
| Master's degree or higher              | 10 (1.7)     |
| Health insurance                       |              |
| Civil Servants Medical Benefits Scheme | 45 (7.5)     |
| Universal coverage                     | 370 (61.7)   |
| Social security                        | 141 (23.5)   |
| Others                                 | 44 (7.3)     |
| Average household income (baht/month)  |              |
| < 10,000                               | 260(43.3)    |
| 10,000–30,000                          | 284 (47.3)   |
| 30,000–50,000                          | 35 (5.8)     |
| More than 50,000                       | 21 (3.5)     |

**Table 2** Ceiling effect of original EQ-5D-5L dimensions and the two Thai-specific dimensions

| Dimensions               | Ceiling effect |
|--------------------------|----------------|
| MO                       | 480 (80.0%)    |
| SC                       | 597 (99.5%)    |
| UA                       | 576 (96.0%)    |
| PD                       | 386 (64.3%)    |
| AD                       | 511 (85.2%)    |
| The best health (11111)  | 303 (50.5%)    |
| IR                       | 573 (95.5%)    |
| AK                       | 492 (82.0%)    |
| The best health (111111) | 273 (45.5%)    |

MO mobility, SC self-care, UA usual activities, PD pain/discomfort, AD anxiety/depression, IR interpersonal relationships, AK activities related to bending knees

respondents reported “no problems.” The percentage of respondents reporting perfect health was lower for the EQ-5D-5L+AK+IR (45.5%) than for the EQ-5D-5L (50.5%).

## Correlations

Table 3 presents the Spearman's rho correlation coefficients between the two new dimensions and the existing EQ-5D dimensions. As shown in the table, correlations did not exceed 0.75 [28], indicating that the two new dimensions were not redundant with the existing five dimensions of the EQ-5D. The highest correlation (0.371) was found between MO and AK.

Table 4 shows the Spearman's correlation coefficients between the EQ-5D-5L+AK+IR and the SF-36v2 dimensions. For AK, a moderate correlation with PF was found ( $r = -0.430$ ,  $p < 0.01$ ). In terms of correlations between AK and each item of PF, the highest correlation coefficient ( $r = -0.497$ ,  $p < 0.01$ ) was found between AK and PF 6 (i.e., being able to bend, kneel, or stoop). Weak or no correlations were observed between AK and other dimensions of the SF-36v2. Similarly, IR had a moderate correlation with the SF dimension ( $r = -0.304$ ,  $p < 0.01$ ) and weak or no correlations with other dimensions of the SF-36v2. In terms of the correlation between IR and each item of SF, the highest correlation coefficient ( $r = -0.325$ ,  $p < 0.01$ ) was found between IR and SF 2 (i.e., physical health or emotional problems interfering with normal social activities with family, friends, neighbors, or groups in the past 4 weeks).

## Hierarchical multiple regression

Table 5 displays the results of hierarchical multiple regression. Since better health on the VAS and the EQ-5D-5L+AK+IR is scored in opposite directions, a negative correlation represents consistency between these scales. Model 1 showed the overall association between the original EQ-5D dimensions as binary-independent variables predicting the dependent variable, the VAS score. It was found that all EQ-5D dimensions (except SC) were significantly associated with the VAS score with the adjusted  $R^2$  of 0.306. The addition of the IR item, shown as Model 2, reduced the coefficient of AD by 4.76% (5.880–5.600) while the adjusted  $R^2$  increased from Model 1 by only 0.001 ( $p$  value  $> 0.05$ ). The addition of the AK item, shown as Model 3, substantially reduced the coefficient of MO by 37.16% (4.023–2.528), while significantly increasing the adjusted  $R^2$  by 0.023 ( $p$  value  $< 0.01$ ). In the final model (Model 4), the inclusion of IR and AK significantly increased adjusted  $R^2$  from Model 1 by 0.023 ( $p$  value  $< 0.01$ ), the same adjusted  $R^2$  as Model 3.



**Table 3** Correlation coefficients between the original EQ-5D-5L dimensions and two Thai-specific dimensions

| Dimensions | MO      | SC      | UA      | PD      | AD      | IR      | AK |
|------------|---------|---------|---------|---------|---------|---------|----|
| MO         | 1       |         |         |         |         |         |    |
| SC         | 0.089*  | 1       |         |         |         |         |    |
| UA         | 0.290** | 0.106** | 1       |         |         |         |    |
| PD         | 0.268** | 0.040   | 0.170** | 1       |         |         |    |
| AD         | 0.133** | 0.035   | 0.090*  | 0.169** | 1       |         |    |
| IR         | 0.052   | 0.097*  | 0.036   | 0.125** | 0.212** | 1       |    |
| AK         | 0.371** | 0.084*  | 0.290** | 0.164** | 0.055   | 0.128** | 1  |

MO mobility, SC self-care, UA usual activities, PD pain/discomfort, AD anxiety/depression, IR interpersonal relationships, AK activities related to bending knees

\*Significant at  $p < 0.05$

\*\*Significant at  $p < 0.01$

**Table 4** Correlation coefficients between the original EQ-5D-5L dimensions and two Thai-specific dimensions with the eight dimensions of the SF-36v2 questionnaire

| Dimensions               | PF       | RP       | BP       | GH       | VT       | SF       | RE       | MH       | PCS      | MCS      |
|--------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| EQ-5D-5L                 |          |          |          |          |          |          |          |          |          |          |
| MO                       | -0.328** | -0.116** | -0.179** | -0.102*  | -0.120** | 0.004    | -0.084*  | -0.007   | -0.244** | -0.041   |
| SC                       | -0.065   | -0.069   | -0.042   | -0.048   | -0.088*  | -0.035   | -0.031   | -0.060   | -0.068   | -0.071   |
| UA                       | -0.275** | -0.233** | -0.174** | -0.150** | -0.141** | -0.053   | -0.155** | -0.049   | -0.244** | -0.027   |
| PD                       | -0.256** | -0.263** | -0.391** | -0.276** | -0.170** | -0.107** | -0.118** | -0.183** | -0.382** | -0.098*  |
| AD                       | -0.127** | -0.170** | -0.199** | -0.175** | -0.172** | -0.130** | -0.236** | -0.343** | -0.096*  | -0.286** |
| Thai-specific dimensions |          |          |          |          |          |          |          |          |          |          |
| IR                       | -0.098*  | -0.138** | -0.187** | -0.097*  | -0.091*  | -0.304** | -0.196** | -0.214** | -0.115** | -0.219** |
| AK                       | -0.430** | -0.134** | -0.245** | -0.220** | -0.174** | -0.067   | -0.200** | -0.101*  | -0.298** | -0.064   |

PF physical functioning, RP role limitations due to physical problems, BP bodily pain, GH general health, VT vitality, SF social functioning, RE role limitations due to emotional problems, MH mental health, MO mobility, SC self-care, UA usual activities, PD pain/discomfort, AD anxiety/depression, IR interpersonal relationships, AK activities related to bending knees, PCS physical component score, MCS mental component score

\*Significant at  $p < 0.05$

\*\*Significant at  $p < 0.01$

## Discussion

Ours is the first study examining the impact of adding culture-specific bolt-on dimensions to the EQ-5D-5L questionnaire. In this study, children < 18 years of age and the elderly over 70 years of age were not recruited. However, the respondents were considered to represent the general Thai population in terms of gender, living areas, and education level as these characteristics were similar to those of the sample of general Thai population in the recent national health examination survey [29].

We found that adding culture-specific dimensions may enhance the discriminative capacity of the conventional EQ-5D questionnaire as the ceiling effect was reduced by approximately 10%. The pattern of correlations between the original five dimensions of the EQ-5D and the SF-36 was similar to those identified by a previous study conducted in Thailand [30] while the ceiling effect of the EQ-5D

in this study was higher possibly due to the difference in sample characteristics. The relationships between the two culture-specific dimensions and related dimensions of the SF-36v2 were also confirmed although relationships were not as strong as anticipated. One possible reason for this is that EQ-5D-5L+AK+IR questionnaire required respondents to rate their health status on the day we conducted the interviews, while for the SF-36v2 respondents were asked to rate their health status in the past 4 weeks.

Results from hierarchical regression models revealed that improvement in predicting VAS score was achieved by adding AK, but not IR, into the model as an independent variable along with the original EQ-5D dimensions. We found that the adjusted  $R^2$  increased from 0.306 to 0.329 (7.52% increase) when AK was added. It should also be noted that our regression models found no association between the self-care dimension and the VAS scores. This might be due to the fact that very few respondents (0.5%) reported that they have problems in SC.

**Table 5** Regression analysis evaluating the impact of adding culture-specific “bolt-on” dimensions in predicting VAS score

| Dimensions     | Coefficient ( $\beta$ ) |            |            |            |
|----------------|-------------------------|------------|------------|------------|
|                | Model 1                 | Model 2    | Model 3    | Model 4    |
| MO             | − 4.023**               | − 4.026**  | − 2.528*   | − 2.556*   |
| SC             | 6.278                   | 6.943      | 7.605      | 7.976      |
| UA             | − 9.250**               | − 9.249**  | − 7.205**  | − 7.241**  |
| PD             | − 10.441**              | − 10.340** | − 10.226** | − 10.170** |
| AD             | − 5.880**               | − 5.600**  | − 5.961**  | − 5.794**  |
| IR             | −                       | − 2.579    | −          | − 1.532    |
| AK             | −                       | −          | − 5.485**  | − 5.388**  |
| $R^2$          | 0.312                   | 0.314      | 0.336      | 0.337      |
| Adjusted $R^2$ | 0.306                   | 0.307      | 0.329      | 0.329      |
| $P$ -value     | −                       | 0.220      | < 0.01     | < 0.01     |

MO mobility, SC self-care, UA usual activities, PD pain/discomfort, AD anxiety/depression, IR interpersonal relationships, AK activities related to bending knees

\*Significant at  $p < 0.05$

\*\*Significant at  $p < 0.01$

Our findings are consistent with previous bolt-on studies [5–7, 9, 31] in that some bolt-on dimensions could improve measurement properties of the EQ-5D questionnaire while others could not. With the bolt-on study among psoriasis patients, the addition of both self-confidence and skin irritation dimensions increased  $R^2$  in predicting psoriasis severity measured by the Dermatology Life Quality Index (DLQI) and the Self-Administered Psoriasis Area and Severity Index (SAPASI). For the DLQI score,  $R^2$  increased from 0.422 to 0.646, and  $R^2$  for the SAPASI score increased from 0.182 to 0.445 when the bolt-on items were added as independent variables along with the standard EQ-5D questionnaire items [31]. A bolt-on study conducted in the general population in French-speaking Switzerland found the explained variance ( $R^2$ ) in predicting VAS scores increased from 0.47 (adjusted  $R^2 = 0.65$ ) to 0.56 (adjusted  $R^2 = 0.78$ ) when five candidate dimensions—sleep, memory/concentration, energy/fatigue, sight/hearing, and contacts with others—were added to the original EQ-5D [7]. On the other hand, a bolt-on sleep item was not a significant predictor when added to the original EQ-5D dimensions in a model to predict health state utilities measured by time-trade-off (TTO) in a study by Yang et al. [9] conducted in the United Kingdom.

The addition of AK substantially reduced the coefficient and level of significance of MO in the model to predict the VAS. It should be noted that there was a moderate correlation between AK and MO. A disadvantage of adding bolt-on dimensions to the EQ-5D questionnaire is an increase in the number of health states to be valued to generate preferences. To resolve the problem of increasing health states and still provide a culturally relevant instrument, adding AK to

the current description of MO could be a proposed option rather than adding AK as a new dimension. Nevertheless, it must be noted that adding AK to the current description of MO could invalidate EQ-5D-5L comparisons across studies. Also, it is not consistent with the objective of adding “bolt-on” dimensions, which aims to retain the existing five dimensions while adding more dimensions to improve validity of the EQ-5D, and still permit direct comparisons across studies. Given these disadvantages, adding AK to the current description might not be a wise option. Instead, further studies to examine the additional value of a separate AK dimension should be conducted. Specifically, the impact of adding the AK dimension on prediction of utilities measured by TTO as well as testing other psychometric properties such as known-groups validity and reliability deserve further investigation.

Overall, this study found little to support the use of the IR item as a bolt-on dimension; however, it might still be premature to reject consideration of the IR dimension. In our study, relatively few patients reported any problems in this dimension. Additional qualitative work and possible rewording the item for the IR dimension should be considered in the future studies.

This is the first study to explore culture-specific bolt-on dimensions to enhance the sensitivity of the EQ-5D for the Thai population. Candidate dimensions were selected using systematic review, in-depth interviews, and focus group discussion. Incremental validity and structure were examined using data from a sample drawn from five provinces across Thailand. We believe this study can pave the way for more details on exploration of other culture-specific “bolt-on” dimensions to improve the measurement properties of the EQ-5D questionnaire for other populations. Nevertheless, it should be noted that a culture-specific “bolt-on” deserves investigation only when there is sufficient evidence supporting that one or more important culture-specific domains of health are not captured by the existing five dimensions of the EQ-5D. In addition, careful consideration should be given to the added value of the culture-specific “bolt-on” dimensions, the comparability of the EQ-5D across populations, and the development of the value set.

Several limitations should be mentioned. First, we were unable to examine some psychometric properties including known-groups validity and reliability. Future studies should include repeated interviews to assess test–retest reliability, and collect information on comorbidities to compare outcomes between participants with and without known health problems. Second, only respondents who were relatively healthy were included. A larger number of respondents with some levels of impairment should be included in future studies. Third, the impact of adding the two culture-specific dimensions was evaluated only in terms of ability to predict VAS. Although VAS has been used to derive utility values in

many studies [32–34], some concerns regarding its validity have been raised [35–38]. Further studies should examine the impact of the bolt-on dimensions in predicting utility measured by TTO.

## Conclusion

Similar to the previous studies [30, 39], our preliminary study supports the psychometric properties of the current EQ-5D questionnaire among Thai population. Nevertheless, our findings indicated that adding AK as a culture-specific dimension may improve the sensitivity of the EQ-5D questionnaire. In addition, Thais perceived that adding AK into the current EQ-5D could better describe their health status. Although the IR dimension was strongly endorsed as culturally important dimension based on qualitative work, our IR dimension failed to demonstrate a significant value in psychometric analyses. The specific wording used in our study and/or the low prevalence of IR problems in our samples could account for this. Therefore, it is premature to drop consideration of adding the IR dimension to the EQ-5D-5L questionnaire. In summary, further research is strongly encouraged to carefully assess the value of the two new dimensions as well as the trade-off for the modification.

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## Compliance with ethical standards

**Conflict of interest** All authors declare that they have no conflict of interests in this study.

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