Mapping the GIS to the EQ-5D-5L and SF-6Dv2 among Chinese Patients with Gout

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OBJECTIVES

- This study aimed to develop mapping algorithms to predict EQ-5D-5L and SF-6Dv2 utility values from Gout Impact Scale (GIS) scores in gout patients in China.

METHODS

- Respondents recruited from the representative regions of China completed an online survey and the sample was randomly divided into development (80%) and validation (20%) datasets.
- Spearman's correlation analyses were conducted to assess the conceptual overlap for GIS with the EQ-5D-5L and SF-6Dv2.
- **Seven models**, including OLS, Tobit, CLAD, GLM, TPM, ALDVMM, BM, were explored.
- **Five predictor sets** including 1) GIS total score, 2) 1) plus total score square, 3) 2) plus total score cubic, 4) GIS subscale score, 5) GIS subscale score after stepwise regression were explored to estimate mapping algorithms using the development dataset.
- The MAE, RMSE, AIC, BIC, and ICC were used to calculate the average rank (AR) to assess the model performance. Model interpretability was also incorporated into the evaluation.

RESULTS

Socio-demographic characteristics of respondents

- A total of **1,000 patients** with gout (**69.7% male, mean [SD] age 54.5 [13.4] years**) were included in this study..
- The average score (SD) of **GIS** was **53.763 (13.624)** and the mean utility value (SD) of **EQ-5D-5L** and **SF-6Dv2** was **0.772(0.189)** and **0.658 (0.156)**, respectively.

Conceptual overlap

- As shown in Table 1, the Spearman's correlation coefficients for GIS score with EQ-5D-5L and SF-6Dv2 utilities were **0.470** and **0.540**, respectively.

Table 1 Spearman's correlation coefficients between GIS and EQ-5D-5L/SF-6Dv2

GIS	EQ-5D-5L						SF-6Dv2						
	MO	SC	UA	PD	AD	Utility	PF	RL	SF	PA	MH	VI	Utility
Concern Overall	0.028	0.097	0.049	-0.109	-0.150	-0.039	-0.150	-0.138	-0.145	-0.141	-0.209	-0.236	-0.204
Medication Side Effect	-0.060	-0.023	-0.037	-0.090	-0.135	-0.095	-0.106	-0.117	-0.161	-0.121	-0.190	-0.088	-0.166
Unmet Gout Treatment Need	-0.157	-0.046	-0.138	-0.213	-0.178	-0.206	-0.168	-0.244	-0.249	-0.215	-0.211	-0.246	-0.287
Well-Being during Attack	-0.339	-0.397	-0.415	-0.412	-0.470	**-0.523**	-0.243	-0.443	-0.483	-0.347	**-0.535**	-0.436	**-0.521**
Concern during Attack	-0.155	-0.140	-0.106	-0.181	-0.301	-0.242	-0.204	-0.264	-0.275	-0.225	-0.364	-0.299	-0.337
Total score	-0.298	-0.301	-0.336	-0.397	-0.463	**-0.470**	-0.277	-0.454	-0.480	-0.365	-0.545	-0.458	**-0.540**

Table 2 Model performance of seven regression methods for mapping GIS to the EQ-5D-5L

Mapping Methods	Development group (N = 800)										Validation group (N = 200)							
	Mean	SD	Min	Max	MAE	RMSE	AIC	BIC	ICC	AR	Mean	SD	Min	Max	MAE	RMSE	ICC	AR
OLS1	0.769	0.084	0.556	1.050	0.127	0.169	-548	-539	0.326	12	0.776	0.082	0.569	1.018	0.115	0.156	0.369	15
OLS2	0.769	0.084	0.580	1.086	0.128	0.169	-547	-533	0.327	14	0.775	0.083	0.590	1.045	0.116	0.156	0.372	14
OLS3	0.769	0.085	0.630	1.008	0.127	0.169	-547	-528	0.330	13	0.775	0.082	0.630	1.000	0.114	0.155	0.379	6
OLS4	**0.769**	**0.098**	**0.514**	**0.999**	**0.123**	**0.163**	**-612**	**-584**	**0.418**	**3**	**0.776**	**0.091**	**0.540**	**0.985**	**0.115**	**0.154**	**0.408**	**5**
OLS5	**0.769**	**0.097**	**0.509**	**0.986**	**0.122**	**0.163**	**-612**	**-593**	**0.413**	**2**	0.775	0.091	0.540	0.986	0.116	0.156	0.396	11
Tobit1	0.763	0.081	0.536	0.966	0.132	0.172	-285	-271	0.315	32	0.770	0.078	0.550	0.954	0.118	0.157	0.352	25
Tobit2	0.762	0.079	0.614	0.991	0.131	0.171	-291	-272	0.313	30	0.768	0.076	0.618	0.981	0.117	0.156	0.358	21
Tobit3	0.763	0.079	0.630	0.987	0.131	0.172	-289	-266	0.314	31	0.768	0.076	0.631	0.977	0.117	0.156	0.360	17
Tobit4	**0.763**	**0.093**	**0.496**	**0.942**	**0.125**	**0.165**	**-338**	**-305**	**0.402**	**10**	**0.770**	**0.086**	**0.524**	**0.937**	**0.115**	**0.154**	**0.396**	**6**
Tobit5	0.763	0.092	0.480	0.933	0.126	0.166	-336	-318	0.391	11	0.770	0.087	0.515	0.927	0.116	0.156	0.387	12
CLAD1	0.808	0.078	0.612	1.067	0.126	0.172	--	--	0.297	25	0.814	0.076	0.623	1.037	0.114	0.160	0.340	20
CLAD2	0.803	0.085	0.548	1.024	0.126	0.173	--	--	0.315	24	0.811	0.082	0.566	1.007	0.114	0.160	0.354	18
CLAD3	0.804	0.083	0.578	1.020	0.126	0.173	--	--	0.311	26	0.811	0.080	0.592	1.006	0.113	0.159	0.352	15
CLAD4	**0.784**	**0.101**	**0.516**	**0.994**	**0.122**	**0.166**	--	--	**0.418**	**1**	**0.792**	**0.095**	**0.539**	**0.996**	**0.113**	**0.155**	**0.414**	**3**
GLM1	0.876	0.048	0.755	1.035	0.127	0.168	-549	-539	0.161	17	0.879	0.047	0.762	1.017	0.133	0.188	0.186	32
GLM2	0.876	0.048	0.759	1.040	0.128	0.169	-547	-533	0.161	27	0.879	0.047	0.766	1.021	0.133	0.188	0.186	31
GLM3	0.876	0.048	0.793	0.999	0.127	0.169	-547	-528	0.162	18	0.879	0.046	0.793	0.998	0.132	0.188	0.190	29
GLM4	0.875	0.056	0.728	1.004	0.122	0.162	-613	-585	0.217	7	0.879	0.052	0.742	0.997	0.134	0.186	0.215	28
GLM5	**0.875**	**0.056**	**0.725**	**0.998**	**0.122**	**0.163**	**-614**	**-595**	**0.215**	**6**	0.879	0.052	0.742	0.998	0.134	0.187	0.210	30
PTM1	0.769	0.089	0.547	1.013	0.127	0.168	-126	-107	0.338	19	0.776	0.086	0.560	1.001	0.114	0.156	0.381	9
PTM2	0.769	0.084	0.594	1.002	0.127	0.169	-139	-111	0.328	27	0.775	0.082	0.597	1.000	0.115	0.156	0.372	12
PTM3	0.769	0.085	0.627	1.004	0.127	0.169	-139	-101	0.329	29	0.775	0.082	0.627	0.997	0.115	0.156	0.375	9
PTM4	0.769	0.102	0.514	0.997	0.121	0.162	-195	-139	0.433	9	**0.776**	**0.094**	**0.538**	**0.983**	**0.114**	**0.153**	**0.426**	**1**
PTM5	**0.769**	**0.102**	**0.512**	**0.982**	**0.121**	**0.162**	**-198**	**-161**	**0.429**	**8**	0.776	0.095	0.540	0.982	0.115	0.155	0.414	4
ALDVMM1	0.772	0.082	0.544	0.960	0.127	0.169	-467	-434	0.316	22	0.779	0.079	0.558	0.953	0.116	0.157	0.355	22
ALDVMM2	0.774	0.078	0.653	0.994	0.127	0.168	-488	-446	0.310	14	0.780	0.075	0.654	0.987	0.114	0.155	0.358	8
ALDVMM3	0.774	0.078	0.555	0.980	0.127	0.169	-492	-441	0.310	20	0.778	0.076	0.580	0.979	0.115	0.157	0.346	22
ALDVMM4	**0.773**	**0.096**	**0.503**	**0.947**	**0.121**	**0.163**	**-543**	**-473**	**0.404**	**5**	**0.782**	**0.090**	**0.525**	**0.944**	**0.112**	**0.154**	**0.409**	**1**
BM1	0.769	0.065	0.560	0.922	0.133	0.173	-2233	-2200	0.263	22	0.775	0.063	0.576	0.912	0.120	0.159	0.293	27
BM2	0.770	0.072	0.688	0.984	0.131	0.172	-2242	-2200	0.290	14	**0.775**	**0.070**	**0.688**	**0.975**	**0.116**	**0.156**	**0.342**	**19**
BM3	0.769	0.063	0.667	0.926	0.132	0.173	-2232	-2185	0.263	21	0.774	0.060	0.672	0.914	0.119	0.157	0.302	26
BM4	**0.766**	**0.092**	**0.473**	**0.919**	**0.127**	**0.167**	**-2290**	**-2219**	**0.387**	**4**	0.774	0.086	0.505	0.913	0.117	0.158	0.369	24

Table 3 Model performance of six regression methods for mapping GIS to the SF-6Dv2

Mapping Methods	Development group (N = 800)										Validation group (N = 200)							
	Mean	SD	Min	Max	MAE	RMSE	AIC	BIC	ICC	AR	Mean	SD	Min	Max	MAE	RMSE	ICC	AR
OLS1	0.658	0.080	0.455	0.926	0.097	0.130	-988	-978	0.432	29	0.664	0.078	0.467	0.895	0.098	0.128	0.513	26
OLS2	0.658	0.083	0.539	1.051	0.096	0.129	-1003	-989	0.452	9	0.663	0.083	0.541	0.989	0.097	0.128	0.527	12
OLS3	**0.658**	**0.083**	**0.562**	**0.962**	**0.096**	**0.129**	**-1006**	**-987**	**0.457**	**6**	**0.663**	**0.082**	**0.562**	**0.938**	**0.097**	**0.127**	**0.530**	**2**
OLS4	0.658	0.084	0.427	0.907	0.097	0.129	-1009	-980	0.463	13	0.662	0.079	0.454	0.849	0.097	0.129	0.511	23
OLS5	0.658	0.083	0.441	0.893	0.097	0.129	-1007	-988	0.457	7	0.662	0.078	0.466	0.858	0.098	0.130	0.501	29
Tobit1	0.658	0.080	0.452	0.906	0.097	0.131	-925	-911	0.431	31	0.664	0.078	0.465	0.883	0.098	0.128	0.512	28
Tobit2	**0.657**	**0.081**	**0.549**	**0.978**	**0.096**	**0.129**	**-946**	**-927**	**0.450**	**11**	0.663	0.081	0.549	0.953	0.098	0.128	0.522	20
Tobit3	0.658	0.082	0.563	0.951	0.096	0.129	-947	-923	0.454	15	**0.663**	**0.081**	**0.563**	**0.931**	**0.098**	**0.127**	**0.526**	**14**
Tobit4	0.658	0.084	0.424	0.896	0.097	0.129	-946	-913	0.462	18	0.662	0.079	0.452	0.844	0.097	0.129	0.512	21
Tobit5	0.658	0.084	0.428	0.902	0.097	0.129	-946	-918	0.460	16	0.662	0.079	0.456	0.844	0.097	0.129	0.514	18
CLAD1	0.663	0.090	0.436	0.963	0.097	0.130	--	--	0.458	26	**0.670**	**0.088**	**0.450**	**0.929**	**0.096**	**0.127**	**0.547**	**1**
CLAD2	0.669	0.081	0.544	1.045	0.097	0.130	--	--	0.446	27	0.674	0.081	0.546	0.987	0.098	0.129	0.519	22
CLAD3	0.666	0.081	0.572	0.937	0.097	0.129	--	--	0.448	24	0.671	0.079	0.572	0.923	0.098	0.128	0.518	23
CLAD4	**0.661**	**0.091**	**0.431**	**0.888**	**0.097**	**0.130**	--	--	**0.460**	**21**	0.669	0.086	0.441	0.864	0.097	0.128	0.535	3
GLM1	0.658	0.083	0.479	0.983	0.096	0.129	-998	-988	0.446	12	0.664	0.081	0.488	0.938	0.097	0.127	0.527	4
GLM2	0.658	0.082	0.517	1.059	0.096	0.129	-1001	-987	0.448	19	0.664	0.082	0.522	0.990	0.097	0.128	0.525	16
GLM3	0.658	0.083	0.562	0.937	0.096	0.129	-1007	-988	0.457	5	**0.663**	**0.082**	**0.562**	**0.929**	**0.097**	**0.127**	**0.530**	**5**
GLM4	**0.658**	**0.086**	**0.455**	**0.945**	**0.096**	**0.129**	**-1016**	**-988**	**0.473**	**3**	**0.662**	**0.080**	**0.474**	**0.868**	**0.097**	**0.128**	**0.522**	**11**
GLM5	**0.658**	**0.085**	**0.458**	**0.957**	**0.096**	**0.128**	**-1016**	**-992**	**0.471**	**1**	0.662	0.080	0.477	0.863	0.096	0.127	0.523	7
PTM1	0.658	0.082	0.456	0.943	0.097	0.130	-910	-891	0.440	30	0.664	0.080	0.468	0.911	0.098	0.128	0.522	19
PTM2	0.658	0.082	0.544	1.005	0.096	0.129	-928	-900	0.450	22	0.664	0.083	0.544	0.982	0.097	0.128	0.526	15
PTM3	0.658	0.083	0.555	0.973	0.096	0.129	-929	-892	0.455	20	**0.664**	**0.082**	**0.555**	**0.950**	**0.097**	**0.127**	**0.528**	**6**
PTM4	0.658	0.085	0.434	0.950	0.097	0.129	-931	-875	0.469	23	0.662	0.080	0.458	0.916	0.098	0.129	0.512	25
PTM5	0.658	0.057	0.501	0.973	0.111	0.145	-770	-741	0.249	32	0.655	0.056	0.501	0.948	0.119	0.153	0.235	32
ALDVMM1	0.653	0.084	0.436	0.886	0.098	0.130	-989	-956	0.442	28	**0.660**	**0.082**	**0.449**	**0.874**	**0.098**	**0.127**	**0.527**	**9**
ALDVMM2	0.659	0.079	0.574	0.982	0.096	0.129	-1011	-969	0.440	10	0.664	0.079	0.574	0.963	0.099	0.129	0.507	30
ALDVMM3	**0.662**	**0.080**	**0.584**	**0.914**	**0.097**	**0.129**	**-1057**	**-1006**	**0.439**	**8**	0.666	0.078	0.584	0.914	0.099	0.130	0.499	31
ALDVMM4	0.652	0.086	0.409	0.901	0.097	0.129	-1015	-945	0.467	16	**0.657**	**0.081**	**0.439**	**0.848**	**0.097**	**0.128**	**0.524**	**9**
BM1	0.657	0.086	0.405	0.875	0.099	0.132	-1568	-1535	0.432	25	0.665	0.083	0.422	0.859	0.098	0.129	0.519	26
BM2	**0.658**	**0.081**	**0.565**	**0.947**	**0.096**	**0.129**	**-1604**	**-1562**	**0.452**	**2**	0.663	0.080	0.565	0.926	0.098	0.128	0.523	17
BM3	0.658	0.083	0.564	0.924	0.096	0.129	-1606	-1555	0.455	4	0.664	0.081	0.564	0.908	0.098	0.127	0.527	13
BM4	0.656	0.089	0.365	0.852	0.098	0.131	-1588	-1518	0.461	14	**0.663**	**0.085**	**0.400**	**0.825**	**0.096**	**0.128**	**0.527**	**8**

Mapping GIS onto EQ-5D-5L utility value

- The model performance was summarized in Table 2. 3 regression models were not presented due to not fit.
- **Predictor set 4 and 5** consistently behaved as the best-performing predictor set based on the AR. Given the GIS's limited subscale count (n=5), removing any would lead to substantial information loss, predictor 4 should be prioritized compared with predictor set 5 when AR differences are acceptable.
- **OLS4, CLAD4, and ALDVMM4** showed superior performance than others. Given the extensive adoption and superior interpretability of OLS in empirical research, we ultimately selected **OLS4** as the final algorithm to map GIS onto EQ-5D-5L.

Mapping GIS onto SF-6Dv2 utility value

- The model performance was summarized in Table 3.
- **OLS3, GLM3, and GLM4** showed better performance than others. When model performance are similar, prioritizing **GLM4** (same predictor set with EQ-5D-5L mapping algorithm) ensured comparability.

Use of optimal mapping algorithms

- The final mapping algorithms from GIS to EQ-5D-5L and SF-6Dv2 utility values are defined as follows:

$$EQ-5D-5L\ Utility\ value = 0.89974 + (0.14099 * GISConcern_{Overall} + 0.03714 * GIS_{Medication\ Side\ Effect} - 0.13277 * GIS_{Unmet\ Gout\ Treatment\ Need} - 0.41959 * GIS_{Well\ being\ during\ Attack} - 0.08613 * GIS_{Concern\ during\ Attack})/100$$

$$SF-6Dv2\ Utility\ value = [0.95206 + (0.07117 * GISConcern_{Overall} + 0.02133 * GIS_{Medication\ Side\ Effect} - 0.07006 * GIS_{Unmet\ Gout\ Treatment\ Need} - 0.24477 * GIS_{Well\ being\ during\ Attack} - 0.04204 * GIS_{Concern\ during\ Attack})/100]^2$$

CONCLUSION

- This study provided evidence to estimate EQ-5D-5L and SF-6Dv2 utility values from GIS scores. OLS and GLM models with the GIS subscale score can be used to predict the EQ-5D-5L and SF-6Dv2 utility values among patients with gout in China.