Mapping the NEI-VFQ-25 to the EQ-5D-Y-3L and CHU-9D among High School Students with Myopia in China

Chang Luo[1], Xiaoyan Yang[2], Jing Wang[3], Tianqi Hong[4], Mengdi Li[3], Jie Zhang[5], Wei Qi[6], Lihua Li[2], Shitong Xie[1], Jing Wu[1*]

1. School of Pharmaceutical Science and Technology, Faculty of Medicine, Tianjin University, Tianjin, China, 2. Tianjin Eye Hospital, Tianjin, China, 3. Institute of Optometry and Vision Science, Nankai University, Tianjin, China, 4. School of Biomedical Engineering, McMaster University, Hamilton, ON, Canada, 5. Heping District Education Comprehensive Service Center, Tianjin, China, 6. Jeemei Eye hospital, Qingdao, China

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OBJECTIVES

- To develop algorithms to map the National Eye Institute 25-Item Visual Function Questionnaire (NEI-VFQ-25) onto the EQ-5D-Y-3L and CHU-9D among high school students with myopia in China.

METHODS

- Respondents recruited from the Chinese high school myopic students completed an online survey and the sample was randomly divided into development (80%) and validation (20%) datasets. The "driving" subscale of the NEI-VFQ-25 was excluded due to its inapplicability to adolescents.
- Spearman's correlation analyses were performed to assess conceptual overlap.
- **Six models**, including OLS, Tobit, CLAD, GLM, TPM and ALDVMM, and **five predictor sets** including 1) NEI-VFQ-25 total score, 2) 1) plus total score square, 3) 2) plus total score cubic, 4) NEI-VFQ-25 subscale scores, 5) NEI-VFQ-25 subscale scores after stepwise regression were explored to estimate mapping algorithms using the development dataset.
- The MAE, RMSE, AIC, BIC, and the proportions of absolute error (AE) within the threshold of 0.05 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 **2,198 students** with myopia (53.1% male, mean [SD] age 16.7 [0.8] years) were included.
- The average score (SD) of **NEI-VFQ-25** was **91.112 (9.619)** and the mean utility value (SD) of **EQ-5D-Y-3L and CHU-9D** was **0.962(0.070) and 0.851 (0.160)**.

Conceptual overlap

- As shown in Table 1, the Spearman's correlation coefficients for NEI-VFQ-25 score with EQ-5D-Y-3L and CHU-9D utilities were **0.366** and **0.502**, respectively.

Table 1 Spearman's correlation coefficients between NEI-VFQ-25 and EQ-5D-Y-3L/CHU-9D

NEI-VFQ-25	EQ-5D-Y-3L						CHU-9D									
	MO	SC	UA	PD	AD	Utility	WO	SA	PA	TI	AN	SH	SL	DR	AJA	Utility
General Vision	0.0285*	0.0671**	0.1187	0.1889	0.2456	0.2720	0.3005	0.2395	0.2412	0.3489	0.1801	0.2837	0.2129	0.1593	0.2287	0.3901
Ocular Pain	0.0621**	0.0904	0.1583	0.2722	0.2678	0.3241	0.3435	0.2620	0.3183	0.3766	0.2706	0.3328	0.2980	0.1728	0.2570	**0.4456**
Near Activities	0.1127	0.1169	0.1651	0.2275	0.2164	0.2747	0.2626	0.2394	0.2627	0.2691	0.1766	0.2617	0.2485	0.1799	0.2661	0.3405
Distance Activities	0.0798	0.0808	0.1280	0.2430	0.2543	0.3070	0.2995	0.2332	0.2727	0.2953	0.1732	0.2694	0.2478	0.1576	0.2604	0.3709
Social Functioning	0.1063	0.1267	0.1532	0.2051	0.1713	0.2357	0.1879	0.2033	0.2078	0.1684	0.1880	0.2192	0.2151	0.2039	0.2250	0.2677
Mental Health	0.0742	0.1071	0.1732	0.2396	0.2826	0.3216	0.3532	0.2710	0.2961	0.3582	0.2408	0.3416	0.2553	0.1925	0.2927	**0.4524**
Role Difficulties	0.0725	0.0902	0.1379	0.1874	0.1571	0.2135	0.1841	0.1826	0.2257	0.1973	0.1522	0.1928	0.1765	0.1644	0.2156	0.2657
Dependency	0.0784	0.0949	0.1507	0.1688	0.1855	0.2167	0.1891	0.1662	0.1957	0.1960	0.1483	0.1967	0.1869	0.1920	0.2463	0.2657
Color Vision	0.1222	0.1713	0.1472	0.1089	0.0846	0.1443	0.0950	0.1612	0.1528	0.0965	0.1301	0.1509	0.1446	0.2388	0.1824	0.1686
Peripheral Vision	0.1023	0.1028	0.1143	0.2094	0.1983	0.2487	0.1819	0.2243	0.2084	0.1889	0.1645	0.2151	0.2004	0.1984	0.2097	0.2711
Total Score	0.0884	0.1208	0.1862	0.2788	0.3114	**0.3656**	0.3800	0.3128	0.3349	**0.4074**	0.2662	0.3641	0.2999	0.2270	0.3269	**0.5018**

Table 2 Model performance of six regression methods for mapping NEI-VFQ-25 to the EQ-5D-Y-3L

Mapping Methods	Development group (N = 1758)									Validation group (N = 440)						
	N	Mean	SD	MAE	RMSE	AIC	BIC	AE>0.05	AR	N	Mean	SD	MAE	RMSE	AE>0.05	AR
OLS1	1758	0.963	0.027	0.046	0.065	-4586	-4575	27.70%	14	440	0.964	0.024	0.046	0.062	30.7%	12
OLS2	1758	0.963	0.027	0.047	0.066	-4589	-4572	26.17%	13	440	0.964	0.023	0.047	0.063	29.3%	13
OLS3	1758	0.963	0.030	0.044	0.064	-4668	-4646	31.40%	10	440	0.964	0.024	0.045	0.061	33.4%	10
OLS4	1739	0.964	0.028	0.043	0.061	-4824	-4764	27.26%	3	435	0.964	0.028	0.044	0.060	31.0%	5
OLS5	**1747**	**0.964**	**0.028**	**0.043**	**0.061**	**-4843**	**-4794**	**27.02%**	**2**	**438**	**0.964**	**0.027**	**0.044**	**0.060**	**30.4%**	**4**
Tobit1	1758	0.965	0.031	0.046	0.066	719	736	26.22%	22	440	0.967	0.026	0.047	0.064	30.0%	25
Tobit2	1758	0.965	0.028	0.045	0.068	706	728	28.50%	25	440	0.966	0.026	0.046	0.063	31.8%	26
Tobit3	1758	0.965	0.033	0.044	0.074	645	673	31.91%	25	440	0.966	0.024	0.045	0.062	34.8%	19
Tobit4	1739	0.966	0.033	0.041	0.062	587	652	26.11%	8	435	0.967	0.032	0.043	0.062	30.8%	7
Tobit5	**1754**	**0.966**	**0.033**	**0.041**	**0.062**	**583**	**627**	**25.60%**	**6**	**439**	**0.967**	**0.030**	**0.043**	**0.062**	**29.2%**	**3**
CLAD2	1758	0.997	0.013	--	--	--	--	28.44%	24	440	0.998	0.009	0.040	0.075	32.0%	19
CLAD3	1758	0.997	0.016	0.037	0.076	--	--	28.67%	20	440	0.998	0.009	0.039	0.075	32.3%	19
CLAD4	**1739**	**0.990**	**0.023**	**0.035**	**0.068**	**--**	**--**	**28.00%**	**17**	**435**	**0.991**	**0.021**	**0.040**	**0.072**	**32.0%**	**16**
GLM1	1758	0.963	0.027	0.046	0.065	-4586	-4575	27.70%	15	440	0.964	0.024	0.046	0.062	30.7%	13
GLM2	1758	0.963	0.027	0.046	0.066	-4589	-4572	26.17%	12	440	0.964	0.023	0.047	0.063	29.3%	13
GLM3	1758	0.963	0.030	0.044	0.064	-4668	-4646	31.40%	10	440	0.964	0.024	0.045	0.061	33.4%	10
GLM4	1739	0.964	0.028	0.043	0.061	-4824	-4764	27.26%	3	435	0.964	0.028	0.044	0.060	31.0%	5
GLM5	**1750**	**0.964**	**0.028**	**0.043**	**0.061**	**-4850**	**-4806**	**26.40%**	**1**	**439**	**0.964**	**0.028**	**0.044**	**0.060**	**29.6%**	**2**
PTM1	1758	0.963	0.029	0.047	0.066	726	747	26.96%	23	440	0.965	0.026	0.047	0.063	29.1%	19
PTM2	1758	0.963	0.025	0.067	0.046	675	707	27.19%	19	440	0.964	0.023	0.047	0.062	30.5%	17
PTM3	1758	0.963	0.031	0.044	0.066	604	648	34.07%	21	440	0.964	0.025	0.045	0.062	35.2%	23
PTM4	1739	0.964	0.029	0.042	0.061	489	609	26.97%	7	435	0.964	0.029	0.044	0.061	31.0%	8
PTM5	**1754**	**0.964**	**0.028**	**0.042**	**0.061**	**486**	**562**	**26.17%**	**5**	**439**	**0.965**	**0.027**	**0.044**	**0.061**	**28.2%**	**1**
ALDVMM1	1758	0.963	0.029	0.048	0.066	526	564	22.75%	16	440	0.965	0.022	0.049	0.064	24.8%	23
ALDVMM2	1758	0.963	0.025	0.048	0.067	522	571	23.66%	18	440	0.964	0.022	0.048	0.063	26.8%	17
ALDVMM4	**1739**	**0.964**	**0.033**	**0.045**	**0.063**	**465**	**602**	**24.55%**	**9**	**435**	**0.964**	**0.031**	**0.046**	**0.063**	**29.0%**	**9**

Table 3 Model performance of six regression methods for mapping NEI-VFQ-25 to the CHU-9D

Mapping Methods	Development group (N = 1758)									Validation group (N = 440)						
	N	Mean	SD	MAE	RMSE	AIC	BIC	AE>0.05	AR	N	Mean	SD	MAE	RMSE	AE>0.05	AR
OLS1	1758	0.854	0.069	0.111	0.145	-1784	-1773	77.1%	25	440	0.857	0.062	0.107	0.142	72.3%	23
OLS2	1758	0.854	0.071	0.109	0.145	-1803	-1787	76.4%	21	440	0.856	0.067	0.106	0.141	73.0%	20
OLS3	1758	0.854	0.078	0.106	0.144	-1889	-1867	65.9%	16	440	0.856	0.072	0.105	0.141	64.8%	12
OLS4	1739	0.856	0.082	0.101	0.137	-2009	-1949	63.8%	10	435	0.856	0.083	0.102	0.137	62.3%	7
OLS5	**1750**	**0.855**	**0.083**	**0.101**	**0.136**	**-2022**	**-1978**	**63.7%**	**4**	**439**	**0.855**	**0.083**	**0.101**	**0.137**	**61.7%**	**3**
Tobit1	1758	0.854	0.069	0.111	0.145	-1782	-1765	77.1%	26	440	0.857	0.062	0.107	0.142	72.3%	23
Tobit2	1758	0.854	0.071	0.109	0.145	-1801	-1780	76.4%	21	440	0.856	0.067	0.106	0.141	73.0%	20
Tobit3	1758	0.854	0.078	0.106	0.144	-1887	-1860	65.9%	17	440	0.856	0.072	0.105	0.141	64.8%	12
Tobit4	1739	0.856	0.082	0.101	0.137	-2007	-1941	63.8%	9	435	0.856	0.083	0.102	0.137	62.3%	7
Tobit5	**1750**	**0.855**	**0.083**	**0.101**	**0.136**	**-2020**	**-1971**	**63.7%**	**4**	**439**	**0.855**	**0.083**	**0.101**	**0.137**	**61.7%**	**3**
CLAD1	1758	0.897	0.090	0.107	0.152	--	--	58.9%	8	440	0.895	0.080	0.106	0.152	56.8%	16
CLAD2	1758	0.892	0.092	0.110	0.157	--	--	59.8%	12	440	0.886	0.089	0.104	0.151	57.3%	12
CLAD3	1758	0.882	0.085	0.102	0.149	--	--	61.0%	7	440	0.891	0.070	0.104	0.151	58.9%	15
CLAD4	**1739**	**0.884**	**0.108**	**0.095**	**0.141**	**--**	**--**	**59.6%**	**1**	**435**	**0.885**	**0.109**	**0.101**	**0.148**	**59.3%**	**10**
GLM1	1758	0.854	0.072	0.110	0.144	-1798	-1787	76.3%	21	440	0.857	0.066	0.107	0.141	72.0%	20
GLM2	1758	0.854	0.073	0.108	0.144	-58139	-58133	76.6%	13	440	0.856	0.070	0.106	0.141	72.0%	17
GLM3	1758	0.854	0.080	0.104	0.140	-1912	-1890	64.2%	14	440	0.855	0.075	0.104	0.141	63.6%	9
GLM4	1739	0.856	0.083	0.101	0.137	-2011	-1951	63.5%	6	435	0.856	0.083	0.101	0.137	63.0%	3
GLM5	**1750**	**0.855**	**0.083**	**0.101**	**0.136**	**-2026**	**-1982**	**63.0%**	**2**	**439**	**0.855**	**0.083**	**0.101**	**0.137**	**62.2%**	**1**
PTM1	1758	0.854	0.075	0.110	0.144	640	662	76.4%	24	440	0.857	0.069	0.106	0.142	71.1%	19
PTM2	1758	0.854	0.074	0.109	0.146	564	596	76.7%	27	440	0.856	0.071	0.106	0.141	72.5%	18
PTM3	1758	0.854	0.079	0.105	0.142	428	472	64.9%	18	440	0.855	0.075	0.104	0.141	64.3%	11
PTM4	**1739**	**0.856**	**0.085**	**0.099**	**0.135**	**358**	**478**	**62.9%**	**11**	**435**	**0.856**	**0.085**	**0.101**	**0.137**	**62.5%**	**2**
PTM5	1754	0.855	0.085	0.101	0.137	362	428	63.6%	15	439	0.857	0.082	0.101	0.137	64.0%	6
ALDVMM1	1758	0.856	0.037	0.116	0.148	-13301	-13274	78.0%	19	440	0.858	0.033	0.113	0.145	75.0%	27
ALDVMM2	1758	0.856	0.037	0.116	0.149	-13299	-13266	77.9%	20	440	0.858	0.033	0.113	0.145	74.8%	26
ALDVMM3	**1758**	**0.859**	**0.039**	**--**	**--**	**-13322**	**-13284**	**76.7%**	**3**	**440**	**0.860**	**0.035**	**0.111**	**0.144**	**73.9%**	**25**

Mapping NEI-VFQ-25 onto EQ-5D-Y-3L utility value

- The model performance was summarized in Table 2. 4 regression models were not presented due to not fit. The exclusion of the "driving" subscale resulted in sample size reduction for specific models.
- **Predictor set 5** consistently behaved as the best-performing predictor set based on the AR.
- **OLS5 and GLM5** showed superior performance than others. Given the extensive adoption and superior interpretability of OLS in empirical research, we ultimately selected **OLS5** as the final algorithm to map NEI-VFQ-25 onto EQ-5D-Y-3L.

Mapping NEI-VFQ-25 onto CHU-9D utility value

- The model performance was summarized in Table 3. **Predictor set 5** remained with superior AR.
- **OLS5, Tobit5, and GLM5** showed better performance than others. Although **OLS5** was not the highest-performing model, its superior interpretability resulted its adoption as the final mapping algorithm.

Use of optimal mapping algorithms

- The final mapping algorithms from NEI-VFQ-25 to EQ-5D-Y-3L and CHU-9D utility values are defined as follows:

$$EQ-5D-Y-3L\ Utility\ value = 0.70717 + (0.02557 * NEI-VFQ-25_{General\ Vision} + 0.08663 * NEI-VFQ-25_{Ocular\ Pain} + 0.08459 * NEI-VFQ-25_{Near\ Activities} + 0.04849 * NEI-VFQ-25_{Distance\ Activities} + 0.07119 * NEI-VFQ-25_{Mental\ Health} - 0.02914 * NEI-VFQ-25_{Role\ Difficulties} - 0.04293 * NEI-VFQ-25_{Dependency} + 0.03971 * NEI-VFQ-25_{Peripheral\ Vision})/100$$

$$CHU-9D\ Utility\ value = 0.22356 + (0.14666 * NEI-VFQ-25_{General\ Vision} + 0.30783 * NEI-VFQ-25_{Ocular\ Pain} + 0.10096 * NEI-VFQ-25_{Near\ Activities} + 0.16626 * NEI-VFQ-25_{Distance\ Activities} + 0.24037 * NEI-VFQ-25_{Mental\ Health} - 0.07818 * NEI-VFQ-25_{Role\ Difficulties} - 0.15548 * NEI-VFQ-25_{Dependency})/100$$

CONCLUSION

- OLS models with the NEI-VFQ-25 subscale score from stepwise regression can be used to predict both the EQ-5D-Y-3L and CHU-9D utility values among high school students with myopia in China.