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Comparison of the Early Childhood Oral Health Impact Scale (ECOHIS-4D) and Child Health Utility Index (CHU-9D) in children with oral diseases

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Abstract

Objective: Accurate assessment of child oral health is important for guiding economic evaluations and informing healthcare decision-making. Early Childhood Oral Health Impact Scale (ECOHIS-4D) is a preference-based instrument that measures the oral health-related quality of life of young children. The aim of this study was to compare the utility scores of ECOHIS-4D and Child Health Utility Index (CHU-9D), against an oral health indicator to evaluate which utility score corresponds better with the oral health indicator.

Method: The ECOHIS-4D and CHU-9D were applied to 314 parent/child dyads from preschools in a primary healthcare setting in Perth, Western Australia. Four parameters were used to assess which instrument corresponds better with the oral health indicator (decayed, missing and filled teeth score-dmft score): (i) discrimination, the ability to discriminate between different clinical severity groups, (ii) external responsiveness, how much the utility values relate to the changes in dmft scores, (iii) correlation, the association between the two instruments and the related dimensions and (iv) differences in the utility values across the two instruments.

Results: Most participants (81%) were 2–6 years old, and nearly 50% had a dmft score <3. ECOHIS-4D demonstrated a superior ability to differentiate between dmft severity groups and respond to changes in dmft scores. A significant weak correlation was observed between dmft and ECOHIS-4D (−0.26, 95%, CI −0.36 to −0.15) compared to a non-significant very poor correlation between dmft and CHU-9D (0.01, 95% CI −0.12 to 0.10). The utility scores of the two instruments had relatively good agreement towards good health and weak agreement towards poor health.

Conclusions: ECOHIS-4D, the oral health-specific instrument, is more sensitive in assessing children's oral health-related quality of life than the generic CHU-9D. Thus, ECOHIS-4D is more appropriate for utility estimates in economic evaluations of oral health-related interventions and resource allocation decision-making.

KEYWORDS
oral health, oral health-related quality of life, preference based

1 | INTRODUCTION

Dental caries is one of the most prevalent childhood oral diseases with around 9% of the global child population reported to suffer in 2010.[1] The global burden of disease study has estimated 147000 disability-adjusted life years (DALY) due to untreated caries in deciduous teeth in 2015.[2] According to the Australian 2012–14 National Child Oral Health Study, 41.7% of 5–10-year-old Australian children had experienced dental caries in their primary teeth, and more than 25% of them had at least one tooth with untreated dental caries.[3]

Oral diseases significantly impact health systems, children and their caregiver's quality of life due to the high cost associated with oral treatments. Dental treatment accounts for 5% of total health expenditure and 20% of out-of-pocket health expenditure in most high-income countries.[1] In the United States, the total dental expenditure was 101 billion US dollars in 2016[4] and €79 billion (87.1 billion USD) in Europe in 2020.[5] In Australia, AUD$ 9.5 billion (6.6 billion USD) was spent on dental services, and per capita expenditure on dental services was AUD$374 (260 USD) in 2019–2020.[6]

Given the high economic burden associated with oral health interventions, efficient allocation of scarce health resources is paramount. Economic evaluations facilitate the prioritization of healthcare interventions that provide the best value for money.[7] Cost-utility analysis (CUA) is one of the methods used to assess the cost effectiveness that is recommended by health technology assessment agencies in developed countries, including Australia, to prioritize cost-effective new health interventions. Cost-effectiveness is measured by dividing the change in cost (incremental cost) by change in health outcome (incremental outcome) (Supplementary text). In CUA, health outcomes are measured in terms of quantity and quality of life, with Quality-adjusted life-years (QALYs) the main summary outcome measure. Multi-attribute utility instruments (MAUIs) (also known as preference-based quality of life measures [PBMs]), such as CHU-9D and ECOHIS-4D are used to calculate the utility component of quality of life to derive QALYs and inform the CUA. The accuracy of the cost effectiveness analysis depends on the accurate measurement of the incremental outcome, which is QALY in CUA. Therefore, the choice of the MAUI used may adversely influence the results of CUA and, consequently, the decision-making process as different MAUI can produce different utility measures.[8] There are two types of PBMs: generic, which measure a participant's general level of quality of life, and disease-specific, which measure the participant's disease-related quality of life. Generic tools like CHU-9D are designed to measure health-related quality of life across various disease conditions and thus, might not capture all the nuances of a specific condition like oral health. Despite the importance of obtaining accurate QALY assessment, often generic PBMs are used for oral health-related QoL assessments.[9] However, the effectiveness of CHU-9D in evaluating oral health-related interventions has not been extensively evaluated. Few studies have found that CHU-9D could detect differences in the impact of dental caries[10] and findings have found the observed differences between caries status and the CHU-9D scores to not be statistically significant.[11] Given the broad nature of these quality-of-life measures, evidence suggests that these generic instruments may not be sufficiently sensitive to identify changes in specific disease conditions.[12] Instead, more targeted, disease-specific MAUIs may be more responsive to the changes in quality of life due to health interventions, as disease-specific MAUIs include the relevant domains for the disease under investigation.

Based on the valid and reliable non-preference-based oral health-related quality of life (OHRQL) measuring original ECOHIS-13 instrument,[13] in 2022, a paediatric oral health-specific preference-based measure (ECOHIS- 4D) was developed that can be used as a MAUI for young children.[14] The study hypothesis was the oral health-specific ECOHIS-4D instrument would be more sensitive to the changes in oral health conditions than the CHU-9D, given a broad nature of the generic quality-of-life measure, and would be a better instrument to evaluate oral health interventions. Therefore, the main aim of this study was to compare the utility scores of ECOHIS-4D and CHU-9D against an oral health indicator to evaluate which utility score corresponds better with the (decayed, missing and filled teeth score-dmft score) oral health indicator.

2 | METHODS

The CHU-9D and ECOHIS-4D comparison was made using existing cross-sectional data from 314 parent/child dyads residing in selected communities in the Kimberley region of Western Australia.[15,16] All children who gave their consent to participate were included in the study with their parents. However, children with complex medical conditions (e.g. congenital heart disease) or developmental syndromes (e.g. Trisomy 21) were excluded from the primary study as these conditions limited dental treatment at the primary care setting.

Parents were asked to complete a questionnaire which consisted of questions on the child's socio-demographic factors and oral health-related quality of life, as measured using the Early Childhood Oral Health Impact Scale (ECOHIS-13, non-preference-based oral health-related scale) and CHU-9D. A subsequent oral examination was completed by trained oral health professionals.

2.1 | Utility measurement

2.1.1 | Early Childhood Oral Health Impact Scale (ECOHIS-13)

ECOHIS-13 (Supplementary text—Annex III) was developed by scholars at the University of North Carolina, USA. The aim of the tool was to provide a valid and reliable instrument to measure the negative impact of dental diseases and treatment experiences on the quality of life of young children.[13] The ECOHIS-13 scale, validated for use with Australian preschool children, was used in the primary study and comprised 13 items and five levels of responses.[17] The ECOHIS-13 cannot be directly used to calculate QALYs as it is not a preference-based instrument.

Based on the original ECOHIS-13 instrument, ECOHIS-4D[14] was developed in 2022 to assess young children's oral health-related quality of life. Exploratory factor analysis and Rasch analysis were conducted to reduce the 13 items to four items: pain, eating, irritability and talking (Supplementary text-Annex II). The original six levels were reduced to three levels: never, occasionally and very often. The development of ECOHIS-4D has been described elsewhere.[14] The Australian utility value set for this instrument ranges from 0.0376 to 1.000 in 81 health states (levels ^ $^{\text{items}} = 3^4$) classification system.[18] The estimated utility values are then used to weight number of years of live lived to determine QALYs.

2.1.2 | Child Health Utility Index (CHU-9D)

CHU-9D is a paediatric preference-based instrument suggested for use in children aged 7–11 years. The questionnaire consisted of nine items: worried, sad, pain, tired, schoolwork, sleep, annoyed, daily routine and ability to join in activities (Supplementary text-Annex I). Each item is rated in terms of five levels of responses representing increasing severity: 'do not feel', 'a little', 'a bit of', 'a quite a lot of' and 'very'.[19] The Australian value set is available for this instrument with 1953,125 possible health states where the utility values range from 0.1059 to 1.0.[20]

This study analysed proxy-reported ECOHIS-4D and CHU-9D responses owing to the children cannot complete the questionnaires by themselves.

2.2 | Oral examination of children

The decayed, missing and filled teeth (dmft) score is considered a key indicator of oral health status[6] and was used as the clinical indicator of this study. It measures the oral health status of a population, and measures lifetime caries experience.[21] Since most oral health interventions are aimed at improving oral health status (e.g. caries and status of dentition), dmft is the most commonly used indicator in evaluating the effectiveness of oral health interventions.[22] The dmft score is calculated by summing the number of teeth decayed (d), missing (m) or filled (f) due to dental caries in the primary dentition.[6] Assessment of the tooth status was completed by trained and calibrated examiners.[15]

2.3 | Statistical analysis

The methodology of recently published articles comparing preference-based instruments in cardiovascular and chronic kidney disease[8,23] was followed in this study. Four parameters were used to assess which utility score (ECOHIS-4D vs. CHU-9D) is more sensitive to the changes in the outcome indicator (dmft score): (1) assessment of discriminatory ability between clinical severity groups, (2) external responsiveness, (3) correlation analysis between dmft score and utility measure, and related dimensions of both instruments (Supplementary Table S1) and (4) the differences across the two instruments. All statistical analysis was performed using R programming software version 4.2.2.

2.3.1 | Assessment of discriminatory ability between clinical severity groups

A valid instrument should be able to discriminate between groups with different clinical severity.[12] The dmft score was used to assess the clinical severity of the child's oral health condition, with high dmft scores indicating higher clinical severity. The dmft score was divided into three severity levels: '0' (no disease), '1–7' and 'equal or more than 8'[24] based on the Significant Caries Index (SCI) of this population. This is estimated by sorting the individual dmft scores from highest to lowest, then taking the average dmft score of the one third of individuals with the highest scores. The effect size was used to determine the discriminatory ability of the two instruments. The effect size was calculated by dividing the mean utility difference of two adjacent severity groups by the standard deviation of the milder severity group.[12] Effect sizes were calculated for ECOHIS-4D and CHU-9D utility measures separately, with larger effect sizes indicating better discriminating ability of the instrument. The effect sizes were categorized into small (0.2–0.5), medium (0.5–0.8) and large (more than 0.8).[25]

2.3.2 | External responsiveness

As suggested by Husted et al. (2000), linear regression models were used to assess the external responsiveness of the two instruments.[26] The skewed distribution of the data was addressed by employing bootstrapped linear regression analyses. The external responsiveness of the ECOHIS-4D and CHU-9D instruments was investigated, focusing on the impact of changes in dmft scores on utility values while accounting for potential confounding factors (i.e. age and sex[27,28]). Robust estimates of coefficients and confidence intervals were obtained by utilizing bootstrapping method. A negative coefficient for dmft was expected, with the coefficient's size indicating the extent of the utility score change for each unit change in dmft. The instrument with the largest statistically significant negative coefficient showed the best responsiveness. Higher dmft scores indicated poorer oral health and quality of life.

Furthermore, ceiling and floor effects were estimated as indirect measures of responsiveness. The ceiling effect was assessed by the percentage of children reporting 'no problem' in each dimension.[12] The floor effect was evaluated by the percentage of children reporting the 'worst' across all dimensions. High percentages for these two measures indicate the inability of the instrument to detect improvement or worsening of QoL.[29]

2.3.3 | Correlation analysis between dmft score and utility measure, and related dimensions of both instruments

Spearman's rho was used to estimate the correlation between dmft and utility scores. The utility measure with the largest negative correlation coefficient correlates best with the dmft score. Furthermore, Spearman rho was calculated to compare the utility values of the two instruments and the related dimensions of both instruments. The related items of the two instruments were in Supplementary Table S1. The magnitude of the correlation was interpreted according to the following criteria: 0.10–0.39 as weak, 0.40–0.75 as moderate and >0.75 as strong associations.[30]

2.3.4 | Differences across the two instruments

The difference in the utility values (ECOHIS-4D vs. CHU-9D) and the difference in the utility values according to different socio-demographic and dmft categories were compared using Wilcoxon signed rank test. The null hypothesis was that there was no significant difference between ECOHIS-4D and the CHU-9D utility scores against the severity of dental caries. Agreement between the two utilities was examined using the Bland–Altman plot.

3 | RESULTS

The mean utility score for 314 observations was almost the same for ECOHIS-4D and CHU-9D, which were 0.91 (SD = 0.14) and 0.92 (SD = 0.13) respectively (Table 1). The sex distribution of study participants was almost equal (47.8% male), and most participants were 2–6 years of age, with a mean age and SD of 3.6 years (SD = 1.7) (Table 1). The distribution of utilities of the two instruments is shown in Figure 1A,B. The utility distributions were left-skewed, indicating that most had high utility scores in both instruments.

3.1 | Assessment of discriminatory ability between clinical severity groups

With increasing dmft score and oral disease severity level, the mean utility values of the ECOHIS-4D gradually decreased, while CHU-9D values remained almost the same (Table 2). This indicates that the ECOHIS-4D tool is more effective than CHU-9D at showing a decline in quality of life as oral health worsens. Comparatively, high effect sizes were observed in ECOHIS-4D, indicating its superior discriminatory ability compared to CHU-9D. ECOHIS-4D demonstrated a superior discriminative ability to differentiate between high dmft scores (equal or more than 8) and dmft scores 1–7 (ES = 0.32), compared to its ability to distinguish between dmft scores 1–7 and the absence of dental caries (ES = 0.20).

3.2 | External responsiveness

A statistically significant relatively larger negative coefficient (−0.01; 95% CI −0.012 to −0.004) was observed with ECOHIS-4D compared to the non-significant comparatively smaller coefficient of CHU-9D (0.002; 95% CI -0.002 to 0.005) (Table 3), indicating that the ECOHIS-4D was more responsive to changes in dmft score.

High ceiling effects, ranging from 77.1% (worry) to 96.5% (schoolwork), were observed in all items of CHU-9D (Supplementary Material Table S2). Comparatively, low ceiling effects were observed in the items of ECOHIS-4D (Supplementary Material Table S3), indicating the instrument's ability to respond more to changes in the lower range of dmft score. Both instruments had very low floor effects.

TABLE 1 Demographic distribution of the sample by the ECOHIS-4D and the CHU-9D utility scores.

Variables	*N* (%)	ECOHIS-4D utility mean (SD)	CHU-9D utility mean (SD)	*p* value
All sample	314 (100)	0.91 (0.14)	0.92 (0.13)	.30
Sex				
Male	150 (47.8)	0.90 (0.15)	0.92 (0.12)	.13
Female	164 (52.2)	0.92 (0.12)	0.91 (0.13)	.97
Age				
<2.0 years	60 (19.1)	0.91 (0.13)	0.91 (0.16)	.86
2.0–4.0 years	119 (37.9)	0.94 (0.13)	0.93 (0.11)	.18
>4 years	135 (43.0)	0.89 (0.12)	0.92 (0.10)	.01
dmft score				
0	112 (35.7)	0.93 (0.11)	0.91 (0.15)	.16
1–7	143 (45.5)	0.91 (0.15)	0.91 (0.13)	.94
Equal or more than 8	59 (18.8)	0.86 (0.13)	0.93 (0.09)	.0001

Note: Mean age and SD = 3.6 years (SD 1.7), *p* value <.05, Wilcoxon signed rank test.
Abbreviation: dmft, decayed, missing and filled teeth.

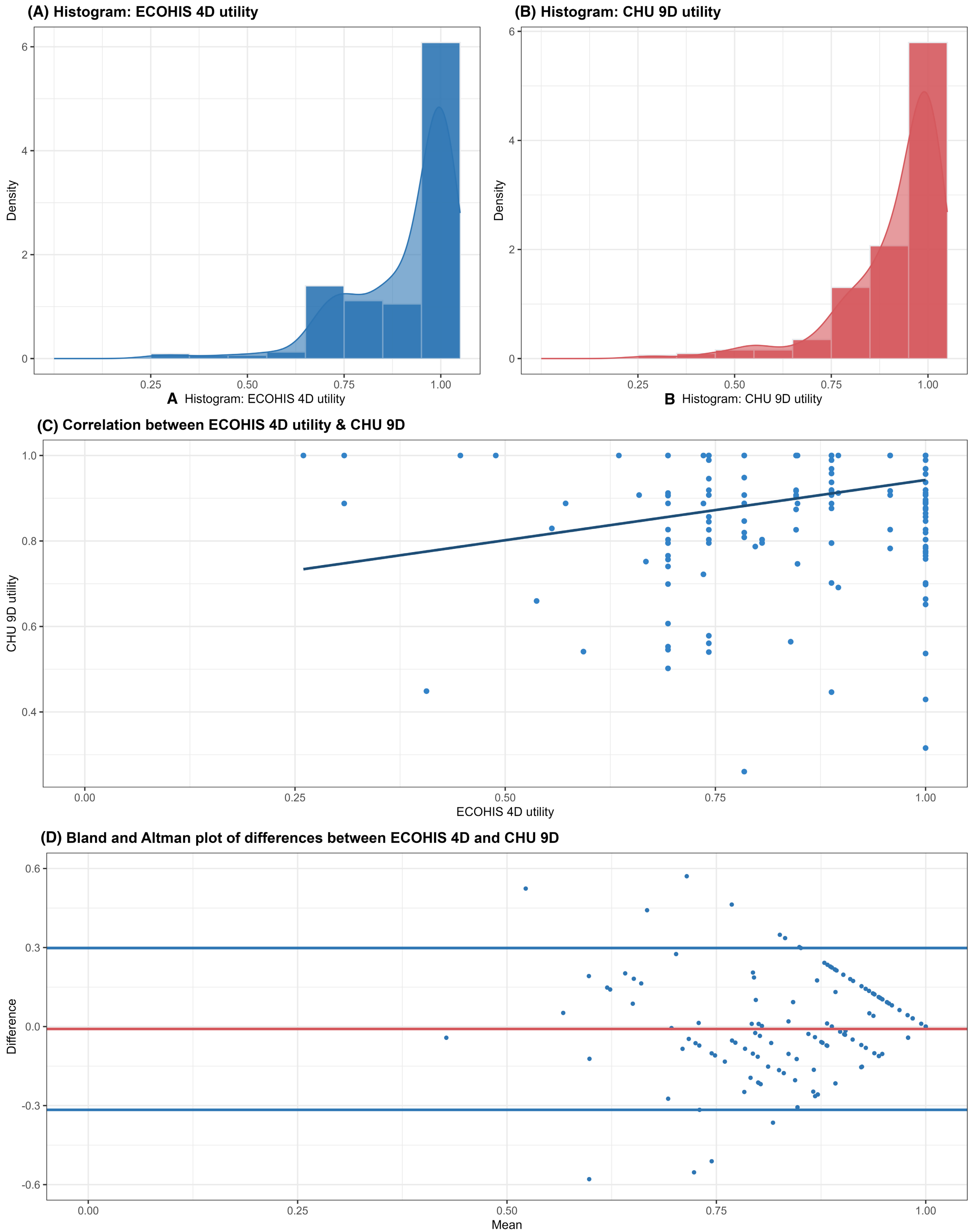

FIGURE 1 (A) Distribution of ECOHIS 4D utility values. (B) Distribution of CHU 9D utility values. (C) Correlation of ECOHIS 4D and CHU 9D utility values. (D) Altman plot of differences between ECOHIS- 4D and CHU- 9D utility values against the average of ECOHIS-4D and CHU-9D utility values.

TABLE 2 Discrimination across clinical severity groups.

	ECOHIS-4D				CHU-9D			
dmft category	*N*	Mean (SD)	Median	ES	*N*	Mean (SD)	Median	ES
0	112	0.93 (0.11)	1.00		112	0.91 (0.14)	0.98	
1–7	143	0.91 (0.15)	1.00	0.20	143	0.91 (0.12)	1.00	−0.01
Equal or more than 8	59	0.86 (0.13)	0.89	0.32	59	0.93 (0.09)	1.00	−0.17

Abbreviation: dmft, decayed, missing and filled teeth.

TABLE 3 Prediction of utility values using the dmft score.

Utility score (dependent variable used in the multivariable regression model)	Bootstrapped mean coefficient of the dmft score	Bootstrapped 95% confidence interval
CHU-9D	0.001	−0.002 to 0.005
ECOHIS-4D	−0.008	−0.012 to −0.004

Note: Other independent variables controlled in the model: Age and gender.
Abbreviation: dmft, decayed, missing and filled teeth.

3.3 | Correlation analysis between dmft score and utility measure, and related dimensions of both instruments

A statistically significant weak correlation (0.31) was observed between ECOHIS-4D and CHU-9D utility values (Figure 1C). A statistically significant weak correlation was observed between dmft and ECOHIS-4D (−0.22, 95%, CI −0.36 to −0.15). In contrast, there was a weak correlation between dmft and CHU-9D which was not statistically significant (0.01, 95% CI −0.12 to 0.10) (Table 4).

The correlations between the two instruments against the items are presented in Supplementary Material Table S4. Most items of the two instruments showed a poor correlation. The highest correlation was observed in pain/pain (0.31). The lowest correlation (0.07) was observed in talking (ECOHIS-4D)/ability to join in activities (CHU-9D).

3.4 | Differences across the two instruments

A statistically significant difference ($p = .001$) in the mean utility scores of the two instruments was observed only in the group with dmft score 'equal or more than 8' (Table 1). A diagram of the 'Bland–Altman plot' is presented in Figure 1D. Decreasing differences between ECOHIS-4D and CHU-9D utility values were observed with decreasing level of decay experience, and more scattered with high mean differences were observed related to poor health (utility value towards 0). This indicated better agreement of two instruments towards good health and poorer agreement towards non-optimal health.

4 | DISCUSSION

This study aimed to extensively compare the utility scores of ECOHIS-4D and CHU-9D against an oral health indicator to evaluate which utility instrument is more appropriate to measure child oral health-related quality of life for use in CUA. This study followed the methodology used by Kularatna et al.[8,23]

This is the first study to comprehensively compare utility scores from an oral health-related preference-based instrument (ECOHIS-4D) and generic preference-based CHU-9D in children. Results indicate that the ECOHIS-4D has superior ability to discriminate between groups with different clinical severities (i.e. discrimination) and respond to changes in clinical severity (i.e. responsiveness) compared to CHU-9D. Though the correlation between the oral health indicator (dmft score) and ECOHIS-4D was weak, it was stronger and statistically significant compared to the correlation observed between the dmft score and CHU-9D. The results of this study indicate that ECOHIS-4D is more sensitive to children's oral health-related quality of life and, thus, should be preferred in health economic evaluations of oral health interventions.

While other preference-based OHRQoL instruments are available for use with paediatric populations, the selection is limited. In addition to ECOHIS-4D, as evaluated in this study, alternative instruments include the CARIES-QCU, a child-centred caries-specific instrument[31] and the Dental Caries Utility Index (DCUI).[32] Furthermore, there was no evidence of comparing the utility values of the CARIES-QCU and DCUI with the utility values of generic preference-based instruments and with an oral health indicator (e.g. dmft score). Therefore, this limits the ability to discuss which instrument is more sensitive to an oral health indicator.

Though some studies have shown CHU-9D is a useful generic instrument in estimating QALYs in economic evaluation of interventions catered for children,[10] evidence indicates that CHU-9D is not a reliable instrument for assessing oral health-related QoL. Foster et al.(2015) demonstrated that CHU-9D has poor responsiveness to changes compared against the dmft score.[11] Similar results were reported in a study by Roger et al. (2019), who found no statistically significant correlation between the CHU-9D and dmft or any component of dmft. Furthermore, there were no significant differences in utility scores of children with and without dental caries.[33] However, the results indicated that the utility scores of ECOHIS-4D are sensitive to the dmft scores. Therefore, it could be one of the most valid and reliable oral health-related preference-based instruments used in decision-making for children's oral health-related resource allocation. The findings showed that ECOHIS-4D, a disease-specific instrument, is more sensitive than

TABLE 4 Spearman's correlation coefficients between ECOHIS-4D utility values, CHU-9D utility values and dmft score.

	CHU-9D utility values	ECOHIS-4D utility values	dmft scores
CHU-9D utility values			0.01 (95% CI −0.12 to 0.10)
ECOHIS-4D utility values	0.31* (95% CI 0.21 to 0.41)		
dmft scores		−0.26* (95% CI −0.36 to −0.15)	

*Significant at $\alpha = .001$ level.

Abbreviation: dmft, decayed, missing and filled teeth.

the generic instrument in measuring the oral-health related QoL is consistent with the evidence in multiple myeloma and cancer, etc.[12]

The results showed that ECOHIS-4D demonstrated good discrimination among dental caries severity groups, with comparatively high effect sizes and decreasing mean utility values as severity levels of dmft increased. Furthermore, results showed that the ECOHIS-4D exhibited superior responsiveness to changes in oral health conditions, and relatively low ceiling and high floor effects when compared to CHU-9D. The weak correlations observed between the two instruments and their respective items can be attributed to the difference in their intended focus. While CHU-9D measures general health-related QoL, ECOHIS-4D specifically focuses on oral health-related QoL. Notably, weak correlations were observed in the results between talking ability and ability to participate in activities, as well as between pain/pain items of the two instruments, which could be further investigated in future research.

Utility scores changes over time was unable to be assessed in this study due to the single time point of data collection. This is a limitation of this study; however, an indirect measure of responsiveness was used by calculating the ceiling and floor effects. Another limitation is that the CHU-9D instrument was developed for use among 7–11-year-olds. The age of children in this study was less than 7 years; meaning the CHU-9D scores may have been stronger had older children that is the target population for whom the tool was developed. Finally, disease-specific instrument might capture all the nuances of a specific condition but could miss the broad effect on the quality of life that covers multiple health domains. Therefore, the choice of instrument should depend on the context of the intervention.

5 | CONCLUSIONS

Results of this study showed that ECOHIS-4D, the oral health-specific instrument is more sensitive in assessing the OHRQoL of children with Early Childhood Caries than the generic CHU-9D. The results of this study reflect the findings of current evidence that condition-specific instruments are more sensitive than generic ones. The estimates of ECOHIS-4D can be used reliably to produce utility estimates in economic evaluations of oral health-related interventions and resource allocation decision-making.

AUTHOR CONTRIBUTIONS

Sucharitha R. Weerasuriya involved in conception and design, data acquisition, analysis and interpretation, drafted and critically revised the article. Ruvini M. Hettiarachchi involved in conception and design, data acquisition, analysis and interpretation, drafted and critically revised the article. Sanjeewa Kularatna involved in conception and design, data acquisition, analysis and interpretation, supervision, drafted and critically revised the article. Alexia Rohde involved in conception and design, and data interpretation and drafted the article. Utsana Tonmukayakul, Lisa Jamieson and Peter Arrow involved in conception and design, and data interpretation and drafted the article. Sameera Senanayake involves conception and design, data acquisition, analysis, and interpretation, supervision, drafted and critically revised the article. All authors gave their final approval and agreed to be accountable all aspects of work ensuring integrity and accuracy.

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CONFLICT OF INTEREST STATEMENT

The author (s) declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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