Expanding the EQ-TIPS: Comparing 3-level and 5-level performance for infants and toddlers with chronic conditions

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Abstract

Objectives: The EQ-TIPS may support both 3-level and 5-level versions, mirroring the structure of the EQ Adult and Youth descriptive systems. This study therefore aimed to compare the performance of the EQ-TIPS-3L (3L) with the EQ-TIPS-5L (5L) in infants and toddlers aged 0-4 years living with a health condition.

Methods: Caregivers of infants and toddlers, aged 0-4 years, were recruited from specialist outpatient clinics at Red Cross War Memorial Children's Hospital in South Africa. The performance of the EQ-TIPS-5L and EQ-TIPS-3L versions was determined by comparing feasibility with the absolute reduction in the ceiling effect (111111). Discriminatory power was evaluated with Shannon's H' index for absolute informativity and Shannon's J' index for relative informativity or spread of responses. The redistribution of item responses between the 5L and 3L versions was evaluated for inconsistency. If a 5L response is two or more levels removed from a 3L response, that response pair is classified as inconsistent. Convergent validity of EQ-TIPS items was calculated with Kendall Tau B and Gamma correlations.

Results: Preliminary data from 102 children were included with a median age of 37 months (3.1 years) and slightly more males (*n* = 57,56%). The majority of respondents were mothers (*n* = 79,78%). Children were grouped by disease category: epilepsy (*n* = 6,6%), neuromuscular disease (*n* = 9,8%), chronic gastrointestinal disease (*n* = 14,14%), renal disease (*n* = 33,32%) and oncological or haematological diseases (*n* = 40,39%). The ceiling effect (111111) decreased minimally by 4% from the 3L to 5L. Absolute informativity (H') of items improved by 0.620 on the 5L, with retention of the spread of responses for items of Play, Social Interaction, and Communication. Convergent validity was similar with strong correlations on paired 3L and 5L items.

Conclusion: These results indicate that a 5L version of the EQ-TIPS does not influence the ceiling effect in the same way as the Adult and Youth descriptive system. Despite the strong convergent validity between items, caregivers were less likely to report levels 4 and 5 on the 5L version compared to level 3 on the 3L version. This may be due to the nature of the health conditions.

Background

Historically, healthcare for young children has heavily emphasized reducing mortality rates[1]. With significant advancements in medicine and public health, the survival rates of children have dramatically improved[2]. This positive shift necessitates a broader focus within paediatric care. As mortality rates decline, the impact of morbidity—the burden of disease—becomes increasingly crucial. This is particularly relevant in early childhood, a period of rapid neurological development[3]. The concept of health-related quality of life (HRQoL) offers a comprehensive approach to assess children, taking into account not only the presence of disease but also its influence on various aspects of their lives. Impaired HRQoL during childhood can have long-lasting consequences. Neurological development during these early years lays the foundation for future cognitive, emotional, and social functioning. Disruptions in this process can lead to challenges in areas such as scholastic achievement, attention, and overall life performance[3–5]. By recognizing the importance of HRQoL and its potential long-term impact, healthcare providers can adopt a more holistic approach to paediatric care[6]. This shift in perspective has implications for the future outcomes and potentially the associated health costs of these children.

Globally the leading causes of mortality, in children under five years of age, is attributed to infectious diseases including pneumonia, diarrhoea and malaria with ongoing efforts, particularly in low-income countries, to reduce the incidence of communicable diseases[7]. Health care in high income countries is largely focused on non-communicable diseases. The number of children living with disabilities, including long-term physical, mental, intellectual or sensory impairments' is estimated at 240 million[8]. This includes children with genetic conditions, perinatal complications and/or nutritional deficiency or infection resulting in long-term functional consequences[9]. There is further recognition that behaviours (e.g., diet and physical activity) and environmental exposures in early life impact approximately 70% of premature deaths in adults[9]. Measuring HRQoL allows healthcare professionals to assess the burden of these conditions on children and their families, tailor interventions to individual needs, and monitor the effectiveness of treatments over time. Moreover, incorporating HRQoL into economic evaluations enables policymakers to make informed decisions about resource allocation and prioritize interventions that offer the greatest value for money in improving children's health outcomes.

The growing need for comprehensive assessment tools to evaluate HRQoL in young children is being met with the increasing number of generic multi-attribute utility instruments[10]. Most of these instruments have been developed for children older than 5 years. Currently there

are four measures that have been developed for children younger than 5 years, for proxy completion, which have utility values or are amenable to eliciting preference-weighted values[10]. These instruments include the Infant health-related Quality of life Instrument (IQI)[11], Health Utilities Preschool for children (HuPS)[12,13], EuroQol Infant and Toddlers Populations (EQ-TIPS)[14,15], and potentially the Pediatric Quality of Life Inventory (PedsQL) Generic Measures for infants and toddlers[16]. The IQI measures HRQoL for infants 0-12 months and does not currently have any versions available for toddlers or older children[11,17]. The HuPS is recommended for children aged 2–5 years and together with the Health Utilities Index Mark 3 (HUI 3) allows measurement across childhood and adulthood[16]. The PedsQL is a widely used generic health assessment tool, with versions available for infants (1–12 months and 13–24 months), young children (2–4 years and 5–7 years), children (8–12 years), and adolescents (13–18 years)[16]. There are ongoing efforts to develop a PedsQL classification system which will be amenable to generating preference-weighted scores[18,19]. The EQ-TIPS is recommended for children aged 0-3 years[15], with recommendations to increase this to 0–4 years[20], and forms part of the EuroQol family of instruments which includes youth (EQ-5D-Y-3L and EQ-5D-Y-5L) and adult (EQ-5D-3L and EQ-5D-5L)[21]. The EuroQol measurement system is currently uniquely positioned as they are the only family of measures to allow measurement and valuation of health across the lifespan from birth to adulthood.

Although there are currently no Health Technology Assessment (HTA) guidelines for infants and toddlers[22,23], the youth version, EQ-5D-Y, is recommended by the Dutch Healthcare Institute (ZIN) and the adult version, EQ-5D-5L, is the most commonly cited preference-based measure in guidelines across the globe[24]. The EQ-5D adult and youth instruments include versions with 3 and 5-level response scales[21]. The 5-level version is thought to reduce the ceiling effect (where respondents cluster at the highest level of functioning) and increase the instrument's sensitivity to changes in health status[25,26]. However, the current version of the EQ-TIPS, utilizes a 3-level response scale. The EQ-TIPS may support both 3-level and 5-level versions, mirroring the structure of the EQ Adult and Youth descriptive systems and potentially allowing for greater consistency and easier transition between the instruments. Since EQ-TIPS is designed for proxy completion, it is essential to investigate whether the 5-level version offers any advantages over the 3-level version[25,26]. This study therefore aimed to compare the performance of the EQ-TIPS-3L (3L) with the EQ-TIPS-5L (5L) in infants and toddlers aged 0–4 years living with a chronic health condition.

Methods

Study Design and Setting

A cross-sectional study was conducted on caregivers of children with chronic health conditions between the ages of 0 and 4 years. Participants consisted of caregivers, typically a parent, of infants and toddlers attending a tertiary paediatric hospital in the Western Cape, South Africa. Red Cross War Memorial Children's Hospital treats over 250,000 patients a year in both the acute and chronic services. Children with the following diagnoses were included: Oncological or Haematological Disease, Epilepsy, Neuromuscular Disease, Gastrointestinal Disease including Liver Disease and/or transplantation, Renal Disease including dialysis and transplantation.

Instruments

EuroQol Toddler and Infant Population (EQ-TIPS).

The EQ-TIPS is an experimental measure developed by the EuroQol Group to measure and value HRQoL in infants and toddlers. EuroQol experimental measures are tools which are still under development and may change as development proceeds[27]. The EQ-TIPS is a proxy-report instrument completed by the primary caregiver, typically the parent.

The EQ-TIPS descriptive system currently comprises six items: Movement, Play, Pain, Communication, Social Interaction, and Eating. On the 3-level version of EQ-TIPS, each item has 3 levels of severity corresponding to: "no problems", "some problems" and "a lot of problems". The items on the EQ-TIPS-5L (5L) have 5 levels of severity corresponding to: "no problems", "a little bit of a problem", "some problems", "a lot of problems" and "extreme problems". The response on each item is defined as a 1-digit number that expresses the level selected for that item, where "no problems" is assigned a '1' and the most extreme level a '3' or a '5' depending on whether the 3-level or 5-level version is used. The digits for each of the six items can be combined into a 6-digit number that describes the younger patient's health state. For example, on the EQ-TIPS 5-level version, the health state 111245 would represent "no problems" on the items of Movement, Play, and Pain, "a little bit of a problem" with Social Interaction, "a lot of problems" with Communication, and "extreme problems" with Eating.

The EQ-TIPS does not yet have a preference-based score; therefore, a level sum score (LSS), similar to that used on the EQ-5D[28], was used to describe the responses on the descriptive system where the level labels are treated as numeric data with the EQ-TIPS-3L and EQ-TIPS-5L scores ranging between 6-18 and 6-30 respectively. The EQ-TIPS was designed to be amenable to developing preference weights in the future.

EQ VAS, is used to record the proxy's view of how good or bad the infant's health is overall on the day of questionnaire completion. The EQ VAS is vertical visual analogue scale with endpoints labelled "The best health you can imagine" and "The worst health you can imagine". While the EQ-5D-Y-3L is recommended for proxy completion between 4-18 years[21], the EQ-TIPS items are considered more appropriate and have shown to perform better than the EQ-5D-Y-3L in 4-year-old South African children[29,30]. Thus, the EQ-TIPS was used for children 0-4 years in this study.

Study Procedure

Ethical approval from the University Human Research and Ethics Committee (HREC 740_2021) and permission from the hospital Research Review Committee was obtained. Caregivers of children receiving outpatient health care were recruited from the waiting rooms of specialist clinics at the children's hospital. Each caregiver agreed and consented to participate in the study. Data from caregivers was collected on handheld electronic devices and managed using REDCap electronic data capture tools hosted at the University of Cape Town[31,32]. The researcher provided assistance with electronic competition, if needed, and/or was available for any clarification. The survey included information regarding the study and informed consent, EQ-TIPS-3L, PedsQL generic module, demographic and medical information for the child, EQ-TIPS-5L, EQ VAS and caregiver HRQoL and demographic information. The order of the EQ-TIPS-3L and EQ-TIPS-5L were randomised and always separated by the age-specific version of the PedsQL. Data collection is ongoing and only the pre-liminary results of the EQ-TIPS-3L and EQ-TIPS-5L is presented here.

Statistical Analysis

The analysis of the 3L and 5L followed that of Janssen et al (2008) for comparison of the adult versions EQ-5D-3L and EQ-5D-5L[25]. All data analyses were conducted using SPSS Windows 29.0 (IBM SPSS Inc., Chicago, IL, USA).

General Performance

The EQ-TIPS and descriptive data were summarised in terms of frequency and Median (IQR). The ceiling of the EQ-TIPS was defined as the proportion scoring "no problems" across all six items (111111) and for each individual item. The absolute reduction in proportion from the 3L to the 5L was calculated ($ceiling_{Y\text{-}3L}$- $ceiling_{Y\text{-}5L}$).

Redistribution EQ-TIPS-3L responses to the EQ-TIPS-5L:

The redistribution of the paired item responses was plotted using Sankey diagrams[33]. Paired item responses on the 3L and 5L were assessed for inconsistency using criteria established in previous studies comparing the adult EQ-5D versions [34,35]. A response pair was considered inconsistent if the 5L response was at least two levels away from the 3L response (see **Figure 1**).

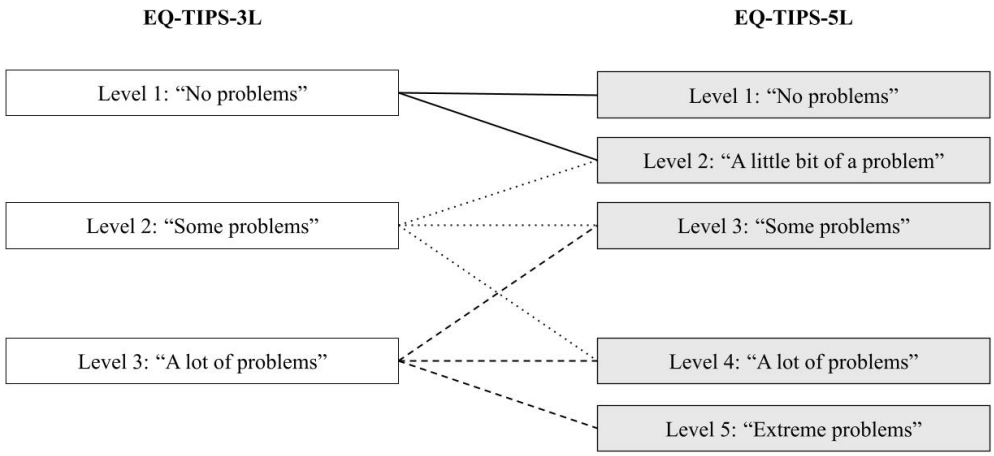

Figure 1. Anticipated Redistribution of EQ-TIPS-3L responses to the EQ-TIPS-5L

Discriminatory Power:

The Shannon Index (H') and the Shannon Evenness Index (J') were used to evaluate the discriminatory power of the 3L and 5L items in terms of absolute and relative informativity [35,36]. The Shannon H' and J' indices are defined as follows:

$$H' = \sum_{i=1}^{L} p_i log_2 p_i \quad \text{and} \qquad J' = \frac{H'}{H'_{max}}$$

Where H' is the absolute amount of informativity, L is the number of items levels and p_i is the proportion of observations in the in the i^{th} level where 3L has three levels and 5L has five levels. A higher H' index reflects that the descriptive system has captured more information, the maximum H'index is 1.58 and 2.32 on the 3L and 5L respectively A higher H' index indicates that the descriptive system has accounted for a greater amount of information. It was expected that the H' index would increase for the EQ-TPS-5L in comparison to the EP-TIPS-3L. The Shannon Evenness Index (J') reveals the distribution of responses across all levels, irrespective of the total number of levels within the descriptive system. It was expected that the J' index would either stay constant or experience a slight

decrease due to its independence from response levels for the EQ-TIPS-5L in comparison to the EQ-TIPS-3L.

***Convergent Validity**:*

The convergent validity between 3L and 5L was evaluated by item response-pairs, using Kendall tau B and Gamma statistic. Correlations coefficients were interpreted according to Cohen: 0.1–0.29 low association, 0.3–0.49 moderate association and ≥0.5 high association [37]. Strong correlation was expected when examining comparable items across these instruments.

Results

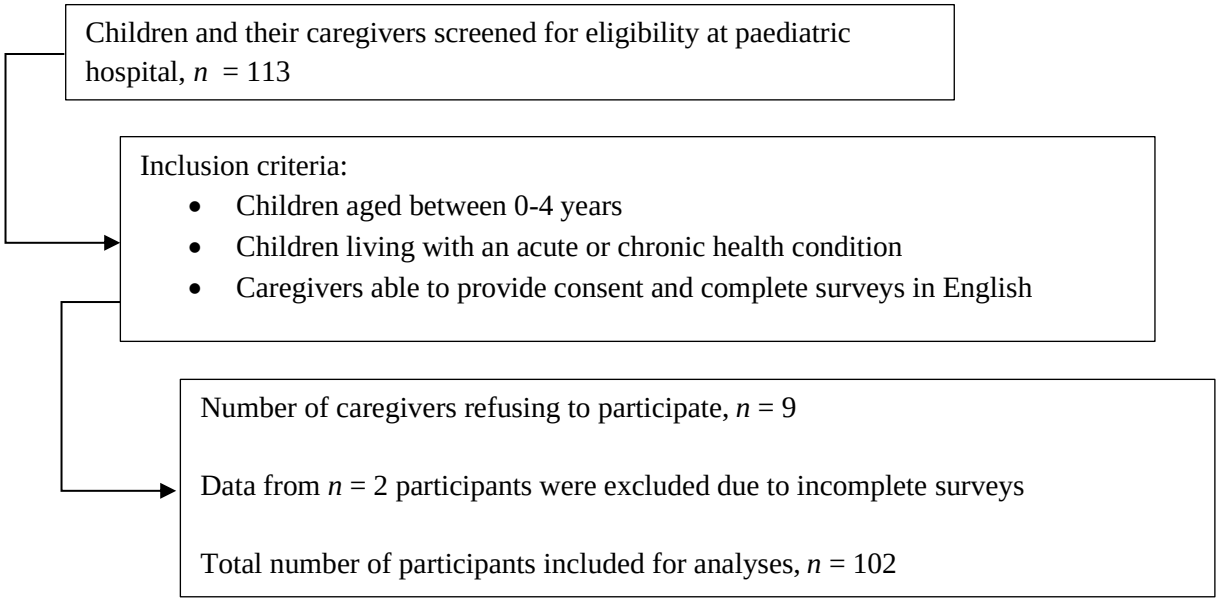

Figure 2. Flow diagram outlining participant recruitment process

Data from 102 caregivers with young children (median age of 37 months) who completed the 3L and 5L (see **Figure 2**). Most children were males (56%) and the most prevalent health condition was Haematology/Oncology (see **Table 1**). The majority of caregivers were mothers (78%), who were full-time (43%) or part-time employed (14%) and the highest completed education level of high school (60%).

The overall ceiling effect (111111) was minimally reduced moving from the 3L to the 5L version (-4%). There was a reduction in reporting of "no problems" across all items on the 5L version with the greatest decrease seen for Pain and Eating. There was no floor effect for

the EQ-TIPS on either version but a reduction in reporting the most severe level was seen for Pain, Communication and Eating on the 5L version (see **Table 2)**.

The Sankey Plots in **Figure 3** show that across all items the level of reporting "no problems" across items of Movement, Play, Social Interaction and Communication. Pain and Eating had greater spread of problems on the 3L and 5L versions. This high reporting of "no problems" was similarly reported across both the 3L and 5L version with 95.6 to 100% of responses redistributing as anticipated from "no problems" on the 3L to "no problems" or "a little bit of a problem" on the 5L. There were very few responses on Level 2 and 3 on the 3L to redistribute with minimal opportunity for inconsistent responses. There was a total of 17 (23%) inconsistent responses with reporting of "some problems" on the 3L and "no problems" on the 5L.

The informativity of items (H' index) improved slightly across all items on the 5L compared to the 3L, consistent with what was expected (see **Table 3)**. The spread of responses on the 3L and 5L were distributed similarly for all items. The difference in spread of responses was greatest for Eating which was the item with the greatest distribution of problems across levels on the 3L and 5L versions. The J' index was expected to remain consistent or minimally changed, and this was largely observed. The most notable change was seen for Eating. Interpretation of the H' and J' indices for other items was limited due to the low reporting of problems.

As anticipated, strong correlation were observed between the same items across the two EQ-TIPS (see **Table 4**) versions. Gamma correlations were moderate to strong between all EQ-TIPS items except Movement and Social Interaction and Movement and Eating.

Discussion

This study represents the first evaluation of a potential 5-level version of the EQ-TIPS, an important undertaking given the instrument's sole reliance on proxy responses for assessing young children's HRQoL. This reliance raises unique challenges, as the intrinsic and extrinsic influences of proxy responses, when rating HRQoL in this age group, remains unclear.

The health conditions of this sample are heterogeneous, but arguably includes severe conditions with many diagnosed with a haematological/oncological disease. The perceived general health, as measured on the EQ VAS, was only slightly higher (Median 89) when compared to older paediatric patients, 8-17 years, with similar haematological malignancies in China (M = 84)[38]. Despite the similarity in general health scores there was far greater report of problems on the EQ-5D-Y-3L and EQ-5D-Y-5L when compared to the EQ-TIPS versions. For

items with obvious conceptual overlap the EQ-5D-Y-5L[38] had relatively less report of "no problems"; for Mobility (60%), Usual Activities (60%) and Pain/Discomfort (54%) compared to the EQ-TIPS items of Movement (84%), Play (93%) and Pain (76%). There was however a similar low reduction ceiling effect, total and by dimension, when moving from the 3-level version to the 5-level version of the EQ-TIPS (range 1-4%) to previous studies comparing the 3-level and 5-level versions of the EQ-5D-Y in haematological malignancies in China (range 0-5%)[38], orthopaedic conditions in South Africa (range 0-6%)[39] and healthy and sick children in Malawi (range 0-5%)[40]. With ongoing data collection efforts the authors aim to compare the performance of the 3L and 5L versions by severity groups within specified health conditions. Further evaluation of psychometric performance between the EQ-TIPS 3L and 5L will further strengthen the evidence base.

An analysis of EQ-TIPS items with the lowest reported problems and their association with developmental milestones reveals strong correlations, particularly between Movement, Play, Social Interaction and Communication. This underscores the interconnectedness of these domains in early childhood. In acute illness, the primary focus is often on treating the immediate condition. Once stabilized, attention can shift towards addressing other developmental areas. However, in chronic conditions like epilepsy, which can significantly impact development, concerns may persist. The concept of the "disability paradox" or response shift to a new normal becomes relevant, as children and families adapt to the challenges posed by the condition. This phenomenon suggests that parents or caregivers may report fewer problems than expected, potentially due to adjusted expectations and a shifted frame of reference. For children with chronic conditions that affect development the point of reference for normalcy may also shift in these situations. The family or the healthcare setting may become the new benchmark for comparison. This altered perception of normal may influence reporting on all developmental domains, except for changes in areas like Eating or Pain, which are more likely to be discussed and addressed in healthcare settings. Self-report on the EQ-5D-Y-3L suggest, that at least for physical dimensions, there is maintenance of this response shift notably in children with physical impairments into older age[41,42]. Similarly, the EQ-5D-Y-3L reports higher variation for Pain/Discomfort.

When examining comparable items across these instruments, a moderate to strong correlation is expected[6]. In infants and toddlers with chronic conditions, problems with Movement, Play, Social Interaction, and Communication may not significantly deviate from their peers, the reference case in the EQ-TIPS. This is likely due to the high dependence on caregivers at this early age [6], which can buffer the impact of developmental delays or challenges.

As children grow older and gain more independence, the developmental disparities may become more pronounced. The influence of referencing age-appropriate behaviour or developmental norms needs to be further investigated in qualitative research. The effect of age on reporting of problems by item should be explored with sub-group analysis by age and/or in longitudinal research.

The influence of proxy reporting of health states remains challenging. Due to the dependence of infants and toddlers on their caregivers the independent assessment of HRQoL may be impossible[6]. This may be particularly pertinent in this study setting, South Africa. South Africa is a developing country and is synonymous with low-income levels, high levels of unemployment, high crime rate, and poor living conditions including high levels of overcrowding and reliance on informal housing, restricted access to running water and/or electricity[43]. These circumstances result in a lower educational level of mothers, lower socio-economic status of the families, and psychosocial stress in the families. Moreover, this results in an enhanced vulnerability to disease which is often enhanced with health inequalities[44]. The sample of caregivers in this study aligns with the general population with the majority receiving basic education, or less, and moderate levels of unemployment. This sample mirrors the socioeconomic context typical of many African or low-income communities. This demographic profile ensures comparability with previous EQ-5D-Y-3L and EQ-5D-Y-5L data collected within similar settings. However, these factors may also influence the reporting of HRQoL as communities are well versed in ill health and socioeconomic stressors. The authors postulate that this may result in poor recognition of the consequences of poor health. The association between poor health literacy, notably the ability to understand written information and confidence in completing written forms, and poor health outcomes is well established in adult health care with most data reported from High Income Countries[45–48]. How this affects reporting in Low Income Countries and when reporting on health outcomes for a young child is currently unclear. Testing the EQ-TIPS across different geographical, cultural and socio-economic contexts is recommended to provide further insight on proxy reporting and to support the validity of the instrument.

The high ceiling across EQ-TIPS items on the 3L and 5L versions limits the interpretation of the Shannon's indices. Targeted recruitment of infants and toddlers with conditions likely to result in higher variation in reporting of problems on the EQ-TIPS is warranted. To enhance the granularity of future data analysis, it is recommended to stratify by age group and disease severity. This approach may reveal nuanced patterns and associations that are not readily

apparent in the aggregated data. The potential superior performance of the 5-level version in responsiveness testing over time warrants further investigation.

Conclusion

These results indicate that a 5L version of the EQ-TIPS does not influence the ceiling effect in the same way as the Adult and Youth descriptive system. Despite the strong convergent validity between items, caregivers were less likely to report levels 4 and 5 on the 5L version compared to level 3 on the 3L version. This may be due to the nature of the health conditions included or the influence of proxy reporting in toddlers and infants where dependence on the caregivers is still notable. Final analysis will focus on the psychometric performance of the 3L and 5L versions including stratification by age and disease severity if possible. Responsiveness testing of the 3L and 5L studies should be prioritised in future work. Furthermore, future evidence of the EQ-TIPS in diverse geographical and cultural contexts is needed.

References

1. Sachs JD. From Millennium Development Goals to Sustainable Development Goals. *The Lancet* **379**, 2206–2211 (2012).
2. Sharrow, D. *et al.* Global, regional, and national trends in under-5 mortality between 1990 and 2019 with scenario-based projections until 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. *Lancet Glob Health* **10**, e195–e206 (2022).
3. Irwin LG, Siddiqi A, Hertzman G. Early Child Development: A *Powerful* Equalizer. Vancouver, BC: Human Early Learning Partnership (HELP); 2007 Jun.
4. Viholainen, H., Ahonen, T., Cantell, M., Tolvanen, A. & Lyytinen, H. The Early Motor Milestones in Infancy and Later Motor Skills in Toddlers. *Phys Occup Ther Pediatr* **26**, 91–113 (2006).
5. Dietrich, K. N. *et al.* Principles and Practices of Neurodevelopmental Assessment in Children: Lessons Learned from the Centers for Children's Environmental Health and Disease Prevention Research. *Environ Health Perspect* **113**, 1437–1446 (2005).
6. Oliveira, C. *et al.* Health-related quality of life in neonates and infants: a conceptual framework. *Quality of Life Research* **29**, 1159–1168 (2020).
7. Azzopardi, P. S. *et al.* The unfinished agenda of communicable diseases among children and adolescents before the COVID-19 pandemic, 1990–2019: a systematic analysis of the Global Burden of Disease Study 2019. *The Lancet* **402**, 313–335 (2023).
8. UNICEF (n.d.). Children with disabilities. *UNICEF DATA*. Retrieved from https://data.unicef.org/topic/child-disability/overview/
9. Azzopardi, P. S. *et al.* The unfinished agenda of communicable diseases among children and adolescents before the COVID-19 pandemic, 1990–2019: a systematic analysis of the Global Burden of Disease Study 2019. *The Lancet* **402**, 313–335 (2023).
10. Kwon, J. *et al.* Systematic Review of the Psychometric Performance of Generic Childhood Multi-attribute Utility Instruments. *Appl Health Econ Health Policy* **21**, 559–584 (2023).
11. Jabrayilov, R. *et al.* A descriptive system for the Infant health-related Quality of life Instrument (IQI): Measuring health with a mobile app. *PLoS One* **13**, e0203276 (2018).

12. Furlong, W. *et al.* Generic Health-Related Quality of Life Utility Measure for Preschool Children (Health Utilities Preschool): Design, Development, and Properties. *Value in Health* **26**, 251–260 (2023).
13. Saigal, S. *et al.* Development, reliability and validity of a new measure of overall health for pre-school children. *Quality of Life Research* **14**, 243–252 (2005).
14. Verstraete, J., Ramma, L. & Jelsma, J. Item generation for a proxy health related quality of life measure in very young children. *Health Qual Life Outcomes* **18**, (2020).
15. Verstraete, J., Ramma, L. & Jelsma, J. Validity and reliability testing of the Toddler and Infant (TANDI) Health Related Quality of Life instrument for very young children. *J Patient Rep Outcomes* **4**, (2020).
16. Varni, J. W. *et al.* The PedsQL™ Infant Scales: Feasibility, internal consistency reliability, and validity in healthy and ill infants. *Quality of Life Research* **20**, 45–55 (2011).
17. Château Santé. IQI [Internet] The Netherlands; 2023 [cited 2024 Jul]. Available from: https://www.chateau-sante.com/
18. Deluca, E. K. The Development of a Preference-Based Health-Related Quality of Life Measure for Children Based on the PedsQL: The PedsUtil Scoring System. [Doctoral Dissertation] (2023).
19. Deluca, E. K., Dalziel, K., Rose, A. M. & Prosser, L. A. Deriving the PedsUtil Health State Classification System to Measure Health Utilities for Pediatric Populations Based on the PedsQL: A Confirmatory Factor Analysis. [Preprint] (2024).
20. Verstraete, J., Lloyd, A., Scott, D. & Jelsma, J. How does the EQ-5D-Y Proxy version 1 perform in 3, 4 and 5-year-old children? *Health Qual Life Outcomes* **18**, (2020).
21. EuroQol Research Foundation. User Guides [Internet] Rotterdam: EuroQol Research Foundation; 2023 [cited 2024 Kul 11]. Available from: https://euroqol.org/information-and-support/documentation/user-guides/
22. Lamb, A., Murray, A. & Lovett, R. The Challenges of Measuring and Valuing Quality of Life in Preschool Children: A Retrospective Review of NICE Appraisals. *Children 2021, Vol. 8, Page 765* **8**, 765 (2021).
23. Rivero-Arias, O. *et al.* Benefits and harms of antenatal and newborn screening programmes in health economic assessments: the VALENTIA systematic review and qualitative investigation. *Health Technol Assess* **28**, 1 (2024).

24. Kennedy-Martin, M. *et al.* Which multi-attribute utility instruments are recommended for use in cost-utility analysis? A review of national health technology assessment (HTA) guidelines. *European Journal of Health Economics* **21**, 1245–1257 (2020).
25. Janssen, M. F., Birnie, E., Haagsma, J. A. & Bonsel, G. J. Comparing the Standard EQ-5D Three-Level System with a Five-Level Version. *Value in Health* **11**, 275–284 (2008).
26. Verstraete, J., Amien, R. & Scott, D. Comparing Measurement Properties of the English EQ-5D-Y 3-Level Version With the 5-Level Version in South Africa. *Value Health Reg Issues* **30**, 140–147 (2022).
27. EuroQol Research Foundation. Intellectual property (IP) protection [Internet]. Rotterdam: EuroQol Research Foundation; 2023 [cited 2024 Jul]. Available from: https://euroqol.org/register/quality/intellectual-property-ip-protection/
28. Devlin, N., Parkin, D. & Janssen, B. *Methods for Analysing and Reporting EQ-5D Data*. *Methods for Analysing and Reporting EQ-5D Data* (2020).
29. Verstraete, J., Lloyd, A. J. & Jelsma, J. Performance of the toddler and infant (Tandi) health-related quality of life instrument in 3–4-year-old children. *Children* **8**, (2021).
30. Verstraete, J. *et al.* Fighting to Breathe and Fighting for Health-Related Quality of Life: Measuring the Impact of Being Dependent on Technology for Breathing on the Child and Their Caregiver. *Patient* **17**, 65–82 (2024).
31. Harris, P. A. *et al.* Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* **42**, 377–381 (2009).
32. Harris, P. A. *et al.* The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform* **95**, 103208 (2019).
33. SankeyMATIC. Build a Sankey Diagram [Internet]. SankeyMATIC; 2023 [cited 2024 Jul 11]. Available from: https://sankeymatic.com/build/
34. Pickard, A. S. *et al.* Psychometric Comparison of the Standard EQ-5D to a 5 Level Version in Cancer Patients Linked references are available on JSTOR for this article: Psychom 5 Level Version in Cancer Patients. *Medical Care* **45**, 259–263 (2007).
35. Janssen, M. F., Birnie, E., Haagsma, J. A. & Bonsel, G. J. Comparing the standard EQ-5D three-level system with a five-level version. *Value in Health* **11**, 275–284 (2008).
36. Janssen, M. F., Birnie, E. & Bonsel, G. J. Evaluating the discriminatory power of EQ-5D, HUI2 and HUI3 in a US general population survey using Shannon's indices.

Quality of Life Research: An international Journal of quality of life aspects of treatment, care and rehabilitation **16**, 895–904 (2007).

37. Cohen, S. L. & Percival, A. Prolonged Peritoneal Dialysis in Patients Awaiting Renal Transplantation. *British Medical Journal* **1**, 409–413 (1968).
38. Zhou, W. *et al.* Patient-caregiver agreement and test–retest reliability of the EQ-5D-Y-3L and EQ-5D-Y-5L in paediatric patients with haematological malignancies. *European Journal of Health Economics* **22**, 1103–1113 (2021).
39. Verstraete, J., Marthinus, Z., Dix-Peek, S. & Scott, D. Measurement properties and responsiveness of the EQ-5D-Y-5L compared to the EQ-5D-Y-3L in children and adolescents receiving acute orthopaedic care. *Health Qual Life Outcomes* **20**, (2022).
40. Ngwira, L. G. *et al.* Psychometric performance of the Chichewa versions of the EQ-5D-Y-3L and EQ-5D-Y-5L among healthy and sick children and adolescents in Malawi. *J Patient Rep Outcomes* **7**, 1–14 (2023).
41. Scott, D., Ferguson, G. D. & Jelsma, J. The use of the EQ-5D-Y health related quality of life outcome measure in children in the Western Cape, South Africa: Psychometric properties, feasibility and usefulness—a longitudinal, analytical study. *Health Qual Life Outcomes* **15**, 1–14 (2017).
42. Jelsma, J. *et al*. Validity and feasibility of the self-report EQ-5D-Y as a generic Health-Related Quality of Life outcome measure in children and adolescents with Juvenile Idiopathic Arthritis in Western Cape, South Africa. *South African Journal of Physiotherapy*, **75**, 1-9 (2019).
43. Richards, R., O'Leary, B. & Mutsonziwa, K. Measuring quality of life in informal settlements in South Africa. *Soc Indic Res* **81**, 375–388 (2007).
44. Shortt, N. K. & Hammett, D. Housing and health in an informal settlement upgrade in Cape Town, South Africa. *Journal of Housing and the Built Environment* **28**, 615–627 (2013).
45. Sayah, F. Al, Qiu, W. & Johnson, J. A. Health literacy and health-related quality of life in adults with type 2 diabetes: a longitudinal study. *Quality of Life Research* **25**, 1487–1494 (2016).
46. Katz, P. *et al.* Impact of Limited Health Literacy on Patient-Reported Outcomes in Systemic Lupus Erythematosus. *Arthritis Care Res (Hoboken)* **73**, 110–119 (2021).
47. Tormey, L. K. *et al.* Limited Health Literacy Is Associated With Worse Patient-Reported Outcomes in Inflammatory Bowel Disease. *Inflamm Bowel Dis* **25**, 204–212 (2019).

48. Hahn, E. A. *et al.* Health Literacy and Patient-Reported Outcomes: A Cross-Sectional Study of Underserved English-and Spanish-Speaking Patients with Type 2 Diabetes. *J Health Commun* **20**, 4–15 (2015).

Table 1. Participant and Caregiver Characteristics

		Total (N = 102)
Characteristics of the Child		
Gender	Female, n (%)	45 (44)
	Male, n (%)	57 (56)
Disease Category	Haematological/Oncology, n (%)	40 (39)
	Renal Disease, n (%)	33 (32)
	Chronic Gastrointestinal Disease, n (%)	14 (14)
	Neuromuscular Disease, n (%)	9 (8)
	Epilepsy, n (%)	6 (6)
EQ-TIPS	VAS, Best health (100), n (%)	17 (17)
	VAS, Median (IQR)	89 (70,96)
	3L LSS, Median (IQR)	6 (6,8)
	5L LSS, Median (IQR)	7 (6,9)
Characteristics of the Caregiver		
Caregiver Relationship	Mother, n (%)	79 (78)
	Father, n (%)	16 (7)
	Other, n (%)	7 (16)
Housing	Formal, n (%)	67 (66)
	Informal, n (%)	34 (33)
Employment	Full-time, n (%)	44 (43)
	Part-time, n (%)	14 (14)
	Unemployed, n (%)	44 (43)
Highest Level of Education completed	Tertiary, n (%)	21 (21)
	High School, n (%)	61 (60)
	Primary School or Lower, n (%)	20 (20)

VAS: Visual Analogue Scale; LSS: Level Sum Score

Table 2. Ceiling effect for the EQ-TIPS-3L and EQ-TIPS-5L

	Total (N = 102)		
	EQ-TIPS-3L	**EQ-TIPS-5L**	**Absolute Reduction**
	n (%)	**n (%)**	
Ceiling effect (111111)	53 (52)	49 (48)	-4
Movement	86 (84)	84 (82)	-2
Play	95 (93)	96 (94)	-1
Pain	78 (77)	74 (73)	-4
Social Interaction	92 (90)	91 (89)	-1
Communication	84 (82)	86 (84)	-1
Eating	73 (72)	76 (75)	-3
Floor effect (333333/555555)	0 (0)	0 (0)	0
Movement	4 (4)	0 (0)	0
Play	1 (1)	1 (1)	0
Pain	2 (2)	0 (0)	-2
Social Interaction	0 (0)	0 (0)	0
Communication	2 (2)	0 (0)	-2
Eating	5 (5)	1 (1)	-4

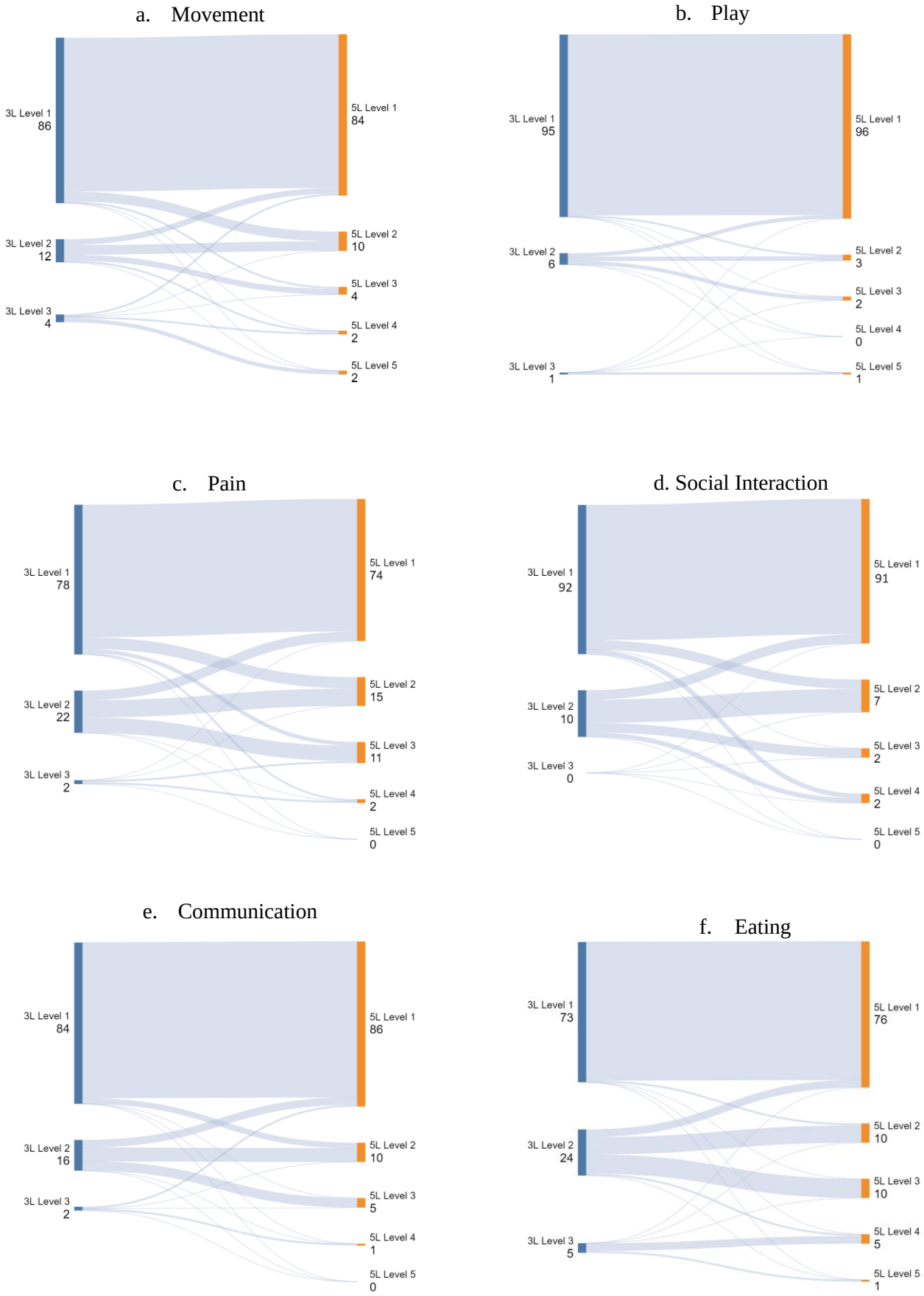

Figure 3. Redistribution of responses: Sankey Plots by item

Table 3. Shannon Index (H′) and Shannon Evenness Index (J′) for the EQ-TIPS-3L and EQ-TIPS-5L items

	EQ-TIPS-5L		EQ-TIPS-3L		Change from EQ-TIPS-3L to EQ-TIPS-5L	
	Shannon Index H'	**Shannon Evenness Index J'**	**Shannon Index H'**	**Shannon Evenness Index J'**	**Difference in H'**	**Difference in J'**
Movement	-0.669	0.279	-0.523	0.383	0.146	0.103
Play	-0.297	0.245	-0.278	0.255	0.019	0.010
Pain	-0.846	0.231	-0.600	0.336	0.245	0.105
Social Interaction	-0.453	0.277	-0.353	0.272	0.101	-0.005
Communication	-0.589	0.174	-0.528	0.183	0.062	0.009
Eating	-0.868	0.266	-0.728	0.077	0.140	-0.189
Average diff.	-0.620	0.245	-0.502	0.251	0.119	0.006

Table 4. Convergent validity of the EQ-TIPS-3L and EQ-TIPS 5L item scores

	Gamma Correlations						**Kendall Tau b Correlations**					
	EQ-TIPS-5L						**EQ-TIPS-5L**					
EQ-TIPS-3L	Move.	Play	Pain	Social	Comm.	Eating	Move.	Play	Pain	Social	Comm.	Eating
Move.	.909*	.745	.668*	.317	.403	.129	.635*	.263	.367*	.095	.153	.047
Play	.722	.992*	.741*	.827*	.542	.582	.282	.760*	.291*	.389*	.176	.204
Pain	.681*	.572	.891*	.627*	.478	.715*	.345*	.172	.634*	.253*	.200	.414*
Social	.593	.823	.777*	.964*	.820*	.717*	.221	.329	.378*	.723*	.458*	.332*
Comm.	-.021	.641	.613*	.702*	.952*	.538*	-.006	.203	.305*	.314*	.711*	.247*
Eating	.309	.500	.733*	.719*	.660*	.996*	.128	.150	.449*	.330*	.335*	.869

$n = 102$, * $p < .05$