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TRAQ changes: Improving the measurement of transition readiness by the Transition Readiness Assessment Questionnaire

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ABSTRACT

Objective: The purpose of the current study was improving the measurement precision of the Transition Readiness Assessment Questionnaire (TRAQ 5.0–20 item) in order to gain better decimation of transition readiness skills across the 5 Stages of Change–from Precontemplation to Mastery.
Methods: In stage 1, starting with the TRAQ 5.0 20-item, 5 domain subscale questionnaire, we eliminated the five lowest discriminating items using Item response theory (IRT) in MPlus v7.4,which eliminated the domain subscale *Managing Daily* Activities, and we e added 15 more difficult and better discriminating items. We added items to both to the remaining 4 domain subscales and created a new domain subscale entitled *Future Planning*. The revised 30-item TRAQ was piloted among 386 youth between 16 and 24 years old (mean = 20 years; 54% female; 87% White).
Results: After examining the model fit, discrimination and difficulty coefficients, and modification indices, we eliminated 10 items and the new *Future Planning* domain subscale we eliminated. The resulting questionnaire has 4 domain subscales and 20 items. It exhibited good to excellent fit to the data, $\chi^2(164) = 887.239$, $p < .001$, CFI = 0.943, TLI = 0.93, RMSEA = 0.0942 (90% CI: 0.090, 0.114), WRMR = 1.111. All items have acceptable discrimination coefficients. Each of the 4 domain subscales have improved reliability as compared with the original TRAQ 5.0 20 item scale.
Conclusions: The revised 20-itemTRAQ 6.0 has 4 domains subscales; Managing medications, keeping appointment, tracking health issues, and Talking with providers and has good construct validity as demonstrated by model fit. By adding more difficult items to the 4 resulting domain subscales, we have demonstrated improved item discrimination and difficulty, and therefore can better measure acquisition of transition readiness skills across the five stages of change from pre-contemplation to contemplation to initiation to action and finally to mastery.

Introduction

Improved life expectancy for children and youth with chronic conditions that were previously considered severely life-limiting has created imperatives for children to transition from pediatric healthcare as they live into adulthood. This process, referred to as Health Care Transition (HCT), is defined as the process of the "purposeful, planned movement of adolescents and young adults with chronic physical and medical conditions from child-centered to adult oriented health care systems," (Blum et al., 1993, p. 570). Dating back to 1993, a series of position papers and policy statements from the AAP, AAFP and ACP (American Academy of Pediatrics et al., 2002; Blum et al., 1993; Rosen et al., 2003) outline the need to evaluate the impact that programs have on adolescents' transition-related knowledge and skills, the logistics of transferring from pediatric to adult health care and how long it takes and how well young adults are integrated into the adult health care system.(McManus et al., 2015). There has been significant increase in the number of transition programs, however the data on their effectiveness to improve patient outcomes is limited to a few specific populations such as youth and young adults with type 1 diabetes and organ transplant recipients. (Gabriel et al., 2017). A critical step to improving the research base on HCT is development of high-quality evidence-based assessment.

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The transition and eventual transfer from pediatric to adult healthcare can be challenging for an adolescent with a chronic condition (American Academy of Pediatrics, 2002; Straus, 2019). As adolescents approach adulthood and assume greater autonomy they are expected to gain the skills needed to manage their own health independently, (e.g., taking their medications reliably; making and keeping appointments; and communicating effectively with healthcare providers). This set of self-management skills constitutes "Transition Readiness." A growing body of literature suggests that many adolescents with chronic conditions do not acquire transition readiness skills and, as a result, experience a decline in their adherence to prescribed medical regimens (e.g. taking medications on time and in the correct amount, attending scheduled follow-up visits with doctors) and suffer poor outcomes such as increased preventable morbidity and even mortality (Andreoni et al., 2013; Felsenstein et al., 2015; Ferris et al., 2015; Mellion et al., 2014).

Transition Readiness, as a construct, refers to youths' level of preparation for the adult world or adult-oriented health care and can include a variety of related activities and knowledge, self-management skills, and tasks, such as managing medications, making and keeping appointments, tracking health issues and communicating with providers (Straus, 2019). Thus, Transition Readiness is measurable, and as a set of skills, and is potentially modifiable before transfer (Annunziato et al., 2013, 2007; Cadario et al., 2009; Schwartz et al., 2011). Higher level of transition readiness has been associated with increasing age and self-rated competence in disease self-management (Sawicki et al., 2014; Wood et al., 2014). Higher transition readiness scores are also predictive of increased adherence with disease self-management (Huang et al., 2014). Therefore, in order to prepare adolescents and young adults (AYAs) to successfully engage in adult medical care, it is critical to track and promote their transition readiness. Supports or interventions that can improve transition readiness vary from face-to-face transition education to electronic texting and goal setting (Chu et al., 2015; Crosby et al., 2016; Maslow et al., 2012). However, evidence regarding the optimal approach to support the acquisition of transition readiness skills is lacking. Advances in the measurement of transition readiness is essential in order to better understand the developmental trajectory of youth with regard to acquisition of self-management skills, and to guide and evaluate interventions to enhance their development and allowing comparisons of transition readiness by conditions and across cohorts (Coyne et al., 2016; Schwartz et al., 2011) (Pai & Schwartz, 2011; Schwartz et al., 2011; Schwartz et al., 2013).

In a recent systematic review, researchers identified disease specific and disease independent transition readiness tools and concluded that further testing and development of new and existing measures are needed (Parfeniuk et al., 2020; Schwartz et al., 2013; Stinson et al., 2014). Of the tools available that use a non-categorical approach (McPherson et al., 1998), the Transition Readiness Assessment Questionnaire (TRAQ 5.0) was identified as the most scientifically sound measure (Parfeniuk et al., 2020; Stinson et al., 2014). Research demonstrates that TRAQ scores increase with age and are sensitive to interventions designed to increase transition readiness (Sawicki et al., 2014, 2011; Wood et al., 2014). The most recent TRAQ, TRAQ 5.0–20 questions, has been translated into 10 languages and is currently being used in numerous clinical programs to guide transition care across most chronic conditions occurring during childhood.

The purpose of the current study was to employ Item Response Theory (IRT) to further refine the TRAQ 5.0 tool and improve its measurement precision. From previous unpublished work, we found that the TRAQ had much higher precision at lower levels of transition readiness (pre-contemplation to contemplation) than at higher levels of transition readiness (initiation to mastery) (Prochaska & Diclemente, 1986). Therefore, in this study we used IRT to assess the strength of individual items, guide decisions regarding item removal/addition and assess the psychometric integrity of the TRAQ's domain subscales (*Managing Medications; Appointment Keeping; Tracking Health Issues; Talking with Providers and Managing Daily Activities*). We accomplished this in three stages. First, we used IRT to examine item discrimination and difficulty across the five stages of transition readiness. Next, based on the results of the IRT we eliminated several items and revised/added others to improve the TRAQ's precision for measuring higher skill levels across the Five Stages of Change. Lastly, we surveyed AYA with the newly revised TRAQ 6.0–30 questions and used IRT to reduce the number of questions and develop a new 4-domain subscale, 20 item TRAQ 6.0 (For a more complete justification of the use of the Stages of Change Model, the authors refer the reader to the manuscript for the first iteration of the TRAQ: Sawicki et al., 2011).

Methods

Stage 1. Sample

Our data for the first step of our analysis was derived from TRAQs completed between 2011 and 2012 by 527 adolescent respondents ranging in age from 14 to 24 years. For this analysis we used only 506 completed surveys of youth 16 and above. The surveys were collected during clinic visits from a convenience sample of adolescents attending the University of Florida, JaxHATS in Jacksonville, FL; the Cystic Fibrosis (CF) Center at Boston Children's Hospital and the University of North Carolina (UNC) Transition Program (See Wood et al., 2014 for sample information). All study protocol were approved by the University of Florida Institutional Review Board. The secondary data analysis for this study for this study was determined by the East Tennessee State University Institutional Review Board that the secondary data analysis for this study is not research involving human subjects according to according to Food and Drug Administration or Department of Health and Human Service regulations. Therefore, IRB review and approval was not required.

Analytic strategy

Item response theory (IRT) was used to model item responses according to the graded response model (GRM) in MPlus v7.4 using the weighted least squares with means and variances (WLSMV) estimator and the probit link function. In IRT, our interest is in using a person's item response pattern to estimate their ability (e. g., transition readiness) as precisely as possible. Accomplishing this requires a set of high quality items that are characterized by uniformly high *discrimination* (e. g., correlation with the transition readiness construct) as well as variable in *difficulty* (e.g., the degree of transition readiness required in order to provide a positive response to the item). Calculating the difficulty and discrimination parameters of a set of items is referred to as the calibration step in an IRT analysis; we calibrated the items using data from 506 previously completed TRAQs collected from several clinical practices. Weak items can be identified via low discrimination coefficients; these items contribute very little to measurement precision and can be safely eliminated in the interest of parsimony. In addition, these items are characterized by low (negative) difficulty values across the 5 levels of response. In each stage, items were eliminated based on their contribution to test information and modification indices. Model fit was assessed using the guidelines provided by Hu and Bentler: chi-square statistic, root mean square error of approximation index (RMSEA), Tucker-Lewis index (TLI) and the comparative fit index (CFI)(Hu & Bentler, 1999).

The amount of item information contributed by the item to the test score's precision decreases as the respondent's ability level deviates from the item difficulties. In other words, it is impossible to precisely measure high transition readiness when all of the items are of uniformly low difficulty. A low-difficulty item provides a great deal of information for precisely measuring low-transition readiness examinees and a hard item does the same for high-transition readiness examinees; thus, the item difficulties must be tailored to the intended use of the scale,

enabling the most precise measurement at the degree of transition readiness that differentiates between success and failure in managing one's medical affairs. Discrimination, which describes how strongly related the item response is to the trait being measured (e.g., transition readiness), reflects the steepness of the item characteristic curve in its middle section. The steeper the curve, the better the item can discriminate. The flatter the curve, the less the item is able to discriminate since the probability of correct response at low ability levels is nearly the same as it is at high ability levels.

Stage 1 Results

Using IRT we re-analyzed data on the five domain subscale TRAQ 5.0 (20 item) scale (*Appointment Keeping, Tracking Health Issues, Managing Medications, Talking With Providers, And Managing Daily Activities* that were piloted to the sample above. Both a one-factor model (χ^2 (104) = 908.847, CFI = 0.946, RMSEA = 0.091) and the designed five-factor hierarchical model (χ^2 (165) = 499.313, CFI = 0.976, RMSEA = 0.062) fit the data reasonably well. The five-factor model fit the data significantly better, χ^2 (5) = 216.327, $p < .001$. Items had discrimination coefficients ranging from 0.537 to 0.906, with 16 items having discrimination coefficients of 0.715 or higher. Four items (14, 15, 18, and 19) had low discrimination coefficients (0.537 to 0.601) and relatively low difficulty (−1.58 to 0.56, see Table 1). Responses to these items were dominated by either the lowest ("No, I do not know how") or the highest ("Yes, I always do this when I need to") categories, with very few responses in the middle response categories, however most response were in the "Yes, I always do this" category. Therefore, we eliminated these four TRAQ items with minimal impact to the conditional test information – the coefficient for quantifying measurement precision in IRT. After elimination of the above items the domain subscale *Managing Daily Activities* subscale had only one remaining item (#20), so this was also eliminated resulting in the elimination of that domain subscale in the overall scale. After the elimination of the five items, we were left with four domain subscales (k = 15), and IRT analysis of this scale demonstrated a four factor structure that had good fit: χ^2 (86) = 365.447, CFI = 0.977, RMSEA = 0.079, WRMR = 1.017.

Stage 2. Scale refinement

After eliminating low-discrimination items as described, we noted that the TRAQ had better measurement precision for low levels of transition readiness (i.e., (Levels 1 and 2 of the 5 levels of Stages of Change—Precontemplation and Contemplation) than at high levels of transition readiness (i.e., Levels 4 and 5 of the 5 stages of Change: action and mastery). This is because of a general paucity of high difficulty items – items requiring a high level of transition readiness for endorsement. To improve the TRAQ's ability to discriminate those who are in higher stages of transition readiness several new items were developed and then ranked in terms of difficulty in completing the specified task. Among the remaining 15 items, we revised two items due to poor discrimination.

We (DW, KJ, with input from WL, JR)e developed 15 new items for the scales of *appointment keeping, tracking health issues* and *talking with providers*. Content and Face validity of these new and revised items were peer-reviewed by two experts in the field of healthcare transition and adolescent development from outside institutions. The questions were then evaluated by 16 AYA between the ages of 16 and 22 (nine youth with juvenile rheumatic conditions who were participating in an advisory group for health care transition and seven adolescents from the community). We then conducted cognitive interviews (n = 10) with AYA to evaluate their comprehension of the items, wording and response categories, and overall appropriateness. We added 15 items deemed by youth to be more difficult to the now 15 item TRAQ for a new scale with a total of 30 item.

Two items were added to the *managing medications* scale, one item to the *appointment keeping* scale, three items were added to the *tracking health issues* scale, and four items were added to the *talking with providers* scale. Additionally, we created four items for a new scale called *future planning*, as transition encompasses all aspects of life.

Table 1
Item characteristics for 20-item TRAQ: Discrimination and Difficulty/threshold by subscale.

Item	Discrimination	Difficulty / Threshold			
		1 vs 2	2 vs 3	3 vs 4	4 vs 5
Managing medications					
1. Do you fill a prescription if you need to?	0.85	−1.09	−0.64	−0.38	0.01
2. Do you know what to do if you are having a bad reaction to your medications?	0.71	−1.02	−0.66	−0.50	−0.09
3. Do you take medications correctly and on your own?	0.72	−1.44	−1.21	−1.01	−0.46
4. Do you reorder medications before they run out?	0.82	−1.06	−0.68	−0.41	0.054
appointment keeping					
5. Do you call the doctor's office to make an appointment?	0.90	−1.00	−0.6	−0.28	0.06
6. Do you follow-up on any referral for tests, check-ups or labs?	0.85	−0.98	−0.63	−0.37	0.11
7. Do you arrange for your ride to medical appointments?	0.81	−0.99	−0.78	−0.57	−0.23
8. Do you call the doctor about unusual changes in your health (For example: Allergic reactions)?	0.86	−0.92	−0.61	−0.34	0.06
9.Do you apply for health insurance if you lose your current coverage?	0.76	−0.42	0.01	0.24	0.51
10. Do you know what your health insurance covers?	0.75	−0.84	−0.25	0.02	0.45
11. Do you manage your money & budget household expenses (For example: use checking/debit card)?	0.74	−0.73	−0.38	−0.13	0.31
Tracking health issues					
12. Do you fill out the medical history form, including a list of your allergies?	0.81	−0.95	−0.69	−0.48	−0.01
13. Do you keep a calendar or list of medical and other appointments?	0.78	−1.11	−0.84	−0.50	0.02
14. Do you make a list of questions before the doctor's visit?	0.58	−0.61	−0.42	0.13	0.56
15. Do you get financial help with school or work?	0.54	−0.36	−0.07	0.11	0.51
Talking with providers					
16. Do you tell the doctor or nurse what you are feeling?	0.79	−1.74	−1.58	−1.29	−0.55
17. Do you answer questions that are asked by the doctor, nurse, or clinic staff?	0.8	−1.92	−1.68	−1.41	−0.69
Managing daily activities					
18. Do you help plan or prepare meals/food?	0.60	−1.22	−1.02	−0.70	−0.08
19. Do you keep home/room clean or clean-up after meals?	0.53	−1.58	−1.38	−1.17	−0.40
20. Do you use neighborhood stores and services (For example: Grocery stores and pharmacy stores)?	0.75	−1.53	−1.33	−1.10	−0.53

To evaluate the performance of the new 30-item TRAQ, we piloted it to 386 adolescents and young adults. As part of a larger study of access to health care and transition readiness among youth in Central and South Central Appalachia, we surveyed college students and junior and senior high school students in Northeast TN. The high school students ($n = 102$) who agreed to participate were members of their high school health classes at the time of the survey. They were provided paper-pencil surveys to complete during their lunch break and provided a $10 incentive. The college students (274) were participating in an introductory psychology class and received class credit for filling out an online anonymous survey. We restricted the responses from the University students to those under the age of 24. In all, 386 AYA between the ages of 16 and 24 (mean age of 20 yrs.; 54% female; 87% White) completed the revised 30-item TRAQ. All recruitment and survey procedures were approved by East Tennessee State University Institutional Review Board.

Stage 2. 30-item TRAQ psychometric analyses

A five-factor model, including subscales for *managing medications* (Q1-Q3, Q5-Q6, Q22), *appointment keeping* (Q7-Q13), *tracking health issues* (Q14-Q16, Q28-Q30), *talking with providers* (Q4, Q17-Q21), and *future planning* (Q23-Q27), was fit to the data. The model exhibited good fit, $\chi^2(395) = 2014.292$, $p < .001$, CFI = 0.891, RMSEA = 0.103 (90% CI: 0.099, 0.108), WRMR = 1.831. After examining the model fit and modification indices, we made changes to the model to improve fit. In order to limit the length of the scale, we once again selected the items with the least favorable discrimination and difficulty coefficients as candidates for elimination as very easy or very difficult items not good discriminators. If an item is so easy that nearly all respondents answer, *"Yes, I always do this"*, or so difficult that nearly everyone responds, "*No, I don't know how to do this,"*, it becomes very difficult to discriminate those who are ready to transition from those who are not. Table 2 demonstrates the difficulty and discrimination statistics.

Based on the above criteria we eliminated the following questions: Q3 (Do you take medications correctly on your own?), Q4 (Do you give an accurate account of your health status?), Q11, (Do you apply for health insurance if you lose your current coverage?), Q12 ("Do you know what your health insurance covers?"), Q13 (Do you manage your money & budget household expenses (For example: use checking/debit card?), Q23 (Do you participate in youth or young adult social or recreation activities?), Q25 (Do you have a plan to transfer to adult healthcare?) and Q26 ("Do you have a plan for where you will live after finishing high school or college?") were eliminated. Dropping Q23, Q25 and Q26 necessitated the elimination of the *future planning* subscale (Q23–27), as an insufficient number of quality items remained to form a valid subscale. A total of 10 items were eliminated, resulting in 4 domain subscales.

Next two items were moved to a different subscale based how well the item conceptually fit within the specified category and modification indices. Specifically, Q21 ("Do you explain your health history to your healthcare providers (including past surgeries, allergies, medications?")

Table 2
Item characteristics for 30-item TRAQ: discrimination and difficulty/threshold.

TRAQ Item Description 30-item					
Item	Discrimination	Difficulty/Threshold			
		1 vs 2	2 vs 3	3 vs 4	4 vs 5
Managing medications					
1. Do you fill a prescription if you need to?	0.713	−1.204	−0.842	−0.484	−0.042
2. Do you know what to do if you are having a bad reaction to your medications?	0.696	−1.335	−0.851	−0.433	0.14
3. Do you take medications correctly on your own?	0.69	−1.863	−1.601	−1.258	−0.803
22. Do you speak with the pharmacist about drug interactions or other concerns related to your medications?*	0.744	−1.218	−0.805	−0.391	0.227
5. Do you reorder medications before they run out?	0.788	−1.204	−0.823	−0.301	0.081
6. Do you explain any medications (name and dose) you are taking to healthcare providers?*	0.75	−1.366	−1.032	−0.642	−0.065
Appointment keeping					
7. Do you call the doctor's office to make an appointment?	0.778	−1.602	−1.26	−0.805	−0.108
8. Do you follow-up on any referral for tests or check-ups or labs.	0.824	−1.416	−1.053	−0.539	0.023
9. Do you arrange for your ride to medical appointments?	0.794	−1.578	−1.4	−1.043	−0.511
10. Do you call the doctor about unusual changes in your health (For example: Allergic reactions).	0.822	−1.437	−0.918	−0.484	0.101
11. Do you apply for health insurance if you lose your current coverage?	0.577	−0.683	−0.059	0.424	0.742
12. Do you know what your health insurance covers?*	0.53	−0.93	−0.26	−0.21	0.7
13. Do you manage your money & budget household expenses (For example: use checking/debit card)?	0.627	−1.335	−0.938	−0.356	0.233
30. Do you attend your medical appointment or part of your appointment by yourself?*	0.796	−1.704	−1.289	−0.908	−0.267
Tracking health issues					
14. Do you fill out the medical history form, including a list of your allergies?	0.803	−1.494	−1.204	−0.823	−0.253
15. Do you keep a calendar or list of medical and other appointments?	0.749	−1.23	−0.967	−0.526	−0.033
4. Do you give an accurate account of your health status?*	0.682	−1.703	−1.366	−0.947	−0.284
21. Do you explain your health history to your healthcare providers (including past surgeries, allergies, medications?*	0.834	−1.941	−1.472	−1.041	−0.351
29. Do you make or help make medical decisions pertaining to your health?*	0.831	−1.795	−1.335	−0.918	−0.121
Talking with providers					
16. Do you tell the doctor or nurse what you are feeling.	0.814	−1.944	−1.677	−1.274	−0.447
17. Do you ask questions of your nurse or doctor about your health or health care?*	0.838	−1.651	−1.091	−0.735	−0.114
18. Do you answer questions that are asked by the doctor, nurse or clinic staff?	0.893	−2.312	−1.677	−1.335	−0.528
19. Do you ask your doctor or nurse to explain things more clearly if you do not understand their instructions to you?*	0.847	−2.037	−1.578	−1.078	−0.36
20. Do you tell the doctor or nurse whether you followed their advice or recommendations?	0.792	−1.944	−1.437	−0.98	−0.274
28. Do you contact the doctor when you have a health concern?*	0.796	−1.651	−1.204	−0.735	−0.016
Managing your future					
23. Do you participate in youth or young adult social or recreation activities? *	0.492	−1.204	−0.908	−0.536	0.075
24. Are you taking necessary steps toward achieving your educational/ career goal?*	0.77	−2.093	−1.677	−1.245	−0.44
25. Do you have a plan to transfer to adult healthcare?*	0.505	−1.068	−0.433	0.055	0.433
27. Do you have a plan for how you will support yourself once you are on your own?*	0.796	−1.651	−1.204	−0.735	−0.016

Note: * denotes item was new addition to the TRAQ

was moved from *tracking health issues* to *talking with providers*; Q16 (Do you tell the doctor or nurse what you are feeling?) was moved from *talking with providers* to *tracking health issues*.

The final model for the 20 item, 4 domain subscale questionnaire exhibited good to excellent fit to the data, $\chi^2(164) = 887.239$, $p < .001$, CFI = 0.943, TLI = 0.93, RMSEA = 0.0942 (90% CI: 0.090, 0. 114), WRMR = 1.111. All items have acceptable discrimination coefficients, implying that eliminating any of these items would negatively affect measurement precision. None of the items stands out as problematic according to this analysis. The item difficulty is increased over the prior TRAQ items and domain subscales, increasing the TRAQ's ability to precisely measure individuals with relatively higher levels of transition readiness.

Test information

In Fig. 1, the curves, demonstrated by a higher and broader curve in relationship to Transition Readiness or (θ), indicate how the measurement precision of the TRAQ varies across levels of underlying transition readiness as described by the stages of change model from pre-contemplation to mastery. It is evident in Fig. 1 that adding the additional items improved the measurement precision of transition readiness from pre-contemplation to initiation and improved the precision of measurement marginally for the stages of change of action and mastery. (Note that the scale of the y-axis changes between panels, and that higher values indicate more precision).

The conditional SEMs presented in Table 3 describe the expected uncertainty of measurement for the two versions of the TRAQ given adolescents with differing underlying levels of transition readiness (θ). While precision has been improved over the entire range, the new 20-item TRAQ achieves its optimal performance (smallest SEMs) for adolescents who are between about one to two standard deviations below the mean level of transition readiness ($z = \{-2, -1\}$) and the mean level of transition readiness ($z = 0$). The performance of the 20-item track is slightly improved for above-average levels of transition readiness. Additionally, internal reliability improved for all subscales and the overall TRAQ scale (tau ranging between 0.76 and 0.94).

Discussion

In this study, we sought to improve the performance of this questionnaire by improving item discrimination across all Stages of Change (pre-contemplation, contemplation, preparation/initiation, action, and mastery) with regard to healthcare self-management skills. Using IRT to examine model fit and item characteristics, we eliminated five of the TRAQ's 20 items that were the lowest discriminating items. We then added items (skills) that we felt would be more difficult and better discriminating across all levels of transition readiness. We piloted this

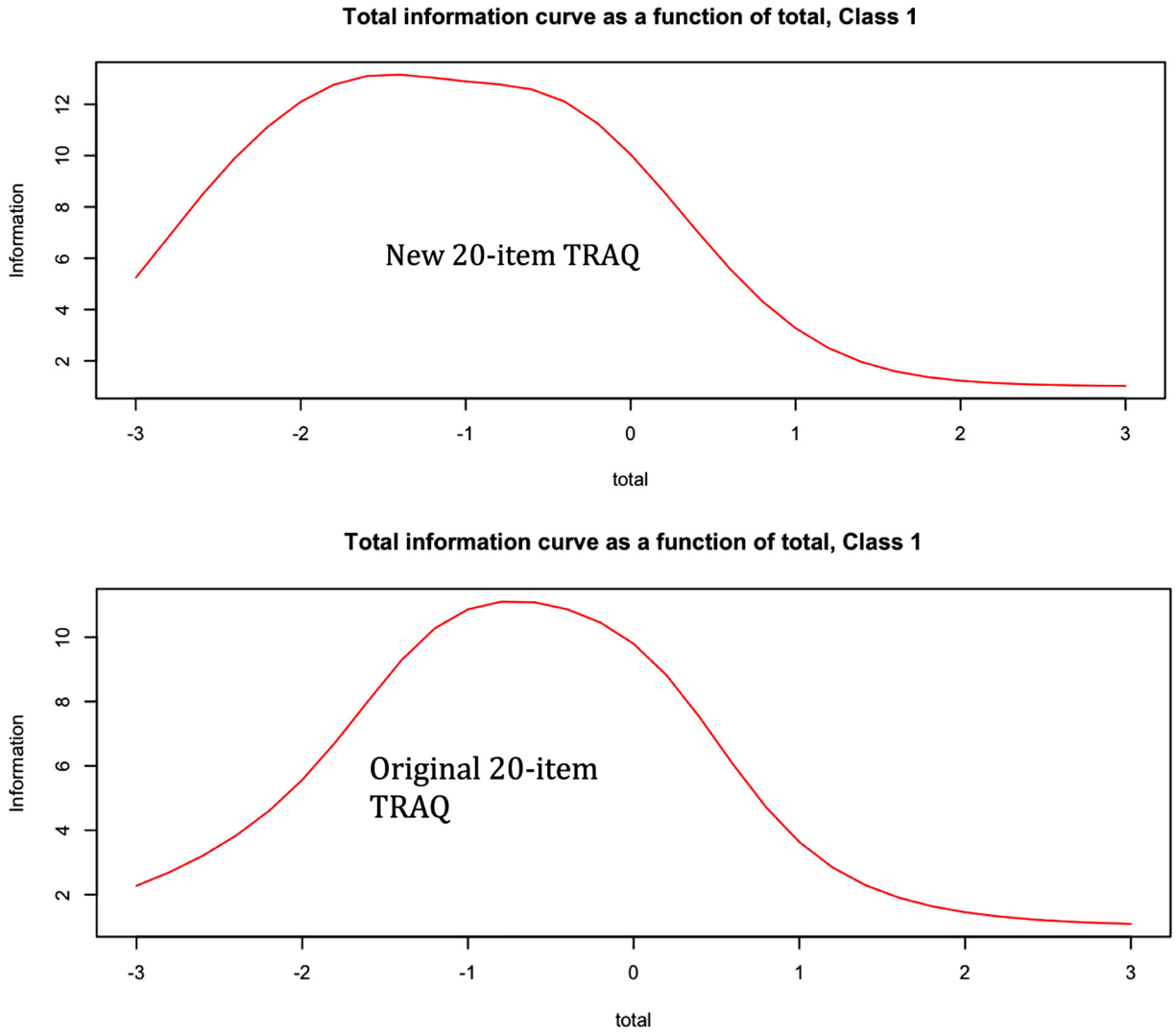

Fig. 1. Comparison of test information for original vs 20-item TRAQ.

Table 3
Conditional SEMs for the two TRAQs.

Transition Readiness	Original 20-item TRAQ	New 20-item TRAQ
−2	0.45	0.26
−1	0.30	0.22
0	0.33	0.31
1	0.51	0.46
2	0.82	0.65

Table 3 shows the conditional Standard Errors of Measurement (SEMs) for the two versions of the TRAQ at various levels of transition readiness (θ), with lower SEM indicating improved precision.

new questionnaire among 386 AYA in our region. The resulting scale is a 20-item, four domain subscale TRAQ 6.0: 1. Managing medications, 2. Keeping appointment, 3. Tracking health issues, and 4. Talking with providers. The revised 20-item TRAQ 6.0 exhibits good construct validity as demonstrated by model fit. By adding more difficult items, we have demonstrated improved item discrimination and difficulty and therefore can better measure progress of transition readiness across the five stages of change from pre-contemplation to mastery of the transition readiness skills.

Practical implications

Published clinical guidelines call for routine use of structured transition readiness assessments and development of transition care plans for all youth, especially for those with chronic health conditions (American Academy of Pediatrics et al., 2011). However, studies in diverse patient populations show that most youths and young adults, including those with special health care needs and their parents, receive limited or no transition readiness assessment nor preparation (Garvey et al., 2013; Kuhlthau et al., 2016; McManus et al., 2013). For example, even among CF centers that have established transition programs, only 50% perform readiness assessments, <10% have a list of desirable skills, and only 26% of these addressed pertinent skills (McLaughlin et al., 2008). As more and more specialty and general pediatrics clinics adopt HCT guidelines, a critical element enabling this practice are validated and highly reliable transition readiness assessment measurement tools that can be implemented in the busy clinical setting.

The TRAQ has been demonstrated to be sensitive to different types of interventions such as face-to-face education to texting and web-based goal setting (Huang et al., 2014). The TRAQ response set, derived from the Stages of Change Trans-theoretical Model, allows the youth to rank their own self-management skill competence from the pre-contemplation stage to initiation to maintenance. TRAQ ratings can be used to identify specific aspects of self-management that the youth, parent and caregiving team can agree to work on collaboratively and set goals for improvement. Using a Motivational Interviewing framework, providers can tailor their interventions to the particular stage of change of the individual youth and help them incrementally adopt self-management skills. For example, if a youth ranks themselves as pre-contemplation, then the provider can help create discrepancy in the youth comparing their current self-management abilities to what will be needed to achieve the youth's future living or education goals (e.g., to leave home or go to college). If the youth has initiated self-management skills, the provider should affirm the youth's current actions and coach the youth to adopt more advanced skills and jointly set goals for the youth to practice and enhance their skills. Over time the progress of the youth toward independence can be documented and new self-management behaviors introduced, reinforced, and celebrate— creating a youth-focused and youth-friendly environment that is conducive to the adoption of increased internal motivation and self-competence, which are critical aspects of positive behavior change (Ryan et al., 2008). Lastly, some clinics have found that the regular use of the TRAQ or other transition readiness questionnaires raises a broader range of patients' needs and identifies gaps in their own services. For example, a urology clinic serving youth with Spina Bifida found, when implementing their use of the TRAQ, that their patients had unmet needs for counseling on health system access and insurance, and they added a social worker to their team to meet with the transitioning youth (Grimsby et al., 2016).

Limitations and conclusion

The original sample in Wood et al., 2014 included youth between the ages of 14–21 years, however, our study included youth between the ages of 16–24 years. We chose age 24 years of age, considering 24 is the tail end of the developmental stage of emerging adulthood/adolescence. This limits the comparison ability to the original sample.

Another limitation to our study is the lack of racial and ethnic diversity in the sample. Specifically, our sample included approximately 87% white youth, drawn from a convenience sample of high school and college students. Although ~20% reported having a special healthcare need as indicated by responses using the Maternal and Child Health Screener, no information is reported on specific medical conditions among these participants. The lack of diversity across dimensions of the present study may limit the generalizability of the revision of the TRAQ to those who are white. Future directions can include validating this new measure using a more representative sample.

The science of Health Care Transition measurement and management is in its infancy. Many questions remain regarding how best to assess and support AYA as they gain self-management skills needed to thrive during a time that is fraught with multiple transitions in their health care, living situations, relationships, education and work. Future research is needed to develop and test transition readiness assessments and coaching programs or applications that can be used by primary care and specialty clinics or by youth and families themselves, while measuring outcomes. Outcome measurement across HCT is critical for validating future HCT assessment tools as well. Moreover further research is needed to test the relation between transition readiness and the triple aim of improved population health (e.g., reduced morbidity and better outcomes), increased satisfaction with care by improved connection to the health care system during transition and reduced costs through reduced hospitalizations or emergency room visits. Improving the measurement of HCT, which is the focus of this work, is an essential component for increasing the evidence base for improving outcomes during HCT.

Declarations of interest

None.

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Appendix: New 20-Item transition readiness assessment questionnaire
Transition Readiness Assessment Questionnaire (TRAQ)
Patient Name: _____Date of Birth: ___/____/____Today's Date ____/_____/____ (MRN#_____)

Directions to youth and young adults
Please check the box that best describes ***your*** skill level in the following areas that are important for transition to adult health care. There is no right or wrong answer and your answers will remain confidential and private.

Directions to caregivers/parents
If your youth or young adult is unable to complete the tasks below on their own, please check the box that best describes ***your*** skill level. **Check here** ☐ if you are a parent/caregiver completing this form.

	No, I do not know how	No, but I want to learn	No, but I am learning to do this	Yes, I have started doing this	Yes, I always do this when I need to
Managing medications					
1. Do you fill a prescription if you need to?					
2. Do you know what to do if you are having a bad reaction to your medications?					
3. Do you reorder medications before they run out?					
4. Do you explain any medications (name and dose) you are taking to healthcare providers?					
5. Do you speak with the pharmacist about drug interactions or other concerns related to your medications?					
Appointment keeping					
6. Do you call the doctor's office to make an appointment?					
7. Do you follow-up on referrals for tests or check-ups or labs.					
8. Do you arrange for your ride to medical appointments?					
9. Do you call the doctor about unusual changes in your health (For example: Allergic reactions).					
Tracking health issues					
10. Do you fill out the medical history form, including a list of your allergies?					
11. Do you keep a calendar or list of medical and other appointments?					
12. Do you tell the doctor or nurse what you are feeling?					
13. Do you contact the doctor when you have a health concern?					
14. Do you make or help make medical decisions pertaining to your health?					
15. Do you attend your medical appointment or part of your appointment by yourself?					
Talking with providers					
16. Do you ask questions of your nurse or doctor about your health or health care?					
17. Do you answer questions that are asked by the doctor, nurse or clinic staff?					
18. Do you ask your doctor or nurse to explain things more clearly if you do not understand their instructions to you?					
19. Do you tell the doctor or nurse whether you followed their advice or recommendations?					
20. Do you explain your health history to your healthcare providers (including past surgeries, allergies, medications)?					

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