

# Development of a New Measure of Housing Security: The REDD-CAT Housing Security Measure



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## ABSTRACT

**BACKGROUND:** Housing security is a key social determinant of behavior related to health outcomes.

**OBJECTIVE:** The purpose of this study was to develop a new patient-reported outcome measure that evaluates aspects of housing security for use in the Re-Engineered Discharge for Diabetes-Computer Adaptive Test (REDD-CAT) measurement system.

**DESIGN:** Qualitative data, literature reviews, and cross-sectional survey study.

**PARTICIPANTS:** A total of 225 people with T2DM provided responses to the items in this item pool.

**MAIN MEASURES:** A new item pool that evaluates important aspects of housing security was developed using stakeholder data from focus groups of persons with T2DM.

**KEY RESULTS:** For the Housing Affordability scale, factor analysis (both exploratory and confirmatory) supported the retention of six items. Of these items, none exhibited sparse cells or problems with monotonicity; no items were deleted due to low item-adjusted total score correlations. For the six affordability items, a constrained graded response model indicated no items exhibited misfit; thus, all were retained. No items indicated differential item functioning (examined for age, sex, education, race, and socioeconomic status). Thus, the final Affordability item bank comprised six items. A Housing Safety index (three items) and a Home Features index (eight items) were also developed. Reliability (i.e., internal consistency and test-retest reliability) and validity (i.e., convergent, discriminant, and known-groups) of the new measures were also supported.

**CONCLUSIONS:** The REDD-CAT Housing Security Measure provides a reliable and valid assessment of housing affordability, safety, and home features in people with type 2 diabetes mellitus. Future work is needed to establish the clinical utility of this measure in other clinical populations.

**KEY WORDS:** type 2 diabetes; housing security; patient-reported outcomes; social determinants of behavior

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The relationship between housing and health has been well-established in public health research with housing conditions, stability, affordability, and location as key areas for intervention.<sup>1</sup> The Shaw conceptual model of housing and health further illustrates that hard factors (physical or material) and soft factors (social or meaningful) can both directly and indirectly impact health.<sup>2</sup> Specifically, housing conditions, housing structure, and homelessness (hard factors), and individual perceptions, impact of poor housing on mental health, worries about affordable housing, and feelings of security (soft factors) *directly* impact health.<sup>2</sup> Additionally, income, wealth, and proximity to services and facilities (hard factors), as well as household culture (soft factors), can *indirectly* impact health. At the neighborhood level, availability of local services/facilities and features of the environment (hard factors), as well as community culture and cohesion (soft factors), also *indirectly* impact health.<sup>2</sup>

While previous research has established that lack of or insufficient housing can have a deleterious impact on health,

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our ability to quantify this impact is limited by the lack of a consensus definition for housing insecurity. Definitions of housing insecurity can include any or all of the following components: housing stability, housing affordability, housing quality, housing safety, and/or homelessness.<sup>3</sup> As such, the measures that have been used to assess housing security are equally varied. In fact, a recent systematic review identified 14 different screening tools that varied in terms of concepts measured, number of items, and psychometric rigor (for a detailed review of these measures, see 3). No measures were identified that exhibited comprehensive reliability and validity data, and most studies only employed a single item to assess housing, which, by design, only focuses on a single aspect of housing and has limited response option variability.

Despite lacking a consensus definition and a consensus measure, housing insecurity remains a key social determinant of health.<sup>1,2</sup> Census-based estimates indicate that more than 25% of households are cost burdened (i.e., at least 30% of their household income goes toward rent),<sup>4</sup> with even higher rates of individuals indicating concerns about housing affordability (rates range between 59.9 and 72.8% by state).<sup>5</sup> Housing insecurity is also associated with increased risk for physical and mental health problems<sup>6–11</sup> and with poor access to ambulatory care and high rates of acute care.<sup>12</sup> People with type 2 diabetes mellitus (T2DM) are among those populations with high rates of housing unaffordability and housing insecurity.<sup>12–16</sup> In T2DM, these high rates of housing insecurity are disruptive to the self-management routines that are critical to the successful treatment and maintenance of the disease,<sup>17,18</sup> and they increase the risk for poor health outcomes (including elevated blood glucose levels, high low-density lipoprotein cholesterol levels, high blood pressure, overall worse health-related quality of life).<sup>14,19–23</sup> Not surprisingly, housing insecurity in T2DM is also costly, with associated elevations in diabetes-related emergency department use, hospitalization, and outpatient visits.<sup>15,23–26</sup>

We aimed to develop and validate a new comprehensive patient-reported outcome measure (PRO) of housing insecurity that could be used to better understand the impact that housing has on health outcomes at the point of discharge from the hospital. We operationalized housing insecurity as a multidimensional concept that includes housing instability, housing affordability, housing safety, housing quality, neighborhood quality, and homelessness, all of which disproportionately impact low-income families in the USA.<sup>12</sup> Specifically, this new measure was developed as part of a larger study focused on developing and validating measures that capture important social determinants of behavior.<sup>27–29</sup> We tested this measure in people with T2DM, although we would expect this measure to have broad applicability across a number of diverse clinical populations. This report describes the development of this new PRO, the Re-Engineered Discharge for Diabetes Computer Adaptive Test (REDD-CAT) Housing Security measure, and provides preliminary score reliability and validity data.

## METHODS

### Study Participants

A total of 225 individuals with T2DM participated in this study. Study eligibility included a clinical diagnosis of T2DM, > 18 years of age, ability to communicate in English, and ability to provide informed consent. In order to complete the PROs independently, participants had to have at least a 5<sup>th</sup> grade reading level, which was confirmed by correctly pronouncing the first 10 words on the Wide Range Achievement Test 4<sup>th</sup> Edition (WRAT4) Reading Subtest;<sup>30</sup> participants with errors on the first 10 words were provided assistance with reading survey items. Study participants were recruited from the Boston Medical Center (BMC) health-care system using three different screening approaches: (1) weekly lists were generated of diabetes patients with upcoming outpatient appointments using BMC's Clinical Data Warehouse; (2) the electronic health record was queried to generate inpatient census reports of inpatients with T2DM; and (3) participants that had agreed to be contacted for future research studies (as part of the consent process for a previous T2DM research study) were contacted. Data were collected in accordance with the local institutional review board, and study participants provided informed consent prior to their participation in this study.

### Measures

**The REDD-CAT Housing Security PRO.** This new PRO was developed using published measurement development standards<sup>31</sup> that include both qualitative and quantitative methodology (e.g., classical test theory and item response theory).<sup>32–34</sup> Literature reviews and semi-structured interviews informed the development of the Housing Security items. Specifically, semi-structured interviews were conducted with 37 patients admitted to a general medical hospital service to identify patient-reported aspects of readmission risk (<https://www.pcori.org/research-results/2012/pilot-project-figuring-out-which-patients-are-likely-return-hospital> and Cancino et al., 2014<sup>35</sup>). This work identified 15 themes related to readmission risk including housing insecurity (housing instability, housing affordability, housing safety, housing quality, neighborhood quality, and homelessness) that served as the basis for Housing Security items. Item writing relied considerably on the content from the semi-structured interviews; verbatim quotations from the patient interviews were used to develop this content when available. Item writing was iterative and included cognitive interviews with patients with a recent hospital readmission, expert review (i.e., professional inpatient providers; PRO development experts), reading level review (reading level does not exceed the 6<sup>th</sup> grade), and translatability review (to inform future adaptation into languages other than English). See Fig. 1. The final Housing Security PRO has 22 items and includes

three broad subdomains (housing safety [3-item index], housing affordability [6-item scale], and housing features [8-item index]). There are also five stand-alone single items (post-discharge housing status; anxiety about affording housing; safety: domestic violence; anxiety about where will sleep next; and reason(s) staying with family/friends/at a shelter). Scores include a Housing Affordability *T*-score ( $M=50$ ,  $SD=10$ ; higher scores indicate less worry about affordability) and Housing Safety and Housing Features index scores (summed scores divided by the number of completed items in the index; higher scores indicate more safety and more available housing features, respectively). The “anxiety about affording housing,” “domestic violence,” and “anxiety about where will sleep next” single items provide scores ranging from 1 to 5, with higher scores indicating less anxiety about affording housing, more personal safety, and less anxiety about where will sleep next.

**Validity Measures.** The 8-item Economic Quality of Life (Econ-QOL)<sup>36</sup> was used to evaluate perceived economic and financial security. This measure is scored on a *T*-score metric ( $M=50$ ;  $SD=10$ ); higher scores indicate worse perceived economic quality of life. We examined those with “better” (scores  $\leq 40$ ) versus “worse” (scores  $\geq 60$ ) economic quality of life.

PROMIS Severity of Substance Use<sup>37,38</sup> provided a measure of self-reported severity of substance use in the last 30 days, Neuro-QoL Anxiety<sup>39,40</sup> provided a measure of perceived worry, fear, and hyperarousal, and PROMIS Pain Interference provided a measure of the effects of pain on a range of daily life activities. These measures are scored on a *T*-score metric ( $M=50$ ;  $SD=10$ ); higher scores indicate worse severity, anxiety, and pain interference, respectively.

We also collected demographic data and several medical record variables including questions about health insurance and finances.

## Data Capture

The study PROs were administered using a HIPPA-compliant electronic data capture system; study participants used either a personal internet-enabled device or a study-specific tablet or laptop to provide item responses.

## Sample Size Justification

Sample size requirements were based on the planned graded response model (GRM) analysis and differential item functioning (DIF) analyses that were conducted as a part of the PRO development (specific analyses described below). The proposed GRM analysis required a minimum sample size of  $N=200$  to generate stable calibration estimates for the PRO.<sup>41,42</sup> In addition, Wald-2-based DIF analyses required at least  $n=100$  participants per subgroup for the proposed demographic comparisons.<sup>43</sup>

## Statistical Analyses

**Housing Affordability Scale Development.** The Housing Affordability scale was developed using an iterative process that included classical test theory and item response theory approaches, as well as clinical input.<sup>32-34</sup> Exploratory and confirmatory factor analyses (EFA, CFA; using Mplus software version 7.4<sup>44</sup>) were used to examine scale dimensionality. EFA was used to help identify the number of potential scale subdomains. Items with sparse cells (response categories with  $n < 5$  respondents), low item-adjusted total score correlations ( $r < 0.40$ ), or items that were non-monotonic (Testgraf Software<sup>45</sup>) were candidates for exclusion. In CFA analyses, items were candidates for exclusion if they exhibited: low factor loadings ( $1x < 0.50$ ), or local dependence (residual correlations  $> 0.20$  or a correlated error modification index  $\geq 100$ ).<sup>32-34</sup> CFA was used to confirm the factor structure of potential item sets. Fit criteria were as follows: comparative fit index (CFI)  $\geq 0.90$ ; Tucker-Lewis index (TLI)  $\geq 0.90$ ; and root mean square error of approximation (RMSEA)  $< 0.15$ .<sup>46-49</sup>

Next, a constrained, common-slope graded response model (GRM)<sup>50</sup> was used to identify items with significant misfit (S-X2 /df effect size  $> 3$ )<sup>51</sup>. This was followed by an investigation for potential differential item functioning (DIF). Items exhibiting meaningful DIF ( $p < 0.01$  group-specific item parameter difference, plus  $> 2\%$  of DIF-corrected vs. uncorrected score differences exceeding individual case uncorrected score standard errors) were candidates for exclusion. DIF was examined for age ( $< 60$  vs.  $\geq 60$  years), sex (male vs. female), education ( $\leq$  high school vs.  $>$  high school), and socioeconomic status (“have enough income to pay rent/mortgage” and “can afford to pay bills on time,” both categorized as never/rarely/sometimes vs. usually/always). Analyses were conducted using IRTPRO software version 3.1.2.<sup>52</sup> CFA was also used to confirm the factor structure of the final item set.

**Housing Safety and Housing Features Index Development.** The Housing Safety and Housing Features indices were developed using an iterative process focused primarily on classical test theory. As with the Housing Affordability scale, EFA and CFA were used to examine dimensionality, following the analytic process outlined above. The multi-dimensional nature of item content precluded a typical unidimensional scale development strategy; the indices, instead, were designed to provide a “count” and an “extent to which” different safety elements and housing features are present.

**Preliminary Reliability and Validity Analyses: Housing Affordability.** Given that the item response data were normally distributed, we proceeded with parametric analyses. Scores on the new Housing Affordability PRO

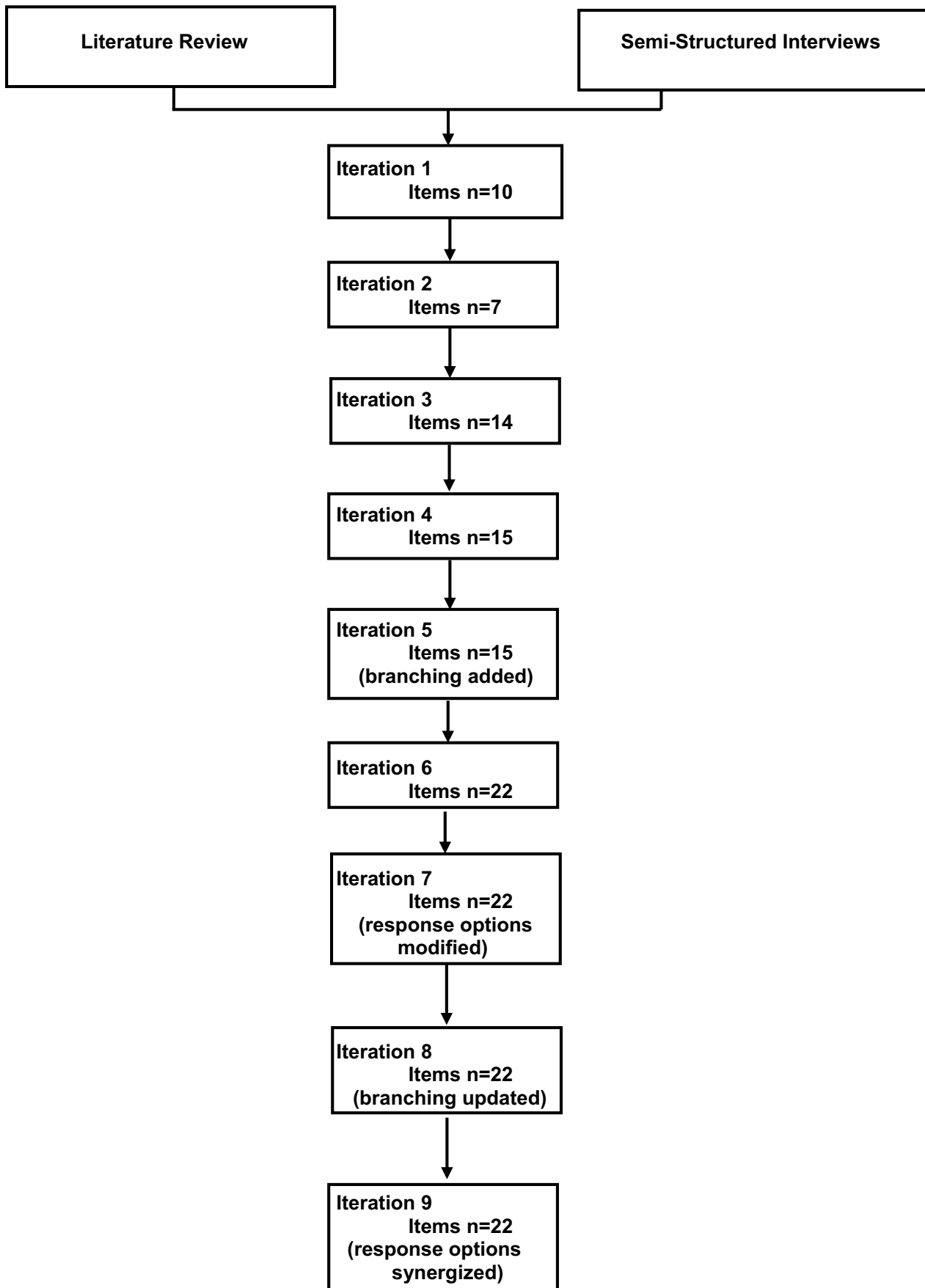


Figure 1 Iterative process for item pool development.

were examined. Cronbach's alpha was used to estimate internal consistency reliability (a priori criterion specified as  $\geq 0.70$ ).<sup>53</sup> Floor and ceiling effects were also examined (a priori criterion specified as  $\leq 20\%$ ).<sup>54,55</sup>

Convergent and discriminant validities were examined using Pearson correlations. Convergent validity would be supported by moderate correlations ( $r's \geq 0.36-0.67$ ) between Housing Affordability and Economic Quality of Life.<sup>56</sup> Discriminant validity would be supported by less robust or "low" correlations ( $r's \leq 0.35$ ) between Housing Affordability and Neuro-QoL Anxiety, and negligible correlations between Housing Affordability and PROMIS Pain Interference.<sup>56</sup>

Independent sample *t*-tests were used to examine known-groups validity. Known-groups categories included those indicating they have enough money to make ends meet versus those who do not have enough money to make ends meet. We expected those who report that they do not have enough money to make ends meet would report more housing insecurity than those with enough money to make ends meet.

In addition, logistic regression models were conducted to determine if Housing Security was related to readmission risk in our sample (high risk was defined as  $\geq 2$  inpatient admissions in the past 6 months; low risk was defined as  $\leq 1$  inpatient admission in the past 6 months). These models included patient demographic variables, objective medical record data, existing hospital risk assessment data, and PRO measure scores.

***Preliminary Descriptive and Validity Analyses: Housing Safety and Housing Features.*** Given that Housing Safety and Housing Features scores are count- and extent-based in nature and thus non-normally distributed, we proceeded with nonparametric analyses. Scores on these two new Housing Security indices were examined, with minimum, maximum, median, and modal observed scores reported. The percent of cases with minimum and maximum possible scores was also reported.

Convergent and discriminant validities were examined using Spearman correlations. Convergent validity would be supported by moderate correlations ( $r's \geq 0.36-0.67$ ) between Housing Safety and Housing Features vs. Severity of Substance Use.<sup>56</sup> Discriminant validity would be supported by low correlations ( $r's \leq 0.35$ ) between Housing Safety and Housing Features vs. Neuro-QoL Anxiety, as well as negligible correlations between Housing Safety and Housing Features vs. PROMIS Pain Interference.

Mann-Whitney *U* tests were used to examine known-groups validity. Known-groups categories included (1) those with enough money to make ends meet versus those without enough money to make ends meet; and (2) "worse" vs. "better" economic quality of life. We expected those without enough money to make ends meet to report less housing safety and less housing features than those with

enough money to make ends meet; we also expected those with "worse" economic quality of life to report less housing safety and less housing features versus those with "better" economic quality of life.<sup>57</sup>

***Preliminary Descriptive Analyses: Anxiety About Affording Housing, Domestic Violence, and Anxiety About Where Will Sleep Next.*** Given that there were only single items each to assess "anxiety about affording housing," "domestic violence," and "anxiety about where will sleep next," we reported each item's minimum, maximum, median, and modal observed scores, as well as the percent of cases with minimum and maximum possible item scores.

## RESULTS

### Study Participants

Table 1 provides detailed descriptive data for both the sample and the different PROs that were administered as a part of this study. Figure 2 includes a final.pdf version as well as scoring criteria for the REDD-CAT Housing Security.

### Housing Affordability Scale

Table 2 provides a summary of the analyses that supported the retention of the six final items in the Housing Affordability scale. Thresholds ranged from  $-1.73$  to  $+1.78$  for the subdomain. There was good information (i.e., test information  $\geq 5.0$ ) for *T*-scores between 31 and 66 and acceptable information (test information  $\geq 3.3$ ) for *T*-scores between 26 and 71; marginal reliability was 0.84 for the 6-item measure. Table 3 provides the final characteristics for the new subdomain.

### Housing Safety and Housing Features Indices Development

The Housing Safety subdomain is evaluated by a 3-item index, while the Housing Features subdomain is assessed by an 8-item index. The Housing Features index is generalized across differing discharge housing locations by referring respondents to, for example, "When I am discharged, the place I will go to." Housing Safety and Housing Features scores are average item scores, which facilitate scoring and score interpretation when missing items occur.

### Reliability and Validity Analyses

***Housing Affordability.*** Internal consistency reliability of the REDD-CAT Housing Affordability subdomain was good, and it was devoid of floor and ceiling effects (Table 4). Convergent validity was supported (Table 5). Those persons



**Table 1 Descriptive Data for Study Participants and PRO Data**

Variable	T2DM (N = 217)
Age (years)	
M (SD)	57.7 (10.97)
Sex (%)	
Female	53
Male	47
Ethnicity (%)	
Not Hispanic or Latino	93
Hispanic or Latino	7
Race (%)	
White	18
Black/African American	75
Other	7
Education (%)	
Less than high school	18
High school graduate or equivalent	31
Some college, no degree	22
Associates or vocational degree	14
4-year college degree	9
Master degree or more	6
Marital status (%)	
Single, never married	55
Married/cohabitating	15
Separated/divorced	21
Widowed	9
Missing	< 1
Insurance coverage (%)	
Medicare/Medicaid	79
Commercial	18
Other	3
At the end of the month... (%)	
I do not have enough money to make ends meet	62
I have enough money to make ends meet	29
I have money left over	9
Annual household income (%)	
No personal income	2
Less than \$5000	16
\$5000–\$9999	13
\$10,000–\$14,999	21
\$15,000–\$19,999	13
\$20,000–\$29,000	7
\$30,000–\$39,000	8
\$40,000–\$49,000	4
\$50,000–\$74,000	4
\$75,000–\$99,000	1
\$100,000 or more	3
Missing	8
Do you usually ask someone to help you read materials you receive from the hospital doctor?	
Yes	24
No	76
Missing	1
HbA1c	
M (SD)	8.1 (2.2)
Comparator measures	
Economic quality of life	
T score (SD)	44.9 (10.33)
PROMIS Severity of Substance Use	
T score (SD)	44.1 (6.11)
Neuro-QoL Anxiety	
T score (SD)	51.4 (9.79)
PROMIS Pain Interference	
T score (SD)	55.7 (10.70)

Entries in the table represent percentage of participants unless otherwise specified

with enough money to make ends meet (versus not enough money) reported less housing insecurity, supporting known-groups validity (Table 6). Logistic regression models indicated that Housing Affordability was one of seven variables that was related to readmission risk (i.e., the observed correlation of  $\geq \pm 0.15$  with our risk level-dependent variable).

**Housing Safety and Housing Features.** Score distributions and the percentages of individuals with the highest and lowest scores are provided in Table 4. Convergent validity and discriminant validity was supported (Table 5). There was a trend ( $p < 0.07$ ) for a significant difference between those with enough money to make ends meet to report less concern with housing safety relative to those without enough money to make ends meets (Table 6). All other known-groups analyses had results as were hypothesized (Table 6).

**Anxiety About Affording Housing, Domestic Violence, and Anxiety About Where Will Sleep Next.** Score distributions and the percentages of individuals with the highest and lowest scores are provided in Table 4 for these three single-item assessments.

## DISCUSSION

This report describes the development of a new measure designed to capture important components of perceived Housing Security. This new measure, the REDD-CAT Housing Security PRO, captures three critical components of housing insecurity: Housing Affordability (6-item scale), Housing Safety (3-item index), and Housing Features (8-item index). To our knowledge, this PRO represents the first comprehensive measurement system of housing insecurity; it is both reliable and has good scale characteristics. There was also support for convergent and discriminant validity, as well as known-groups validity. Taken together, this new PRO has demonstrated that it is psychometrically sound; that is, the majority of our psychometric findings were in accordance with a priori hypotheses.<sup>58</sup>

The new Housing Security PRO includes two discharge housing location items, three distinct scale and index scores, and three single-item assessments. The first discharge housing location item, “When I am discharged, I will go to” has five response options, with respondent instructions to choose the best option: “my own home/family residence,” “a friend’s home/residence,” “a shelter,” “I do not have any options for housing or shelter,” and “I don’t know.” The second discharge housing location item, “With regard to my discharge” has nine response options, with respondent instructions to choose all options that apply; options are worded to elicit reasons for the anticipated discharge housing location (e.g., “because I need someone to take care of me” and “because

## REDD-CAT Housing Security

**Please respond to each question or statement by marking one box per item.**

When I am discharged, I will go to (choose the best option):	<input type="checkbox"/> My own home/family residence <input type="checkbox"/> A friend's home/residence <input type="checkbox"/> A shelter <input type="checkbox"/> I do not have any options for housing or shelter <input type="checkbox"/> I don't know
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With regard to my discharge (select all that apply):	<input type="checkbox"/> I am staying at my own home/family residence and I am able to be independent <input type="checkbox"/> I am staying at my own home/family residence, but I need someone to take care of me <input type="checkbox"/> I am staying with a friend/family member because I have nowhere else to go <input type="checkbox"/> I am staying with a friend/family member because I need someone to take care of me (I am unable to live independently) <input type="checkbox"/> I am staying with a friend/family member because I cannot afford independent housing <input type="checkbox"/> I am staying at a shelter because I have nowhere else to go <input type="checkbox"/> I am staying at a shelter because I cannot afford housing <input type="checkbox"/> I do not have any options for housing <input type="checkbox"/> I do not know where I will stay when I am discharged
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### REDD-CAT Housing Safety Index

**Please respond to each question or statement by marking one box per row.**

		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
HouseSa fety_01	I live in a safe neighborhood .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
		Never	Rarely	Sometimes	Usually	Always
HouseSa fety_02	I feel safe when I go home .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseSa fety_03	I worry about the security of my home while I am in the hospital .....	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
DomViol ence_01	Does a partner, or anyone at home, hurt, hit or threaten you.....	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

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**Figure 2** The final.pdf version as well as scoring criteria for the REDD-CAT Housing Security.

REDD-CAT Housing Features Index

Please respond to each question or statement by marking one box per row.

		Never	Rarely	Sometimes	Usually	Always
HouseFeatures_01	When I am discharged, the place I will go has heating.....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_02	When I am discharged, the place I will go has air conditioning .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_03	When I am discharged, the place I will go has electricity.....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_04	When I am discharged, the place I will go has running water .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_05	When I am discharged, the place I will go has a working toilet .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_06	When I am discharged, the place I will go has a working shower/bath .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_07	I feel like I have my own private space.....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
HouseFeatures_08	I worry that my home is overcrowded...	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
SleepLocation_01	I worry about where I will sleep at night...	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

REDD-CAT Housing Affordability Scale

Please respond to each question or statement by marking one box per row.

		Never	Rarely	Sometimes	Usually	Always
AffordHousing_01	I worry about my ability to afford housing.....	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
AffordScale_01	I am able to pay my mortgage/rent on time .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
AffordScale_02	I am able to pay my heating bill on time .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
AffordScale_03	I am able to pay my electric bill on time .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
AffordScale_04	I am able to pay my water/sewage bill on time .....	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
AffordScale_05	I am concerned about being evicted or foreclosed upon.....	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
AffordScale_06	I worry about paying bills on time.....	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

Figure 2 (continued)



# SCORING INSTRUCTIONS

## REDD-CAT Housing Security Measures

A brief guide to scoring the REDD-CAT Housing Security instruments:

ADULT
REDD-CAT v1.0 – Housing Affordability Scale
REDD-CAT v1.0 – Housing Features Index
REDD-CAT v1.0 – Housing Safety Index
REDD-CAT v.1.0 – Anxiety About Affording Housing Item
REDD-CAT v.1.0 – Domestic Violence Item
REDD-CAT v.1.0 – Anxiety About Where I Will Sleep

### ABOUT REDD-CAT HOUSING SECURITY MEASURES

The REDD-CAT Housing Security instruments assess housing insecurity among people with Type 2 Diabetes Mellitus. It includes 22 items.

TBI-CareQOL Military Health Care Frustration instruments are available for adults (ages 18+).

### VERSION DIFFERENCES

Some REDD-CAT domains have multiple versions of instruments (i.e. v1.0, v1.1, v2.0). **Generally, it is recommended that you use the most recent version which can be identified as the instrument with the highest version number.** In most cases, an instrument that has a decimal increase (v1.0 to v1.1) retains the same item-level parameters as well as instrument reliability and validity. In cases where a version number increases by a whole number (e.g., v1.0 to v2.0), the changes to the instrument are more substantial.

For the Housing Instruments, first version measure.

$$\text{AffordScale\_01} + \text{AffordScale\_02} + \text{AffordScale\_03} + \text{AffordScale\_04} + \text{AffordScale\_05} + \text{AffordScale\_06} = \text{raw score}$$

REDD-CAT Security v1.0 is the of this

### SCORING THE INSTRUMENT

The REDD-CAT v1.0 - Housing Affordability Scale is scored using item-level calibrations. This measure can be scored using the scoring table in this manual. Each question usually has five response options ranging in value from one to five. To find the total raw score for the housing affordability measure, sum the values of the responses on the following 6 items:

The lowest possible raw score is 6; the highest possible raw score is 30 (see the scoring table in Appendix 1). **All questions must be answered in order to produce a valid score using the scoring tables.**

With the total raw score for a measure, locate the applicable score conversion table in Appendix 1 and use this table to translate the total raw score into a T-score for each participant. The T-score rescales the raw score into a standardized score with a mean of 50 and a standard deviation (SD) of 10. Therefore, a person with a T-score of 40 is one SD below the mean.

Figure 2 (continued)

For the REDD-CAT v1.0 – Housing Affordability Scale, a raw score of 13 converts to a T-score of 40.62 with a standard error (SE) of 3.93 (see scoring table in Appendix 1). Thus, a  $\pm 1$  standard error of measurement (SEM) confidence interval around this observed score is from 36.69 to 44.55 [T-score  $\pm (1*SE$  [which is also the SEM]) or  $40.62 \pm (1*3.93)$ ]. The 95% confidence interval around this observed score is from 32.92 to 48.32 [T-score  $\pm (1.96*SE)$  or  $40.62 \pm (1.96*3.93)$ ].

For the REDD-CAT v1.0 – Housing Affordability Scale, a score of 50 is the average (with a standard deviation of 10) for persons with Type 2 Diabetes Mellitus because calibration testing was performed on a sample of patients with Type 2

Mellitus. The provided with term (Standard SE). The Error is a measure of represents the error” for the

$$\frac{\text{HouseFeatures\_01} + \text{HouseFeatures\_02} + \text{HouseFeatures\_03} + \text{HouseFeatures\_04} + \text{HouseFeatures\_05} + \text{HouseFeatures\_06} + \text{HouseFeatures\_07} + \text{HouseFeatures\_08}}{\text{total number of housing features items completed}}$$

Diabetes T-score is an error Error or Standard statistical variance and “margin of T-score.

**Important:** A

REDD-CAT T-score represents more of the concept being measured. For positively worded concepts, such as the REDD-CAT v1.0 – Housing Affordability Scale, a T-score of 40 is one SD worse than average.

higher

The REDD-CAT v1.0 - Housing Features Index is scored by generating a total sum score and dividing that total sum score by the number of items that were administered (i.e., total sum score / total number of completed housing features items [maximum possible 8]):

$$\frac{\text{HouseSafety\_01} + \text{HouseSafety\_02} + \text{HouseSafety\_03}}{\text{total number of housing safety items completed}}$$

Thus overall scores on this index can range from 1-5. Higher scores indicate more available housing features. Additional follow-up is warranted for individuals with Housing Features Index scores < 4.

The REDD-CAT v1.0 - Housing Safety Index is scored by generating a total sum score and dividing that total sum score by the number of items that were administered (i.e., total sum score / number of housing safety items administered [maximum 3]):

Thus overall scores on this index can range from 1-5. Higher scores indicate more housing safety. Additional follow-up is warranted for individuals with Housing Safety Index scores < 4.

The REDD-CAT v1.0 – Anxiety about Affording Housing Item. This is a single item (AffordHousing\_01) have response options with associated point values that range from 1 to 5. Higher scores indicate less anxiety about housing affordability. Any response option score < 5 (i.e., other than “never”) warrants additional follow-up.

The REDD-CAT v1.0 – Domestic Violence Item. This is a single item (DomViolence\_01) has response options with associated point values that range from 1 to 5. Higher scores indicate more personal safety. Any response option score < 5 (i.e., other than “never”) warrants additional follow-up.

The REDD-CAT v1.0 – Anxiety About Where I Will Sleep Item This is a single item (SleepLocation\_01) have response options with associated point values that range from 1 to 5. Higher scores less anxiety about where one will sleep. Any response option score < 5 (i.e., other than “never”) warrants additional follow-up.

Figure 2 (continued)

## SCORING TABLES

REDD-CAT V1.0 - Housing Affordability Scale  
Score Conversion Table

Raw Summed Score	T Score	SE *
6	27.18	5.17
7	30.86	4.48
8	32.54	4.45
9	34.52	4.22
10	36.17	4.12
11	37.73	4.02
12	39.20	3.96
13	40.62	3.93
14	41.99	3.91
15	43.35	3.90
16	44.68	3.90
17	46.02	3.91
18	47.36	3.92
19	48.71	3.94
20	50.08	3.95
21	51.49	3.96
22	52.96	3.96
23	54.51	3.97
24	56.15	3.99
25	57.90	4.02
26	59.81	4.10
27	61.88	4.18
28	64.28	4.42
29	66.84	4.62
30	70.97	5.37

\*SE = T Score standard error

## SCORING SHEET

HOUSING SECURITY DOMAIN	Score	Flag	Score Interpretation
When I am discharged, I will go to:			1, My own home/family residence   2, A friend's home/residence   3, A shelter   4, I do not have any options for housing or shelter   5, I don't know
Housing Affordability Scale		flag scores < 46	T score -- High scores better
Housing Safety Index		flag scores < 4	High scores better (i.e., more safety) scores range from 1-5
Housing Features Index		flag scores < 4	High scores better (i.e., more features) scores range from 1- 5
Anxiety About Affording Housing		flag scores < 5	5= never, 4=rarely, 3=sometimes; 2=usually, 1=always
Domestic Violence		flag scores < 5	5= never, 4=rarely, 3=sometimes; 2=usually, 1=always
Anxiety About Where Will Sleep Next		flag scores < 5	5= never, 4=rarely, 3=sometimes; 2=usually, 1=always

Figure 2 (continued)

**Table 2 Unidimensional Modeling and Analyses for the REDD-CAT Housing Affordability Subdomain**

Domain	Item pool	Unidimensional Modeling								Initial Item performance		IRT modeling	
		EFA E1/E2 ratio (criterion >4)	Percent of variance for E1 (criterion >40)	1-factor CFA loading (criterion <.50)	1-factor CFA residual correlation (criterion >.20)	1-factor CFA modification index (criterion >100)	Item-adjusted total score correlations (Criterion <.40)	Sparse cells (criterion <10)	Problems with monotonicity	IRT item misfit	DIF	Interim/Final measure	
Housing Affordability	7 items	2.8	56.1	0 items	1 item	0 items	0 items	0 items	0 items	0 items	0 items	0 items	6 items

CFA, confirmatory factor analysis; EFA, exploratory factor analysis; IRT, item response theory

**Table 3 Final Overall Model Fit for the REDD-CAT Housing Affordability Subdomain**

Domain	Item bank	CFI (criterion > .90)	TLI (criterion > .90)	CFA-based RMSEA (criterion < .15)	Alpha reliability (criterion > .80)	IRT-based RMSEA (criterion < .15)	Response pattern/person reliability (criterion > .80)
Housing Affordability	6	.992	.987	.13	.82	.17	.84

CFI, Comparative Fit Index; TLI, Tucker-Lewis Index; RMSEA, root mean square error of approximation

**Table 4 Descriptive Data for the new REDD-CAT Housing Security PROs**

	N	Internal consistency reliability	Mean (SD)	% at floor	% at ceiling
Housing Affordability	108	0.82	48.7 (9.04)	1.85	0.93
	N	Score range	Mean (SD)	% responding never to all items	% responding always to all items
Housing Safety	217	1-5	4.4 (0.56)	6.45	0.00
Housing Features	211	1-5	4.6 (0.44)	0.00	33.65
Domestic Violence	195	1-5	4.9 (0.35)	95.90	0.00

**Table 5 Convergent and Discriminant Validity for the new REDD-CAT Housing Security PROs**

	Convergent validity (anticipated <i>r</i> ≥ 0.36*)	Discriminant validity	
		Neuro-QoL Anxiety (anticipated <i>r</i> ≤ 0.35**)	Pain (anticipated <i>r</i> ≤ 0.35**)
Housing Affordability	Economic QOL 0.47	-0.30	-0.15
Housing Safety	Severity of substance use -0.49	-0.31	-0.23
Housing Features	Severity of substance use -0.49	-0.22	-0.19

Pearson correlations were used to examine analyses with Housing Affordability and Spearman correlations were used to examine analyses with Housing Safety and Housing Features

\*The absolute value of 0.36 (i.e., ±0.36)

\*\*The absolute value of 0.35 (i.e., ±0.35)

Table 6 Known-Groups Validity for New REDD-CAT Housing Security PROs

<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>t</i>	<i>p</i>
Housing Affordability <sup>a</sup>					
Not enough money to make ends meet		Enough money to make ends meet			
81	47.4 (8.65)	27	52.4 (9.33)	2.54	0.01
<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>U</i>	<i>p</i>
Housing Safety					
Not enough money to make ends meet		Enough money to make ends meet			
134	4.3 (0.59)	83	4.5 (0.50)	3.23	0.07
“Worse” economic quality of life (scores ≥ 60)		“Better” economic quality of life (scores ≤ 40)			
58	4.2 (0.65)	15	4.6 (0.61)	6.73	<0.001
Housing Features					
Not enough money to make ends meet		Enough money to make ends meet			
130	4.6 (0.48)	81	4.7 (0.35)	5.99	0.01
“Worse” economic quality of life (scores ≥ 60)		“Better” economic quality of life (scores ≤ 40)			
53	4.8 (0.28)	15	4.5 (0.45)	4.16	0.04

<sup>a</sup>Housing Affordability score ≥ 60; independent-samples *T* tests are reported for analyses using Housing Affordability scores and Mann *U* Whitney tests are reported for analyses using Housing Safety and Housing Features scores

I cannot afford independent housing”). Individuals that indicate a shelter, no options, or “I don’t know” should be flagged for additional follow-up to help ensure a safe housing placement at discharge.

Housing Affordability raw scores are converted to *T*-scores (using Table 5), with lower scores indicating more significant concerns with housing affordability. Interpretation of obtained Housing Affordability scores is as follows: (1) scores equal to or below 40 (i.e., ≤ 1 *SD* below the normative mean) indicate Housing Affordability concerns that exceed 83.9% of persons with T2DM; scores less than or equal to 30 (i.e., ≤ 2 *SDs* below the normative mean) indicate Housing Affordability concerns that are worse than 97.9% of persons with T2DM.

Housing Safety scores (i.e., the average score across completed items) range from 1 to 5, with higher scores indicating greater perceived safety. Additional follow-up is warranted for any average score that is less than 4. Housing Features scores (the average score across completed items) also range from 1 to 5, with higher scores indicating more/ more consistently present features of housing. Additional follow-up is warranted for any average score that is less than 4. Finally, any response other than “never” on the Anxiety About Affording Housing, Domestic Violence, or Anxiety About Where Will Sleep Next single-item assessments warrants clinical follow-up.

While this is the first measure designed to capture multiple domains of housing security, there are also several important limitations to our study. First, there are several limitations with regard to generalizability. For example, the new PRO was developed and tested in patients with T2DM; therefore, future testing is needed to determine if this measure will exhibit clinical utility in other populations. In addition, the study sample was recruited through an urban safety-net health system; findings may not be generalizable to other types of health systems. Furthermore, there were high rates of Black/ African American patients and low rates of Hispanic/Latino

patients in this study; more work is needed to ensure generalizability to other racial/ethnic groups. Second, while these data provide a preliminary look at reliability and validity, future work is needed in independent samples to confirm these findings and to examine the responsiveness of scores on this measure in the context of clinical follow-up. Third, while this tool is designed to screen for individuals that have housing insecurity, it is not yet designed to generate follow-up and appropriate referrals, the value of which warrants additional study. In addition, there is ongoing work examining the feasibility and acceptability of using the comprehensive REDD-CAT measurement system as part of the discharge planning process, which should be available in late 2023.

In sum, the new REDD-CAT Housing Security PROs is a psychometrically sound measure that can be used to identify individuals that are at high risk for negative outcomes due to housing insecurity. This measure, in combination with the broader REDD-CAT measurement system, provides a valuable tool for identifying unmet needs among persons with T2DM. It is our hope that this comprehensive measurement system for capturing important social determinants of health can provide an easy way to identify individuals at high risk for negative outcomes and provide them with appropriate referrals to help mitigate these unmet needs and ultimately maximize patient health-related quality of life.

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**Author Contributions** Noelle E. Carlozzi: Principal investigator; data coordination and analysis site; analysis design; initial draft of introduction, methods, results, and discussion; incorporation of revisions. Michael A. Kallen: Study co-investigator and statistician; assistance with analysis design; primary statistician for measurement development portions of manuscript (e.g., factor analyses and IRT analyses); drafted statistical analysis section and a template for the results section Jonathan P. Troost: Statistician and data analyst; primary statistician for reliability and validity analyses; assistance writing methods and results sections; review and feedback on manuscript drafts Jennifer A. Miner: Study data manager; critical review of the methods and results; review and feedback on manuscript drafts Alexa Bragg: Study research coordinator; responsible for data collection; review and feedback on manuscript drafts (critical review of the methods) Jessica Martin-Howard: Study grants manager and project coordinator; review and feedback on manuscript drafts; assistance with study regulatory documents Barbara De La Cruz: Project manager; review and feedback on manuscript drafts; assistance with synthesis of revisions Ioana Moldovan: Study research coordinator; responsible for data collection; review and feedback on manuscript drafts (critical review of the methods) Brian W. Jack: Principal investigator of the PRET study; review and feedback on manuscript drafts (critical review of the summary of the qualitative work that informed this study) Suzanne Mitchell: Principal investigator; data collection site; study design; critical review of the introduction and discussion; review and feedback on manuscript drafts

**Data Availability** The data that support the findings of this study are available from the corresponding author, NEC, upon reasonable request.

#### Declarations:

**Ethics Approval:** Approval was obtained from the ethics committee of Boston Medical Center, who served as the single IRB of record for this study. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

**Consent to Participate:** Informed consent was obtained from all participants prior to their participation in this study.

**Conflict of Interest:** The authors declare that they do not have a conflict of interest.

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